APPENDIX D

Biological Data on Columbia River Salmonids

Appendix D provides technical information on the Evolutionary Significant Units (ESUs) and Distinctive Population Segments (DSPs) of concern in the Columbia River study area. This section is subdivided into four separate technical analyses, each summarizing specific information. The appendix is organized as follows:

D-1: Descriptions of Lower Columbia River Listed Salmonids – Evolutionarily Significant Units and Distinct Population Segments

D-2: Use and Importance of the Lower Columbia River, Estuary, and Ocean Plume to Coastal Cutthroat Trout

D-3: Review of Columbia River Estuary Studies Indicating Size and Location of Cutthroat Trout in the Columbia River Estuary 1967-1971 and 1978-1980

D-4: Ecology and Behavior of Columbia River Salmonids

D-1 DESCRIPTIONS OF LOWER COLUMBIA RIVER LISTED SALMONIDS – EVOLUTIONARILY SIGNIFICANT UNITS AND DISTINCT POPULATION SEGMENTS

1.1 Snake River Fall Chinook

From: Status Review for Snake River Fall Chinook Salmon. Northwest Fisheries Science Center. June 1991.

The Columbia River Basin has historically produced more chinook salmon than any other river system in the world (Van Hyning, 1973). Fall chinook salmon were widely distributed throughout the Snake River and many of its tributaries, from its confluence with the Columbia River upstream 990 kilometers (km) to Shoshone Falls, Idaho (Columbia Basin Interagency Committee, 1957; Haas, 1965; Fulton, 1968; Van Hyning, 1968; Lavier, 1976).

The construction of 12 dams on the mainstem Snake River substantially reduced the distribution and abundance of Snake River fall chinook salmon (Irving and Bjornn, 1981a). Fish passage facilities proved unsuccessful at several projects, and spawning habitats, particularly areas most frequently used by fall chinook salmon, were eliminated with the formation of reservoirs.

The upper reaches of the mainstem Snake River were the primary areas used by fall chinook salmon, with only limited spawning activity reported downstream from river kilometer (RKm) 439. The construction of Brownlee Dam (1958; RKm 459), Oxbow Dam (1961; RKm 439), and Hells Canyon Dam (1967; RKm 397) eliminated the primary production areas of Snake River fall chinook salmon. Habitat was further reduced with the construction of four additional dams on the Lower Snake River. Apart from the possibility of deep-water spawning in lower areas of the river, the mainstem Snake River from the upper limit of the Lower Granite Dam reservoir to Hells Canyon Dam (approximately 165 km) and the lower reaches of the Imnaha, Grande Ronde, Clearwater, and Tucannon Rivers are the only remaining areas available to fall chinook salmon in the Snake River Basin.

Adult Snake River fall chinook salmon enter the Columbia River in July and August and reach the mouth of the Snake River from the middle of August through October. Spawning occurs in the mainstem and in the lower reaches of large tributaries in October and November. Based on what is known of upper Columbia River fall chinook salmon, juveniles in the Snake River presumably emerge from the gravel in March and April and downstream migration usually begins within several weeks of emergence (Chapman, et al., 1991).

Rich (1922) studied the downstream migration of chinook salmon in the lower Columbia River and concluded that fry were present from June to October. Fall chinook salmon fry were found to be abundant in May and June (Reimers, 1964). Van Hyning (1968) reported that chinook salmon fry tend to linger in the lower Columbia River and may spend a considerable portion of their first year in the estuary.

1.2 Lower Columbia River Chinook

From: Status Review of Chinook Salmon from Washington, Idaho, Oregon, and California. Northwest Fisheries Science Center. February 1998.

The Columbia River exerts a dominant influence on the biota of the Pacific Northwest, although smaller, regional distinctions exist within the basin. In the lower Columbia River Basin, the Cowlitz, Kalama, Lewis, White Salmon, and Klickitat Rivers are the major river systems on the Washington side, while the

Willamette and Sandy Rivers are foremost on the Oregon side. Spring chinook salmon, which spawn above the Willamette Falls, will be discussed separately because of their geographic and life-history distinctiveness.

The fall run is predominant in this region. These fall chinook salmon are often called "tules" and are distinguished by their dark skin coloration and advanced maturity at the time of freshwater entry. Tule fall chinook salmon populations may have historically spawned from the mouth of the Columbia River to the Klickitat River (RKm 290). Whatever spawning grounds were accessible to fall chinook salmon on the Klickitat River (below Lyle Falls at RKm 3) would have been inundated following the construction of Bonneville Dam (RKm 243) in 1938 (Bryant, 1949; Hymer, et al., 1992a; WDF, et al.; 1993) There is no record of fall chinook salmon using this lower portion of the Klickitat River (Fulton, 1968). A significant fall run once existed on the Hood River (RKm 272) prior to the construction of Powerdale Dam (1929) and other diversion and irrigation dams (Fulton, 1968); however, this run has become severely depleted and may have been extirpated (Howell, et al., 1985; Nehlsen, et al., 1991; Theis and Melcher, 1995). The Big White Salmon River (RKm 270) supported runs of chinook salmon prior to the construction of Condit Dam (RKm 4) in 1913 (Fulton, 1968). Tule fall chinook salmon begin the freshwater phase of their return migration in late August and the peak spawning interval does not occur until November (WDF, et al. ,1993).

Among other fall-run populations, a later returning component of the fall chinook salmon run exists in the Lewis and Sandy Rivers (WDF, et al., 1993; Kostow, 1995; Marshall, et al., 1995). Because of the longer time interval between freshwater entry and spawning, Lewis and Sandy River fall chinook salmon are less mature at freshwater entry than tule fall chinook salmon and are commonly called lower river "brights" (Marshall, et al., 1995).

The Cowlitz, Kalama, Lewis, Clackamas, and Sandy Rivers currently contain both spring and fall runs; the Big White Salmon River historically contained both spring and fall runs but currently only contains fall-run fish (Fulton, 1968; WDF, et al., 1993). The Klickitat River probably contained only spring chinook salmon because falls blocked access to fall chinook salmon during low autumn flows (Fulton, 1968). The spring run on the Big White Salmon River was extirpated following construction of Condit Dam (Fulton, 1968), while a variety of factors may have caused the decline and extinction of spring chinook salmon on the Hood River (Nehlsen, et al., 1991; Kostow, 1995).

Spring chinook salmon on the lower Columbia River, like those from coastal stocks, enter freshwater in March and April well in advance of spawning in August and September. Fish migrations historically were synchronized with periods of high rainfall or snowmelt to provide access to upper reaches of most tributaries where fish would hold until spawning (Fulton, 1968; Olsen, et al., 1992; WDF, et al., 1993). Dams have reduced or eliminated access to upriver spawning areas on the Cowlitz, Lewis, Clackamas, Sandy, and Big White Salmon Rivers. A distinct winter-spawning run may have existed on the Sandy River (Mattson, 1955) but is believed to have been extirpated (Kostow, 1995).

1.3 Upper Columbia River Spring Chinook

From: Status Review of Chinook Salmon from Washington, Idaho, Oregon, and California. Northwest Fisheries Science Center. February 1998.

East of the Cascade Crest, many river systems support populations of both ocean- and stream-type chinook salmon. Fall-run (ocean-type) fish return to spawn in the mainstem Columbia and Snake Rivers and their tributaries, primarily the Deschutes and Yakima Rivers (Hymer, et al., 1992b; Olsen, 1992). Numerous other Columbia River tributaries in Washington, Oregon, and Idaho historically supported fall runs, but for a variety of reasons these are now extinct (Fulton, 1968; Nehlsen et al.,1991; Hymer et al., 1992a; Olson, et al., 1992; WDF, et al., 1993). Fall salmon historically migrated as far as Kettle Falls on the Columbia River (RKm 1,090) prior to the completion of Grand Coulee Dam (RKm 961) in 1941 (Mullan, 1987). Chapman (1943) observed chinook salmon spawning in deep water just below Kettle Falls in October 1938. Similarly, fall-run chinook salmon migrated up the Snake River to Shoshone Falls (RKm 976), although Augur Falls (RKm 960) probably blocked the passage of most fish (Evermann, 1896; Fulton, 1968).

Summer chinook salmon populations on the Columbia River exhibit an ocean-type life history, while summer chinook salmon on the Snake River exhibit a stream-type life history (Taylor, 1990a; Chapman, et al., 1991; Chapman, et al., 1994; Matthews and Waples. 1991; Waknitz, et al., 1995). Summer-run fish return to freshwater in June through mid-August—slightly earlier than the fall-run fish, which return from mid-August through October (Fulton, 1968). Summer-run fish were able to ascend Kettle Falls (Evermann,1896; Bryant and Parkhurst, 1950) and probably migrated as far as Lake Windermere in British Columbia (Hymer, et al., 1992b; Chapman, et al., 1994). With the completion of the Grand Coulee Dam in 1941 (RKm 961) and Chief Joseph Dam in 1955 (RKm 877) migration of salmon is blocked at Chief Joseph Dam. Naturally spawning ocean-type summer-run chinook salmon are also found in the Wenatchee (RKm 753) and Methow Rivers (RKm 843) (Waknitz, et al., 1995). Summer chinook are also reported to spawn in the lower Entiat and Chelan Rivers, in addition to below mainstem Columbia River dams (Marshall, et al., 1995); however, it has not been determined whether or not these are self-sustaining populations.

Among ocean-type Columbia River populations above Celilo Falls, summer-run chinook salmon spawn in the mid and lower reaches of tributaries, with peak spawning occurring in October; fall chinook salmon spawn in the mainstem Columbia and Snake Rivers and the lower reaches of the Deschutes and Yakima Rivers, with peak spawning occurring in November (Howell, et al., 1985; Marshall, et al., 1995; Mullan, 1987; Garcia, et al., 1996). Additionally, fall chinook salmon in the mainstem Columbia and Snake Rivers have been observed spawning in water 10 meters (m) deep or more (Chapman, 1943; Bruner, 1951; Swan et al., 1988; Hymer, et al., 1992b; Dauble, et al., 1995).

Ocean-type fry west of the Cascade Crest emerge in April and May, and the majority rear from 1 to 4 months in fresh water prior to emigrating to the ocean (Mullan, 1987; Olsen, et al., 1992; Hymer, et al., 1992a; WDF, et al., 1993; Chapman, et al., 1994; Marshall, et al., 1995). A small proportion of summer- and fall-run fish remains in fresh water until their second spring and emigrate as yearlings (Chapman, et al., 1994; Waknitz, et al., 1995). The proportion of yearling outmigrants varies from year to year, perhaps as a result of to environmental fluctuations. Among summer-run populations, the lowest incidence of yearling outmigrants is found in the Okanogan River, where the waters are relatively warm and highly productive (Chapman, et al., 1994).

1.4 Upper Willamette River Chinook

From: Status Review of Chinook Salmon from Washington, Idaho, Oregon, and California. Northwest Fisheries Science Center. February 1998.

Willamette Falls (RKm 42) has historically limited access to the upper river and thus defines the boundary of a distinct geographic region. High flows over the falls provided a window when returning chinook salmon could ascend the falls in the spring, while low flows prevented fish from ascending the falls in the autumn (Howell et al. 1985). The predominant tributaries to the Willamette River that historically supported spring-run chinook salmon—the Molalla (RKm 58), Santiam (RKm 174), McKenzie (RKm 282) and Middle Fork Willamette Rivers (RKm 301)—all of which drain the Cascades to the east (Mattson, 1948; Nicholas, 1995).

Three major populations of spring chinook salmon are currently located above Willamette Falls (McKenzie River and the North and South Forks of the Santiam River) (Kostow, 1995). Fall chinook salmon are present in the upper Willamette River, but these fish are transplants that have obtained access to the upper Willamette River as a result of the construction of fish passage facilities in 1971 and 1975 (Bennett, 1988). Adult spring-run chinook enter the Columbia River in March and April, but they do not ascend the Willamette Falls until May or June. The migration past the falls generally coincides with a rise in river temperatures above 10ºC (Mattson, 1948; Howell, et al., 1985; Nicholas, 1995). Spawning generally begins in late August and continues into early October, with spawning peaks in September (Mattson, 1948; Nicholas, 1995; Willis, et al., 1995).

1.5 Snake River Spring/Summer Chinook

From: Status Review for Snake River Spring and Summer Chinook Salmon. Northwest Fisheries Science Center. June 1991.

Spring and/or summer chinook salmon have historically spawned in virtually all accessible and suitable habitat in the Snake River upstream from its confluence with the Columbia River (Evermann, 1896; Fulton, 1968). Human activities have substantially reduced the amount of suitable spawning habitat in the Snake River. Even prior to hydroelectric development, many small tributary habitats were lost or severely damaged by construction and operation of irrigation dams and diversions; inundation of spawning areas by impoundments; and siltation and pollution from sewage, farming, logging, and mining (Fulton, 1968). More recently, the construction of hydroelectric and water storage dams without adequate provisions for adult and juvenile passage in the upper Snake River has precluded the use of all spawning areas upstream from Hells Canyon Dam.

The Snake River contains five principal subbasins that produce spring and/or summer chinook salmon (CBFWA, 1990). Three of the five subbasins (Clearwater, Grande Ronde, and Salmon Rivers) are large, complex systems composed of several smaller tributaries, which are further composed of many small streams. In contrast, the other two principal subbasins (Tucannon and Imnaha Rivers) are small systems in which the majority of salmon production is in the main rivers themselves. In addition to the five major subbasins, three small streams (Asotin, Granite, and Sheep Creeks) that enter the Snake River between Lower Granite and Hells Canyon Dams provide small spawning and rearing areas (CBFWA, 1990).

Adult spring chinook salmon migrate upstream past Bonneville Dam from March through May; summer chinook salmon migrate June through July. In both rivers, spring chinook salmon tend to use small, higher elevation streams (headwaters), and fall chinook salmon tend to use large, lower elevation streams or mainstem areas. Summer chinook salmon are more variable in their spawning habitats; in the Snake River, they inhabit small, high-elevation tributaries typical of spring chinook salmon habitat; conversely, in the upper Columbia River they spawn in larger, lower-elevation streams more characteristic of fall chinook salmon habitat. Differences are also evident in juvenile outmigration behavior. In both rivers, spring chinook salmon migrate swiftly to sea as yearling smolts, and fall chinook move seaward slowly as subyearlings. Summer chinook salmon in the Snake River resemble spring-run fish in migrating as yearlings, but they migrate as subyearlings in the Upper Columbia River (Schreck, et al., 1986).

1.6 Columbia River Chum

From: Status Review of Chum Salmon from Washington, Oregon, and California. Northwest Fisheries Science Center. December 1997.

At least one Evolutionary Significant Unit (ESU) of chum salmon was historically present in the Columbia River. Chum salmon were historically abundant in the lower reaches of the Columbia River and may have spawned as far upstream as the Walla Walla River (more than 500 km inland). Today, only remnant chum salmon populations exist, all in the lower Columbia River. Small spawning populations of chum salmon are regularly found as far south as the lower Columbia River and Tillamook Bay. They are few in number, low in abundance, and of uncertain stocking history.

Chum salmon are limited to tributaries below Bonneville Dam, with the majority of fish spawning on the Washington side of the Columbia River. Chum salmon have been reported in October in the Washougal, Lewis, Kalama, and Cowlitz Rivers in Washington and in the Sandy River in Oregon (Salo, 1991). Only three Washington runs (Grays River, Hamilton Creek, and Hardy Creek) were listed in the SASSI report, and all return in about October (the peak is mid-November), a run time similar to that of chum salmon in rivers along the Washington coast (WDF, et al., 1993). Grays River chum salmon enter the Columbia River from mid-October to mid-November, but apparently do not reach the Grays River until late October to early December. These fish spawn from early November to late December. Fish returning to Hamilton and Hardy Creeks begin to appear in the Columbia River earlier than Grays River fish (late September to late October) and have a more protracted spawn timing (mid-November to mid-January). The Oregon Department of Fish and Wildlife (ODFW) cited 25 locations in that state where chum salmon spawn in the lower Columbia River, but run times for these fish are unavailable (Kostow, 1995).

Observations of chum salmon fry are often more difficult to make than are observations of juveniles of other salmonids because chum salmon outmigrants (1) are smaller than outmigrants of other salmonids; (2) migrate at night; (3) usually have shorter distances to migrate to reach salt water than do other species; and (4) do not school as tightly as some other salmonids. Nonetheless, several key facets of fry outmigration are known. Downstream migration may take only a few hours or days in rivers where spawning sites are close to the mouth of the river, or it may take several months. Juvenile salmon at southern localities, such as those in Washington and southern British Columbia, migrate downstream earlier (late January through May) than fry in northern British Columbia and southeastern Alaska (April to June) do.

1.7 Snake River Sockeye

From: Status Review for Snake River Sockeye Salmon. Northwest Fisheries Science Center. April 1991.

Sockeye salmon are native to the Snake River and historically were abundant in several lake systems in Idaho and Oregon. In this century, a variety of factors have led to the demise of all Snake River sockeye salmon except those returning to Redfish Lake in the Stanley Basin of Idaho. Adults migrate upstream to Redfish Lake from July to September. Juveniles migrate downstream from Redfish Lake during April and May.

1.8 Lower Columbia River Steelhead

From: Status Review of West Coast Steelhead from Washington, Idaho, Oregon, and California. Northwest Fisheries Science Center. August 1996.

The ESU occupies tributaries to the Columbia River between the Cowlitz and Wind Rivers in Washington and the Willamette and Hood Rivers in Oregon, inclusive. Excluded are steelhead in the upper Willamette River Basin above Willamette Falls and steelhead from the Little and Big White Salmon Rivers, Washington. This ESU comprises both winter and summer steelhead. Genetic data show distinction between steelhead of this ESU and adjacent regions, with a particularly strong difference between coastal and inland steelhead in the vicinity of the Cascade Crest. The majority of stocks for which there are data within this ESU have been declining in the recent past, but some have been increasing strongly.

1.9 Upper Willamette River Steelhead

From: Status Review of West Coast Steelhead from Washington, Idaho, Oregon, and California. Northwest Fisheries Science Center. August 1996.

This ESU occupies the Willamette River and its tributaries upstream from Willamette Falls. The native steelhead of this basin are late-migrating winter steelhead, entering fresh water primarily in March and April. This unusual run timing appears to be an adaptation for ascending Willamette Falls. The falls function as an isolating mechanism for upper Willamette River steelhead. Early migrating winter steelhead and summer steelhead have been introduced to the Upper Willamette River Basin; however, these non-native populations are not components of this ESU. Native winter steelhead within this ESU have been declining on average since 1971 and have exhibited large fluctuations in abundance. The main production of native (late-run) winter steelhead is in the North Fork Santiam River, where estimates of hatchery proportion in natural spawning range from 14 percent to 54 percent. The native steelhead of this basin are late migrating winter steelhead, entering fresh water primarily in March and April.

1.10 Middle Columbia River Steelhead

From: Status Review of West Coast Steelhead from Washington, Idaho, Oregon, and California. Northwest Fisheries Science Center. August 1996.

This ESU occupies the Columbia River Basin from above the Wind River in Washington and the Hood River in Oregon upstream to include the Yakima River, Washington. Steelhead of the Snake River Basin are not included. This ESU includes the only populations of winter inland steelhead in the United States, in the Klickitat River and Fifteenmile Creek. Some uncertainty exists about the exact boundary between coastal and inland steelhead, and the western margin of this ESU reflects currently available genetic data. There is good genetic and meristic evidence to separate this ESU from steelhead of the Snake River Basin. The boundary upstream of the Yakima River is based on limited genetic information and environmental differences, including physiographic regions, climate, topography, and vegetation. Total abundance in the ESU appears to have been increasing recently, but the majority of natural stocks for which there are data within this ESU have been declining, including those in the John Day River, which is the largest producer of wild, natural steelhead. There is widespread production of hatchery steelhead within this ESU, but it is largely based on within-basin stocks. Habitat degradation due to grazing and water diversions has been documented throughout the range of the ESU.

Life-history information for steelhead of this region indicates that most middle Columbia River steelhead smolt at 2 years and spend 1 to 2 years in salt water prior to re-entering fresh water, where they may remain up to a year prior to spawning (Howell, et al., 1985; Bonneville Power Administration, 1992). Within this ESU, the Klickitat River is unusual in that it produces both summer and winter steelhead, and the summer steelhead are dominated by age-2-ocean steelhead, whereas most other rivers in this region produce about equal numbers of both age-1- and age-2-ocean steelhead.

1.11 Upper Columbia River Steelhead

From: Status Review of West Coast Steelhead from Washington, Idaho, Oregon, and California. Northwest Fisheries Science Center. August 1996.

This ESU occupies the Columbia River Basin upstream from the Yakima River. All upper Columbia River steelhead are summer steelhead. The streams of this region that are used by steelhead primarily drain the northern Cascade Mountains of Washington. Stream flow is supplied by snowmelt, groundwater, and glacial runoff, often resulting in extremely cold water temperatures that retard the growth and maturation of steelhead juveniles, causing some of the oldest smolt ages reported for steelhead and residualization of juvenile steelhead that fail to smolt. While total abundance of populations within this ESU has been relatively stable or increasing, this appears to be true only because of major hatchery supplementation programs. Estimates of the proportion of hatchery fish in spawning escapement are 65 percent (Wenatchee River) and 81 percent (Methow and Okanogan Rivers).

Life-history characteristics for Upper Columbia River steelhead are similar to those of other inland steelhead ESUs; however, some of the oldest smolt ages for steelhead, up to 7 years, are reported from this ESU. This may be associated with the cold stream temperatures discussed by Mullan et al. (1992), who stated that the cold water in some of the streams of this area may cause some fish to be "thermally fated to a resident (rainbow trout) life history, regardless of whether they were the progeny of anadromous or resident parents." The relationship between anadromous and nonanadromous *Oncorhynchus mykiss* in this geographic area is unclear. Based on limited data available from adult fish, smolt age in this ESU is dominated by 2-year-olds. Again based on limited data, steelhead from the Wenatchee and Entiat Rivers return to fresh water after 1 year in salt water, whereas Methow River steelhead are primarily age-2-ocean (Howell, et al., 1985). As with other inland steelhead, these remain in fresh water up to a year prior to spawning.

1.12 Snake River Steelhead

From: Status Review of West Coast Steelhead from Washington, Idaho, Oregon, and California. Northwest Fisheries Science Center. August 1996.

This ESU occupies the Snake River Basin of southeast Washington, northeast Oregon, and Idaho. This region is ecologically complex and supports a diversity of steelhead populations; however, genetic and meristic data suggest that these populations are more similar to each other than they are to steelhead populations occurring outside of the Snake River Basin. Snake River steelhead spawning areas are well isolated from other populations and include the highest elevations for spawning (up to 2,000 m) as well as the longest migration distance (up to 1,500 km). Snake River steelhead are often classified into two groups, A-run and B-run, based on migration timing, ocean age, and adult size. While total (hatchery plus natural) run size for Snake River steelhead has increased since the mid-1970s, the increase has resulted from greater production of hatchery fish, and there has been a severe recent decline in natural run size. Parr densities in natural production areas have been substantially below estimated capacity in recent years. Downward trends and low parr densities indicate a particularly severe problem for B-run steelhead, the loss of which would substantially reduce life-history diversity within this ESU. Snake River steelhead enter fresh water from June to October and spawn during the following spring from March to May.

1.13 Cutthroat Southwest Washington/Columbia River

From: Status Review of Coastal Cutthroat Trout from Washington, Oregon, and California. Northwest Fisheries Science Center. January 1999.

The proposed boundaries of this ESU are similar to the Southwestern Washington/Lower Columbia River ESU for coho salmon (Weitkamp, et al., 1995). Support for this ESU designation comes primarily from ecological and genetic information. Ecological characteristics of this region include the presence of extensive intertidal mudflats and sandflats, similarities in fresh water and estuarine fish faunas, and substantial differences from estuaries north of Grays Harbor and south of the Columbia River. The coastal cutthroat trout samples from southwestern Washington show a relatively close genetic affinity to the samples from the Columbia River.

Coastal cutthroat trout parr generally remain in upper tributaries until they are 1 year of age, when they may begin moving more extensively throughout the river system. Once these movements begin, it is difficult to determine whether fish caught in upstream or downstream traps are parr making a freshwater migration or smolts on a seawater-directed migration; many unpaired coastal cutthroat trout of similar size caught in these traps have characteristics of either life-history stage or intermediate characteristics. In Oregon, Lowry (1965) and Giger (1972) found that downstream-directed movement by juveniles in the Alsea River system began with the first springs rains, usually in mid-April with peak movement in mid-May. Giger (1972) also reported that some juveniles entered the estuary and remained there over the summer but apparently did not smolt or migrate to the open ocean. He was unable to determine how many of these parr continued moving seaward and how many remained in the estuaries. Such movement further confounds the difficulty in separating nonanadromous downstream migrations from seaward migrations.

Coastal cutthroat trout may return to freshwater feeding/spawning areas from late June through the following April. Re-entry timing has been found to be temporally consistent from year to year within streams, but varying widely between streams (Giger, 1972). As in other species of anadromous salmonids, entry to large rivers seems to occur consistently earlier than entry to shorter coastal rivers (Giger, 1972; Johnston and Mercer, 1976; Johnston, 1982). These streams usually have low flows. Sumner (1953) found fall-winter movements in Sand Creek, first with large adults (up to 10 years old), followed by smaller (<25 cm) mature freshwater migrants coming from the lower reaches of the estuary. In the Nestucca River, Sumner reported a late reproductive migration in early to mid-May, with large ripe females in rivers as late as June. In large river systems within Washington and Oregon (such as the Stillaguamish, Columbia, Cowlitz, Alsea, and Umpqua Rivers), coastal cutthroat trout return migrations usually begin as early as late June and continue through October, with peaks in late September and October (Lavier, 1963; Bulkley, 1966; Hisata, 1971, 1973; Duff, 1972; Giger, 1972; Wright, 1973; Tipping and Springer, 1980; Tipping, 1981, 1986; ODFW, 1993a).

1.14 Bull Trout

From: Federal Register Notices of Final Listing. November 1, 1999 and June 10, 1998.

Bull trout are char native to the Pacific Northwest and western Canada. They historically occurred in major river drainages in the Pacific Northwest from about 41° N to 60° N latitude, from the southern limits in the McCloud River in northern California and the Jarbidge River in Nevada, north to the headwaters of the Yukon River in Northwest Territories, Canada (Cavender, 1978; Bond, 1992). To the west, bull trout range includes Puget Sound, various coastal rivers of Washington; British Columbia, Canada; and southeast Alaska (Bond, 1992; Leary and Allendorf, 1997). Bull trout are relatively dispersed throughout tributaries of the Columbia River Basin, including its headwaters in Montana and Canada. Bull trout also occur in the Klamath River Basin of south-central Oregon.

The Columbia River Distinct Population Segment (DPS) occurs throughout the entire Columbia River Basin within the United States and its tributaries, excluding bull trout found in the Jarbidge River, Nevada. Although Williams, et al. (1995), identified two distinct clades in the Columbia River basin (upper and lower Columbia River) based on genetic diversity patterns, a discrete geographical boundary between the two clades was not documented. The Columbia River DPS is significant because the overall range of the species would be substantially reduced if this discrete population were lost.

The Columbia River DPS includes bull trout residing in portions of Oregon, Washington, Idaho, and Montana. Bull trout are estimated to have occupied about 60 percent of the Columbia River Basin and currently occur in 45 percent of the estimated historical range (Quigley and Arbelbide, 1997). The Columbia River population segment comprises 141 subpopulations. For discussion and analysis, the U.S.

Fish and Wildlife Service (USFWS) considered four geographic areas of the Columbia River basin: (1) lower Columbia River (downstream of the Snake River confluence), (2) mid-Columbia River (Snake River confluence to Chief Joseph Dam), (3) upper Columbia River (upstream from Chief Joseph Dam), and (4) Snake River and its tributaries (including the Lost River drainage).

The lower Columbia River area includes all tributaries in Oregon and Washington downstream of the Snake River confluence near the town of Pasco, Washington. USFWS identified 20 subpopulations in watersheds of nine major tributaries of the lower Columbia River (number of subpopulations in each watershed): the Lewis River (2), Willamette River (3), White Salmon River (1), Klickitat River (1), Hood River (2), Deschutes River (3), John Day River (3), Umatilla River (2), and Walla Walla River (3). The current distribution of bull trout in the lower Columbia River Basin is less than the historical range (Buchanan, et al., 1997; Oregon Department of Fish and Wildlife [ODFW], 1993). Bull trout are thought to have been extirpated from several tributaries in five river systems in Oregon: the Middle Fork Willamette River, the North and South Forks of the Santiam River, the Clackamas River, the upper Deschutes River (upstream of Bend, Oregon) and the Crooked River (tributary to the Deschutes River) (Buchanan, et al., 1997). Hydroelectric facilities and large expanses of unsuitable, fragmented habitat have isolated these subpopulations. Large dams, such as McNary, John Day, The Dalles, and Bonneville, separate four reaches of the lower Columbia River. Although fish may pass each facility in both upstream and downstream directions, the extent to which bull trout use the Columbia River is unknown. In addition, the nine major tributaries have numerous facilities, many of which do not provide upstream passage.

Migratory bull trout are present with resident fish or exclusively in at least 13 of the 20 subpopulations in the lower Columbia River. Many migratory fish are adfluvial and inhabit reservoirs created by dams. However, this area includes the only extant adfluvial subpopulation in Oregon, which exists in Odell Lake in the Deschutes River basin (Ratliff and Howell, 1992; Buchanan, et al., 1997). The Metolius River-Lake Billy Chinook subpopulation is also found in the Deschutes River basin. It is the only subpopulation considered “strong” and exhibits an increasing trend in abundance. USFWS considers 5 of the 20 subpopulations at risk of extirpation caused by naturally occurring events exacerbated by isolation, single life-history form and spawning area, and low abundance.

The mid-Columbia River area includes watersheds of four major tributaries of the Columbia River in Washington, between the confluence of the Snake River and Chief Joseph Dam. USFWS identified 16 bull trout subpopulations in the four watersheds: Yakima River (8), Wenatchee River (3), Entiat River (1), and Methow River (4). Bull trout have historically occurred in larger areas of the four tributaries and Columbia River. Bull trout are thought to have been extirpated in 10 streams within the area: Satus Creek, Nile Creek, Orr Creek, Little Wenatchee River, Napecqua River, Lake Chelan, Okanogan River, Eightmile Creek, South Fork Beaver Creek, and the Hanford Reach of the Columbia River. Most bull trout in the mid-Columbia River geographic area are isolated by dams or unsuitable habitat created by water diversions. Bull trout in the mid-Columbia River area are most abundant in Rimrock Lake of the Yakima River basin and Lake Wenatchee of the Wenatchee River basin. Both subpopulations are considered "strong" and increasing or stable. The remaining 14 subpopulations are relatively low in abundance, exhibit “depressed” or unknown trends, and primarily have a single life-history form. USFWS considers 10 of the 16 subpopulations at risk of extirpation because of naturally occurring events due to isolation, single life-history form and spawning area, and low abundance.

The upper Columbia River geographic area includes the mainstem Columbia River and all tributaries upstream of Chief Joseph Dam in Washington, Idaho, and Montana. Bull trout are found in two large basins, the Kootenai River and Pend Oreille River, which include the Clark Fork River. Bull trout were historically found in larger portions of the area. Numerous dams and degraded habitat have fragmented bull trout habitat and isolated fish into 71 subpopulations in nine major river basins: Spokane River (1), Pend Oreille River (3), Kootenai River (5), Flathead River (24), South Fork Flathead River (3), Swan River (3), Clark Fork River (4), Bitterroot River (27), and Blackfoot River (1). Bull trout are thought to be extirpated in 64 streams and lakes of various sizes: Nespelam, Sanpoil, and Kettle rivers; Barnaby, Hall, Stranger, and Wilmont Creeks; 8 tributaries to Lake Pend Oreille; 5 tributaries to Pend Oreille River below Albeni Falls Dam; Lower Stillwater Lake; Arrow Lake (Montana); upper Clark Fork River, 12 streams in the Coeur d'Alene River basin; and approximately 25 streams in the St. Joe River basin.

Bull trout typically spawn from August to November during periods of decreasing water temperatures. However, migratory bull trout may begin spawning migrations as early as April and may move upstream as far as 250 km to spawning grounds in some areas of their range.

1.15 References

Northwest Fisheries Science Center. February 1998. Status Review of Chinook Salmon from Washington, Idaho, Oregon, and California.

Northwest Fisheries Science Center. December 1997. Status Review of Chum Salmon from Washington, Oregon, and California.

Northwest Fisheries Science Center. August 1996. Status Review of West Coast Steelhead from Washington, Idaho, Oregon, and California.

Northwest Fisheries Science Center. June 1991. Status Review of Snake River Fall Chinook Salmon.

Northwest Fisheries Science Center. June 1991. Status Review of Snake River Spring and Summer Chinook Salmon.

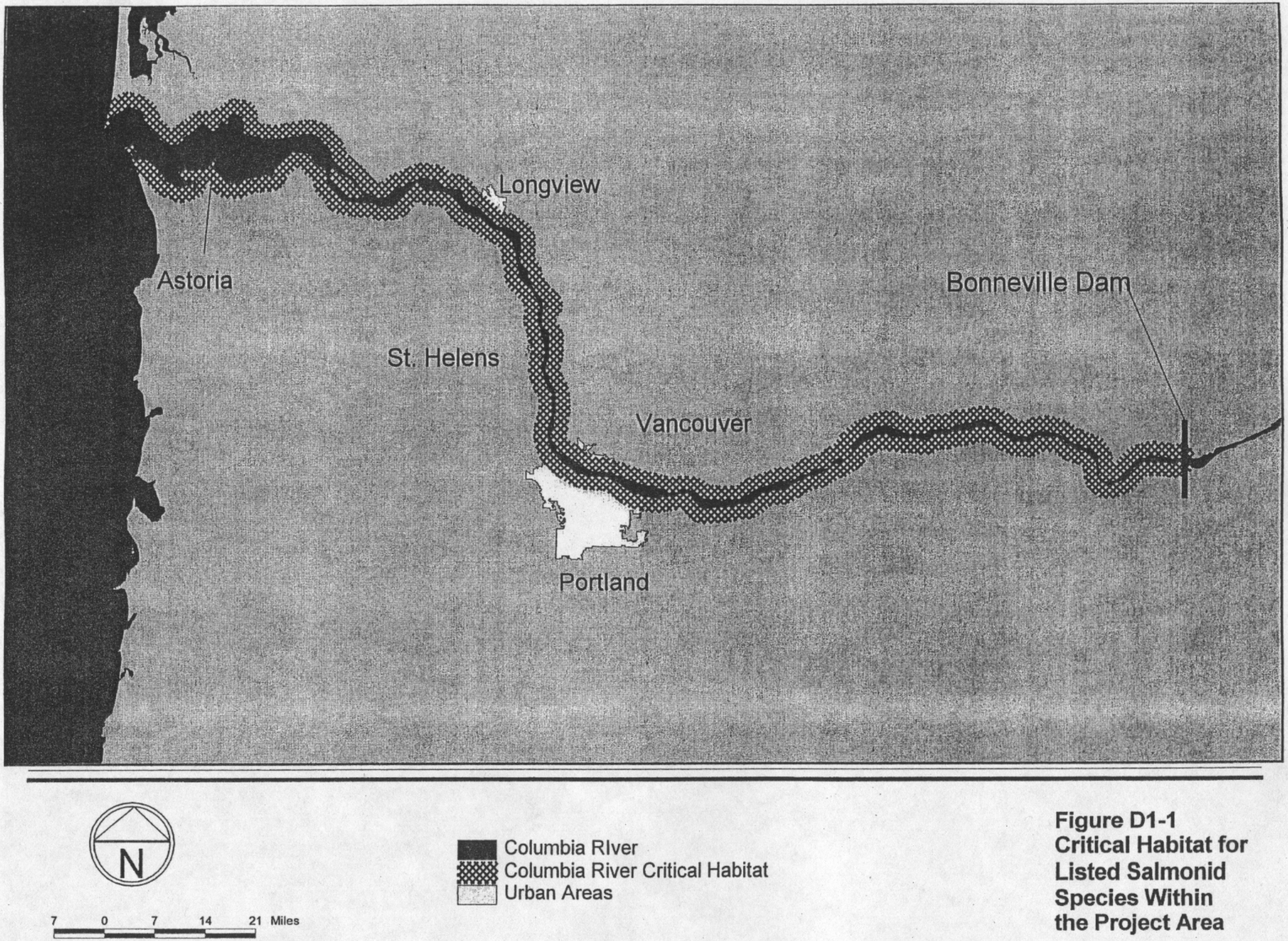
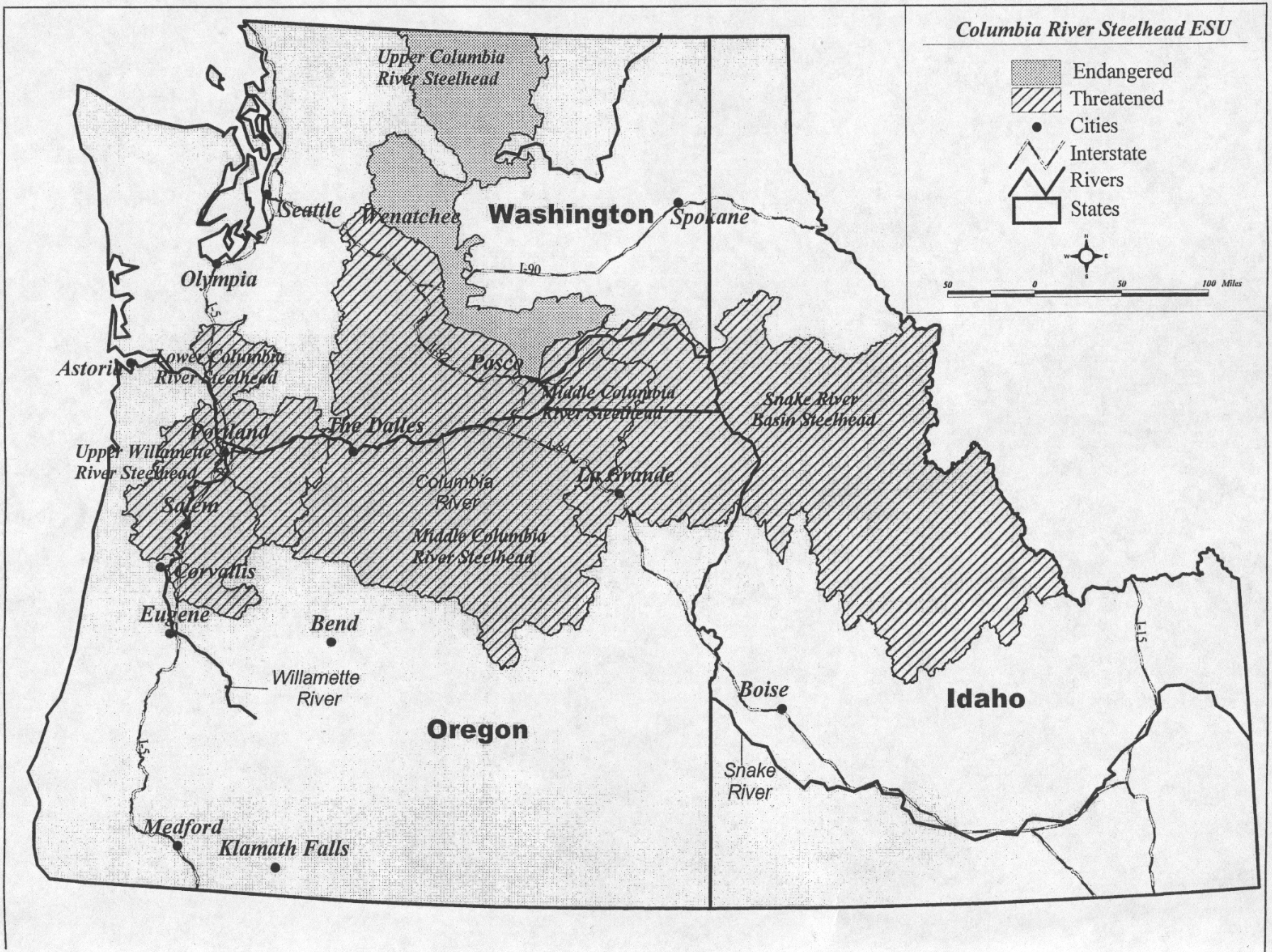
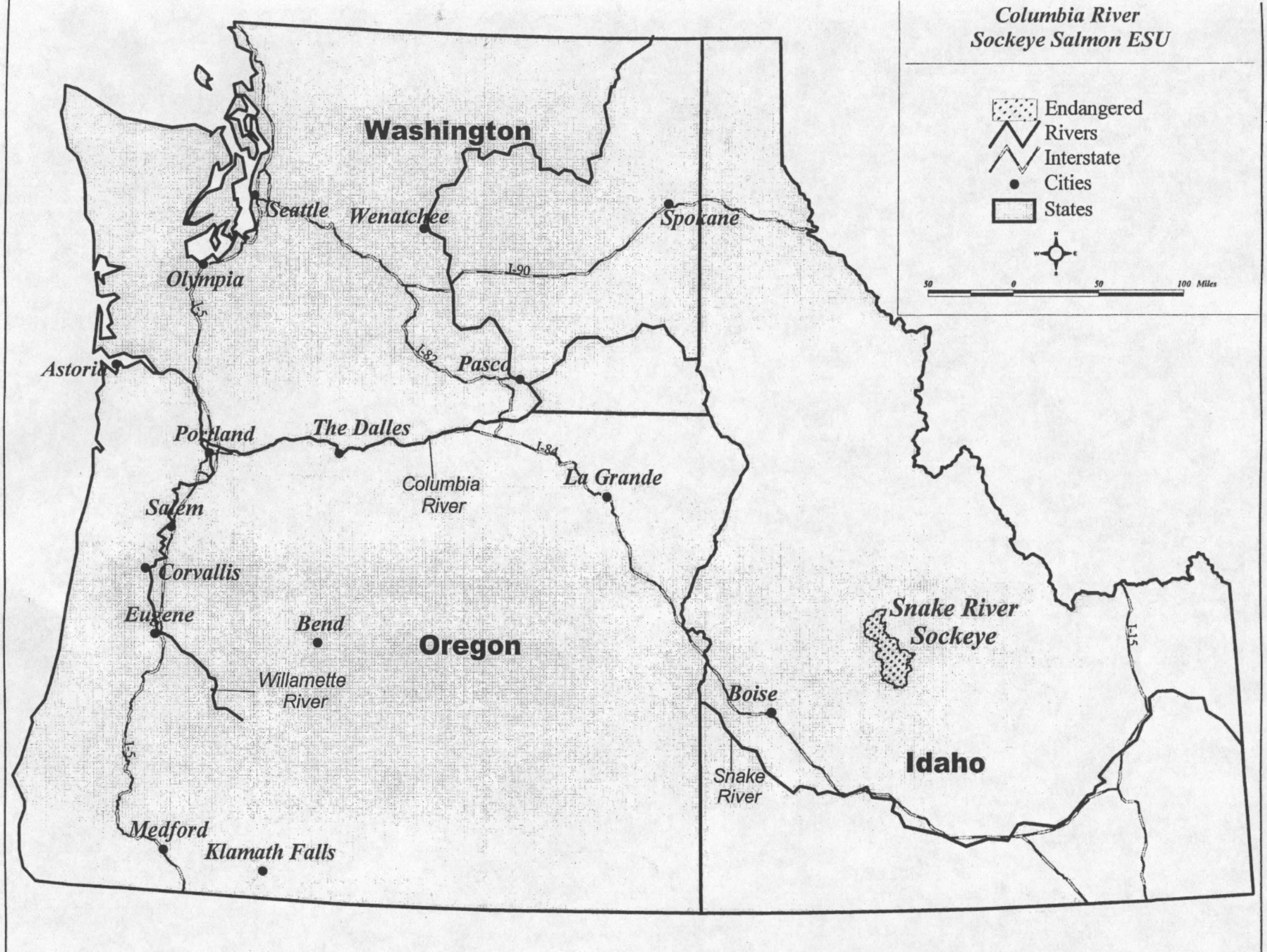


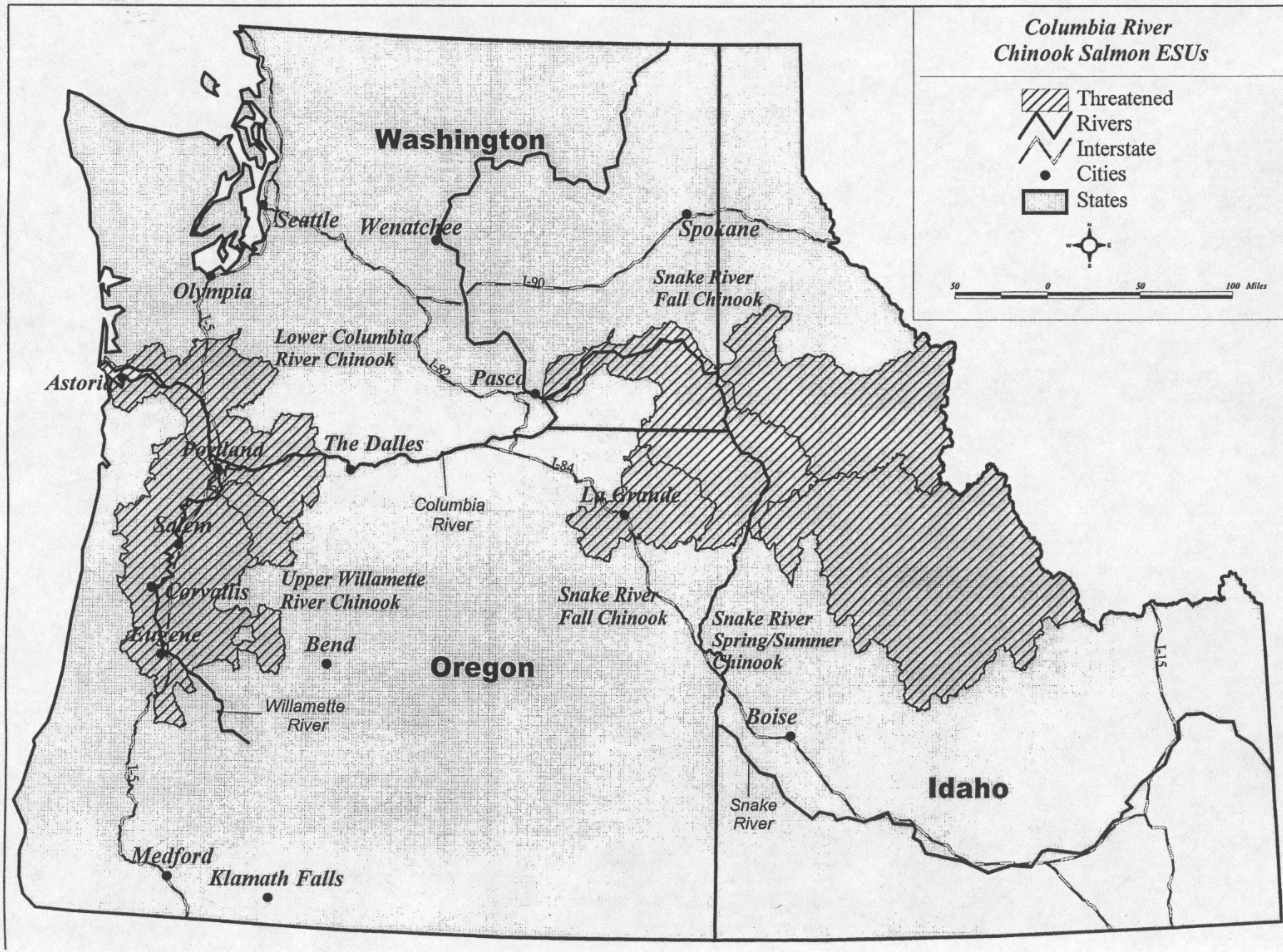
Figure D1-1
Critical Habitat for Listed Salmonid Species Within the Project Area

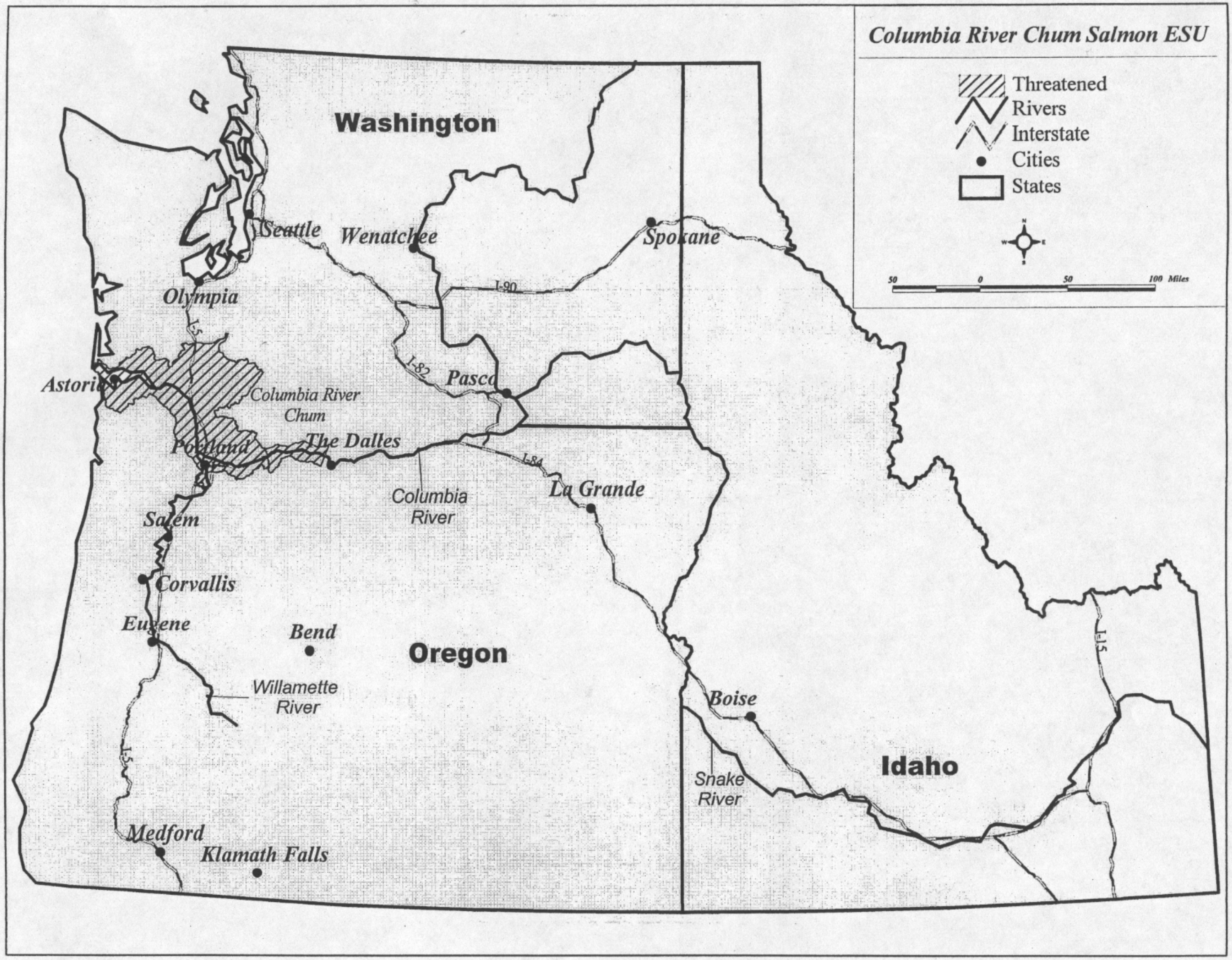


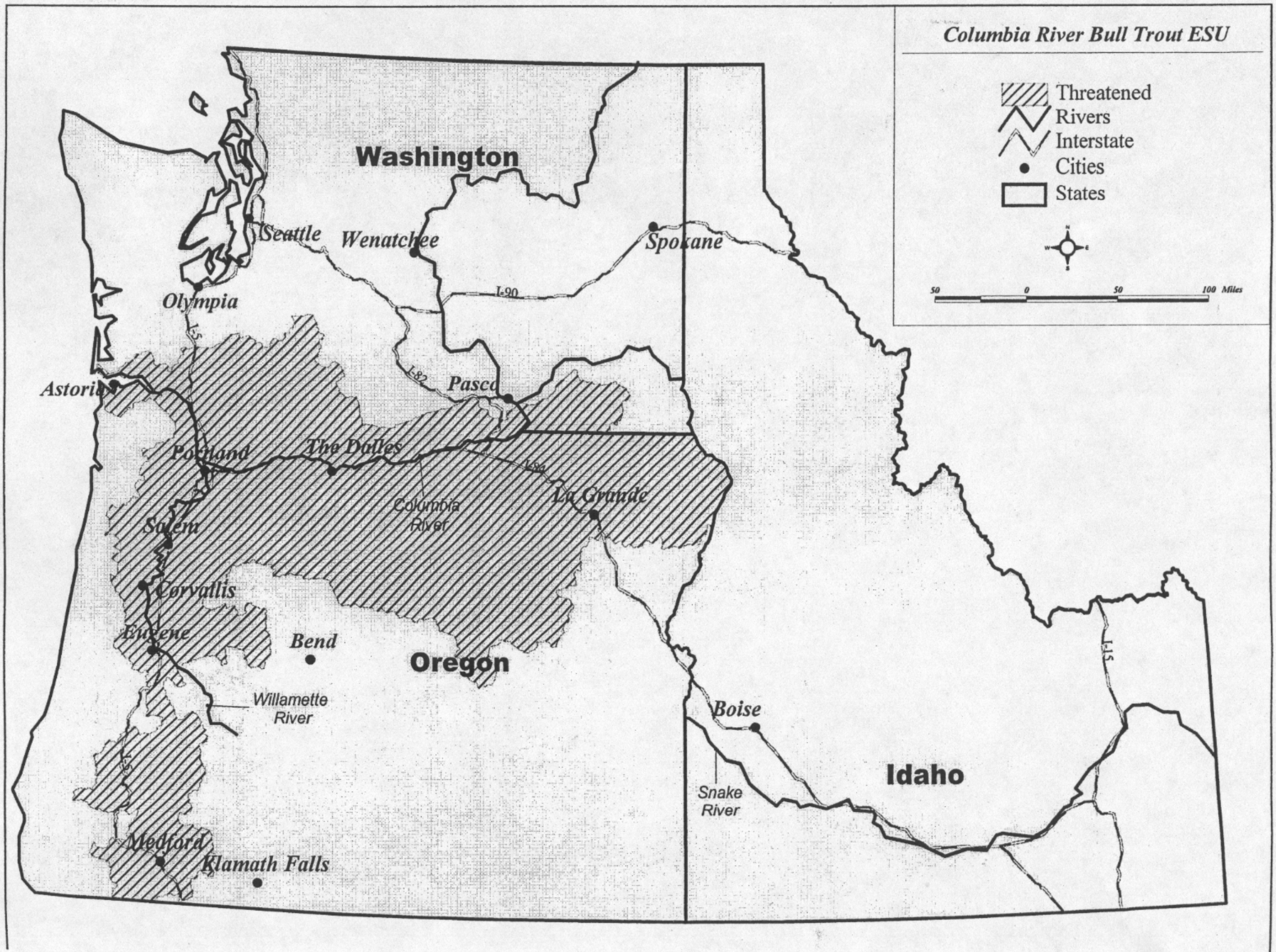
Columbia River Steelhead ESU
Endangered
Threatened
Cities
Interstate
Rivers
States
50
0
50
100 Miles
Upper Columbia
River Steelhead
Washington
Seattle
Wenatchee
Spokane
Olympia
I-90
I-5
Astoria
Lower Columbia
River Steelhead
I-82
Pasco
Middle Columbia
River Steelhead
Snake River
Basin Steelhead
Portland
The Dalles
Upper Willamette
River Steelhead
I-84
La Grande
Columbia
River
Salem
Middle Columbia
River Steelhead
Corvallis
Eugene
Bend
Willamette
River
Boise
Idaho
I-15
Oregon
Snake
River
Medford
Klamath Falls

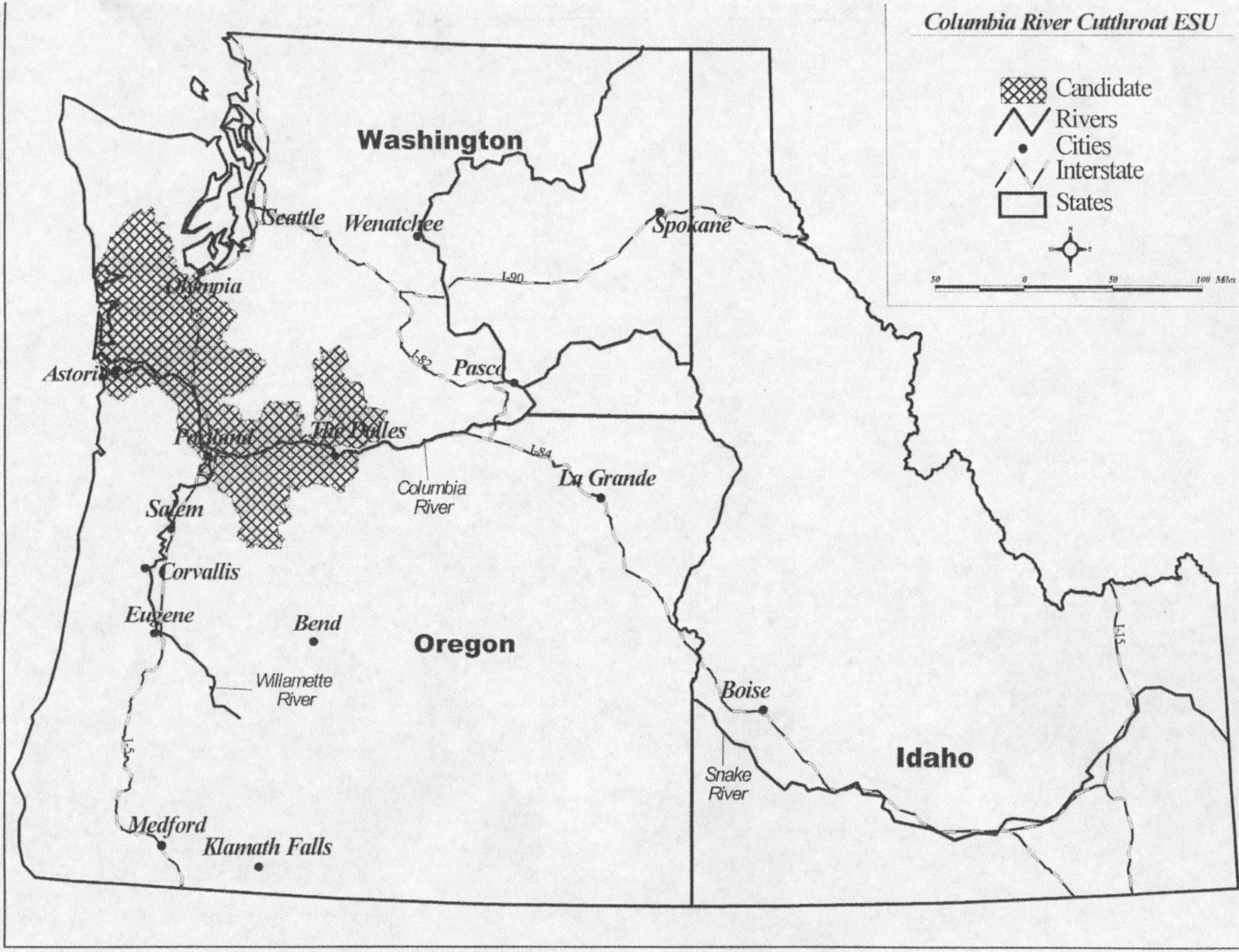


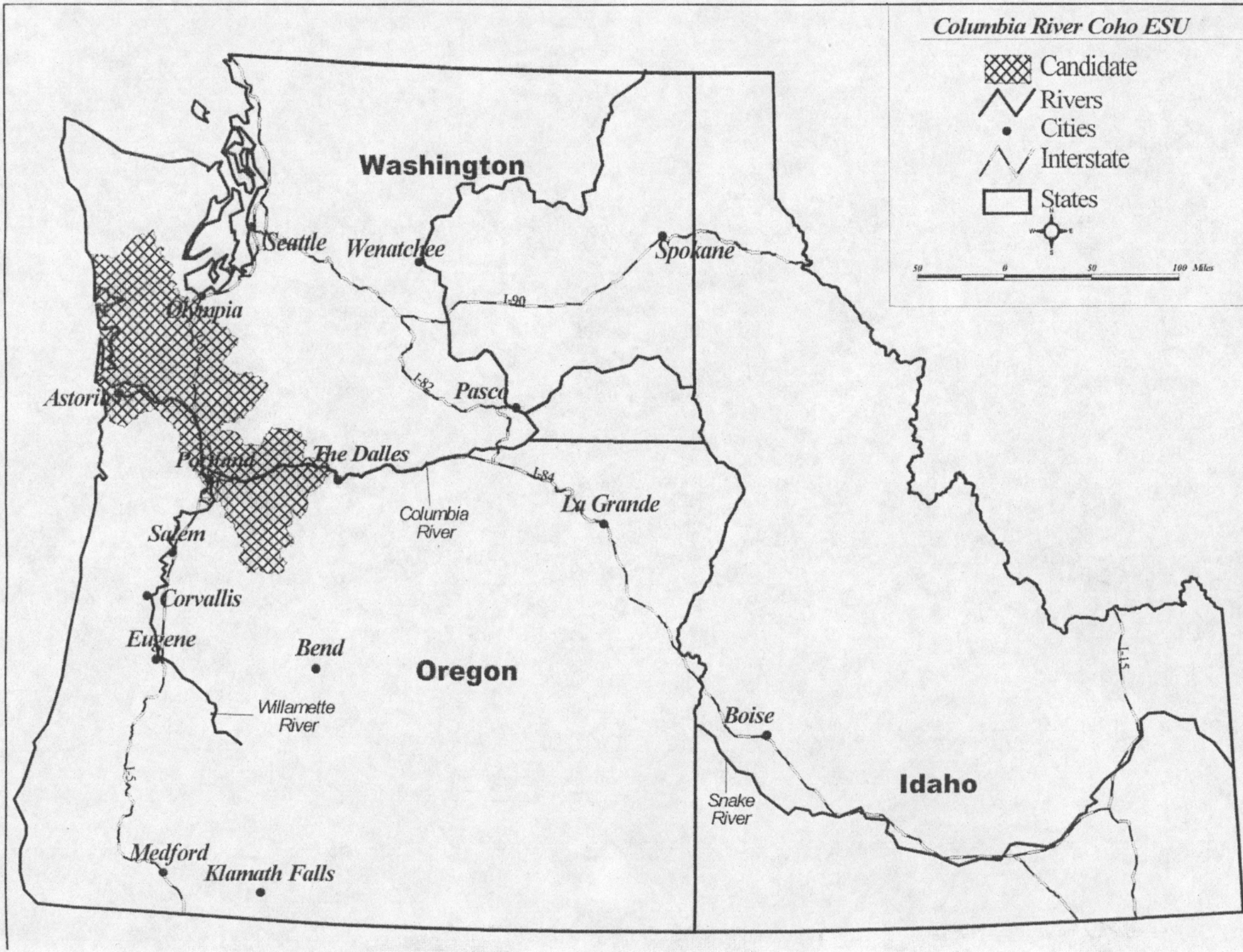
Columbia River
Sockeye Salmon ESU
Endangered
Rivers
Interstate
Cities
States
50
0
50
100 Miles
Washington
Oregon
Idaho
Seattle
Wenatchee
Spokane
Olympia
I-90
I-5
I-82
Pasco
Astoria
Portland
The Dalles
I-84
La Grande
Columbia
River
Salem
Corvallis
Eugene
Bend
Willamette
River
Snake River
Sockeye
Boise
Snake
River
I-15
Medford
Klamath Falls


Columbia River
Chinook Salmon ESUs
Threatened
Rivers
Interstate
Cities
States
50
0
50
100 Miles
Washington
Oregon
Idaho
Seattle
Wenatchee
Spokane
Olympia
Astoria
Pasco
Portland
The Dalles
La Grande
Salem
Corvallis
Eugene
Bend
Boise
Medford
Klamath Falls
I-90
I-82
I-84
I-5
I-15
Lower Columbia
River Chinook
Snake River
Fall Chinook
Upper Willamette
River Chinook
Snake River
Fall Chinook
Snake River
Spring/Summer
Chinook
Columbia
River
Willamette
River
Snake
River


Columbia River Chum Salmon ESU
Threatened
Rivers
Interstate
Cities
States
N
W
E
S
50
0
50
100 Miles
Washington
Oregon
Idaho
Seattle
Wenatchee
Spokane
Olympia
I-90
I-5
I-82
Pasco
Astoria
Columbia River
Chum
Portland
The Dalles
I-84
La Grande
Columbia
River
Salem
Corvallis
Eugene
Bend
Willamette
River
Boise
I-15
Snake
River
Medford
Klamath Falls


Columbia River Bull Trout ESU
Threatened
Rivers
Interstate
Cities
States
50
0
50
100 Miles
Washington
Oregon
Idaho
Seattle
Wenatchee
Spokane
Olympia
Astoria
Pasco
Portland
The Dalles
La Grande
Salem
Corvallis
Eugene
Bend
Medford
Klamath Falls
Boise
I-90
I-82
I-84
I-5
I-15
Columbia River
Willamette River
Snake River


Columbia River Cutthroat ESU
Candidate
Rivers
Cities
Interstate
States
50
0
50
100 Miles
Washington
Oregon
Idaho
Seattle
Wenatchee
Spokane
Olympia
Astoria
Pasco
Portland
The Dalles
La Grande
Salem
Corvallis
Eugene
Bend
Medford
Klamath Falls
Boise
I-90
I-82
I-84
I-5
I-15
Columbia River
Willamette River
Snake River


Columbia River Coho ESU
Candidate
Rivers
Cities
Interstate
States
50
0
50
100 Miles
Washington
Seattle
Wenatchee
Spokane
Olympia
I-90
I-82
Pasco
Astoria
Portland
The Dalles
I-84
Columbia River
La Grande
Salem
Corvallis
Eugene
Bend
Oregon
Willamette River
Boise
Idaho
Snake River
I-5
I-15
Medford
Klamath Falls

D-2 USE AND IMPORTANCE OF THE LOWER COLUMBIA RIVER, ESTUARY, AND OCEAN PLUME TO COASTAL CUTTHROAT TROUT

2.1 Introduction

Coastal cutthroat trout, *Oncorhynchus clarki clarki*, have been studied for many years throughout their geographic range. Regardless, there has never been a concerted effort to obtain for this subspecies the type of information that is commonly collected for management of commercially harvested salmonids. Data on these fish are most often obtained incidentally during studies targeting other salmonids. Interest and concern for coastal cutthroat trout has increased in recent years due to declining numbers in some areas. The Southwest Washington/Columbia River Evolutionarily Significant Unit (ESU) of coastal cutthroat trout was recently proposed for listing as threatened under the Endangered Species Act (Johnson, et al., 1999; National Marine Fisheries Service [NMFS], and U.S. Fish and Wildlife Service [USFWS], 1999). This situation has heightened concerns about the possible effects on this subspecies of proposed routine dredging of the Columbia River shipping channel. Coastal cutthroat trout are known to use the Columbia River's lower reaches and associated marine environs during various stages of their complex life history, however, details of this use are not well understood and available information has not been well synthesized. The purpose of this document, therefore, is to draw together available information about use of the lower Columbia River, estuary, and ocean plume by coastal cutthroat trout to assess the use of this area by this subspecies.

2.1.1 Objectives:

- Assemble available literature on this subject from the area of interest and from highly similar areas
- Include, as available, information from phone interviews with fisheries professionals familiar with cutthroat in the lower Columbia or similar ecosystems
- Determine from the information above, describe where, when, how, and why coastal cutthroat use (or used) the area of interest
- Assess deficiencies in existing information and identify other pertinent data that is unpublished
- Suggest future research needs and methods for studying coastal cutthroat trout in the area of interest

The discussion will be summarized by selected key topics important to an understanding of cutthroat trout in the lower Columbia system.

2.2 Background

2.2.1 Study Area

The geographical area considered in this paper includes the lower Columbia River and sloughs from the city of Portland to the estuary, the estuary itself, and the plume of reduced salinity water (<26 psu, Pearcy and Fisher, 1990) that extends beyond the river mouth into the ocean (Figure D2-1). The ocean plume varies in size seasonally with ocean currents and river discharge, often extending over 50 km offshore and up and down the coast during spring and summer months (Loch and Miller, 1988; Pearcy, et al., 1990; Pearcy, 1997). The estuary is considered to have three zones that also vary somewhat in size seasonally with river discharge: a high salinity marine zone at the river mouth, an estuarine mixing zone, and a tidally influenced, mainly freshwater zone at the upper end of the estuary, referred to as the lower riverine reach in this document as shown in Figure D2-1 (Bottom, et al., 1984; Simenstad, et al., 1990). The upstream boundary of the lower riverine reach is 75 km (47 miles) from the river mouth, and is about 20 km above the maximum extent of salinity intrusion during the low river flow season (Simenstad, et al., 1990). The portion of the study area upstream from this boundary extends from River kilometer (RKm) 75 to about RKm 170, in Portland, and is referred to here as the upper riverine reach. Both riverine reaches are tidally influenced, and tides normally reverse downstream flow up to 115 km from the river mouth (Dawley, et al., 1986).

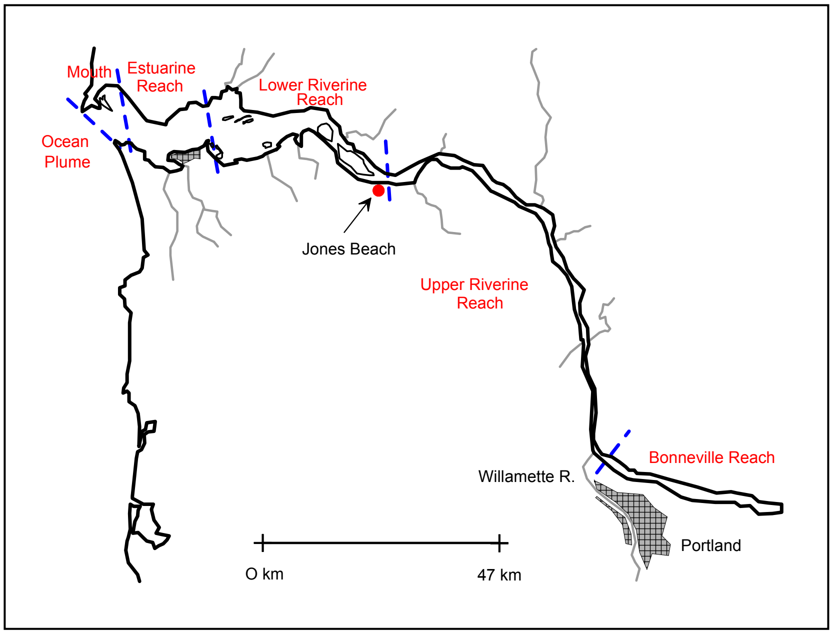


Figure D2-1: Study Area Map Showing the Lower Columbia River, its Estuary, and Ocean Plume, with Principal Subdivision Used in this Document Indicated

The Columbia River in the upper riverine reach (Figure D2-1) is a large, low gradient stream with numerous islands and predominantly fine substrate. It is subject to large seasonal differences in discharge: peak flows typically occur in spring and early summer, with low flows in the fall, and low but variable flows in winter (Sherwood, et al., 1990). Historically, the difference between high and low flows was greater than at present, but dam operations and irrigation withdrawals have damped the hydrograph and reduced mean flow, with greatest changes in both since 1960 (Sherwood, et al., 1990). Winter high flows (November through March) originate mainly from tributaries west of the Cascade Mountains, whereas the spring freshet (April-June) derives mostly from snowmelt in tributary basins east of the Cascade crest (Simenstad, et al., 1990). The study area, which lies entirely west of the Cascade crest, receives inflow from numerous tributaries, of which the largest are the Willamette, Cowlitz, and Lewis Rivers (Figure D2-2).

The Columbia River estuary is a highly dynamic and variable environment with high river flows and strong tidal currents that may limit fish productivity by controlling prey availability and predator's feeding efficiencies (Haertel and Osterberg, 1967; Bottom, et al., 1984; Bottom and Jones, 1990). Variability in the estuary environment is, as in most of the world's large estuaries, both seasonal and annual (Sherwood, et al., 1990; Monoco, et al., 1992). Significant morphological changes to the river and estuary have taken place over the past 150 years, stemming largely from diking, dredging, draining of wetlands, and removal of large woody debris (Maser and Sedell, 1994; Sherwood, et al., 1990). The ocean plume may be affected less directly by human activities, but its environment is also highly dynamic due to influences of river input and variable ocean conditions (McLain, 1984; Lawson, 1993; Pearcy, 1997), and river input is greatly affected by the operation of dams for flood control and hydropower generation (Sherwood et al. 1990).

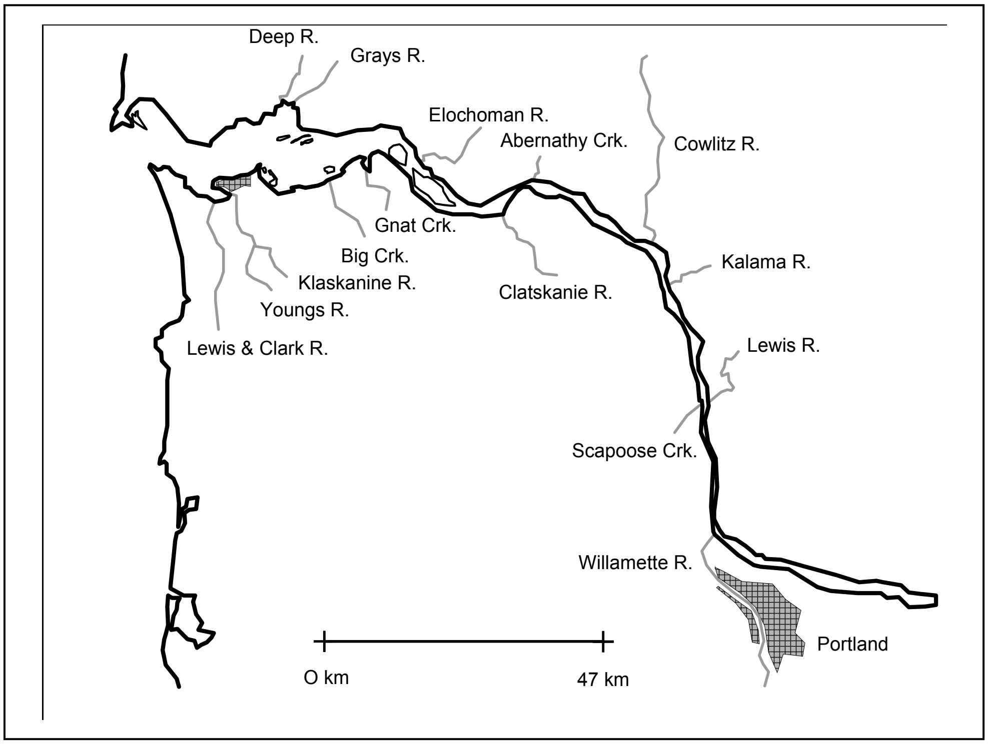


Figure D2-2: Main Tributaries of the Columbia River Within the Study Area (Not all Creeks are Shown)

Outside the study area, but inseparable from it in importance to coastal cutthroat trout, are the numerous tributaries to the lower Columbia River where this subspecies spawns and initially rears (Figure D2-2). Perhaps the most significant change to these streams in the recent past for coastal cutthroat was extensive logging that is thought to have damaged spawning and rearing habitat in many watersheds on the Washington side (Crawford, et al., 1980; Leider, 1997; Blakely, 2000). Similarly, Hooten (1997) attributed probable declines in coastal cutthroat abundance in Oregon tributaries of the lower Columbia to habitat impacts from a variety of land and water-use activities.

2.2.2 Geographical Distribution of Coastal Cutthroat Trout

Coastal cutthroat trout are found in the coastal plains of western North America from southeastern Alaska to northern California (Trotter, 1989). The eastern range of the subspecies rarely extends farther inland than 160 km (usually less than 100 km), and appears to be bounded by the Cascade Mountain Range in California, Oregon, and Washington, and by the Coast Range in British Columbia and southeastern Alaska. This range coincides closely with the coastal temperate rain forest belt defined by Waring and Franklin (1979). The subspecies appears highly adapted to this region. Even when the fish have access beyond the coastal rainforest, as in the Columbia or Stikine rivers, they penetrate only a limited distance inland (Sumner, 1972; Trotter, 1987, 1989).

In Washington and Oregon, coastal cutthroat trout are widespread west of the crest of the Cascade Mountains. Historically, their range may have extended past the Cascade crest into tributaries of the Columbia River as far eastward as the Klickitat River at RKm 290 (Bryant, 1949). At present, freshwater forms (migrants and non-migrants) of coastal cutthroat trout are found at least to the Klickitat River, on the Washington side of the Columbia River east of the study area (Blakely, et al., 2000), and to 15-Mile Creek on the Oregon side (Kostow, 1995). Blakely, et al. (2000), Leider (1997), and Hooten (1997) conclude that current distribution of sea-run fish in the Columbia River appears to be confined to tributaries downstream from Bonneville Dam (RKm 235).

2.2.3 Status of Lower Columbia River Coastal Cutthroat Stocks

NMFS recently completed a comprehensive status review of coastal cutthroat trout populations in Washington, Oregon, and California, which identified six ESUs within this region (Johnson, et al., 1999). Subsequently, a proposal was issued to list the Southwest Washington/Columbia River ESU as threatened under the Endangered Species Act (NMFS and USFWS, 1999), with a final listing decision pending. The Southwest Washington/Columbia River ESU includes cutthroat trout of all streams tributary to Grays Harbor, as well as all populations in Washington coastal streams from Grays Harbor south to the Columbia River, including those of Willapa Bay, and streams entering the lower Columbia River as far east as, but not including, the Deschutes River. Populations in the Willamette River above Willamette Falls comprise a separate ESU.

Abundance of coastal cutthroat trout in the Southwest Washington/Columbia River ESU is considered depressed, particularly in lower Columbia River tributaries. The proposed listing was based on negative abundance trends throughout the ESU, particularly for anadromous forms (NMFS and USFWS, 1999). These declines are mainly attributed to extensive habitat degradation and high potential for negative interactions with hatchery-produced cutthroat and other salmonids, especially coho salmon (NMFS and USFWS, 1999).

2.2.4 Generalized Life History of Coastal Cutthroat Trout with Reference to Columbia River Stocks

Life history forms

Coastal cutthroat trout belong to the same genus as Pacific salmon and steelhead (*Oncorhynchus*), but they are generally smaller, rarely overwinter in the sea, and usually make less extensive oceanic migrations compared to other members of this group. Unlike Pacific salmon, coastal cutthroat trout are capable of spawning in successive years, and adults have been known to spawn each year for more than 6 years (Trotter, 1989). The life history of coastal cutthroat trout is perhaps the most complex of any Pacific salmonid (Northcote, 1997; Johnson, et al., 1999), with four life-history forms widely recognized: resident (non-migratory), adfluvial (lake migrants), fluvial (stream and river migrants), and anadromous or sea-run (saltwater migrants). A trait in common is that all forms tend to spawn in small tributary streams. Resident cutthroat, which complete their entire life cycle in their natal stream, are often found above barriers to anadromous migrations, but they also occur where there is access to the sea (Johnson, et al., 1999). Migratory cutthroat trout juveniles typically rear in small tributary streams for 2-3 years before traveling to either a lake (adfluvial), a river (fluvial), or saltwater (anadromous) on a feeding migration (Northcote, 1997). Multiple forms may occur within a single watershed (Johnston, 1982), and individuals may switch among migratory strategies, skipping seaward migrations in some years (Tomasson, 1978). To a limited extent, resident fish can produce migratory offspring, and visa versa (Johnson, et al., 1999). It is thought that this great behavioral flexibility and life-history diversity may help cutthroat trout respond to changing environmental conditions and allow them to exploit habitats not fully utilized by other salmonids (Johnson, et al., 1999; Johnston, 1982; Northcote, 1997). The following sections pertain to the fluvial and anadromous forms, which may both occur in the study area, but they will focus mainly on the anadromous or sea-run form which is likely the more abundant.

Spawning, incubation, and early rearing

Anadromous cutthroat trout spawn in Washington and Oregon streams from December to May, with peak activity in February (Pauley, et al., 1989; Trotter, 1989). They typically spawn in small, low-order streams, above or slightly overlapping coho salmon and steelhead spawning areas in systems where these species live together (Lowry, 1965; Edie, 1975; Johnston, 1982). Anadromous cutthroat spawn in tributaries with summer low flows often averaging only 0.1 cubic meter per second and seldom exceeding 0.3 cubic meter per second (Johnston, 1982). This choice of locations is believed to have evolved to reduce competition with coho and steelhead for spawning sites and for resources for juvenile rearing (Johnston, 1982; Johnston, et al., 1999). The degree of straying by mature sea- run cutthroat returning to their natal streams has not been clearly defined by studies conducted to date (Johnson, et al., 1999). Early studies of Oregon coastal streams suggested a high rate of straying that may have been real or due to juveniles on feeding migrations to non-natal streams or due to poor imprinting of hatchery fish on the rivers where they were released (Giger, 1972). From their studies of Alaskan and Puget Sound cutthroats, Jones (1976) and Johnston (1982) also believed that fish captured in non-natal streams were mainly immatures on feeding migrations. Campton and Utter (1987) concluded from an analysis of allele frequencies that homing of Puget Sound fish to natal tributaries was highly precise. Tagging data from the lower Columbia River suggest that straying among tributary streams may occur there at an unusually high rate, although this phenomenon remains to be substantiated (Loch, pers. comm., 2001).

Cutthroat eggs typically hatch after 6 or 7 weeks of incubation, and fry emerge from the gravel from March through June, with the peak emergence occurring in mid-April over much of the species range (Trotter, 1997). The fry, which are about 25 millimeters (mm) long at emergence, quickly migrate to channel margins, side channels, and backwaters, collectively referred to as “lateral habitats”, where they may remain for several weeks until large enough to cope with higher velocities farther off shore (Glova and Mason, 1976; Moore and Gregory, 1988). Juvenile cutthroat generally remain in small, upper tributary streams for one year before dispersing more widely within their natal river system, if migratory (Trotter, 1997). As discussed in Trotter (1987) and Johnson, et al. (1999), the published literature leaves some uncertainty about habitat preferences of juvenile cutthroat during the growing season once they have left lateral habitats. When cutthroat are the only species present, some workers report that the fry prefer pools (Glova, 1984); others report that the fry prefer low gradient riffles and pool tailouts, while older fish prefer pools with large woody debris and residual depths of at least 0.3 meters (Bisson and Sedell, 1984; Lisle, 1987). Competitive interactions with coho (Glova, 1984) or steelhead (Hartman and Gill, 1968) of similar size usually end in displacement of cutthroat trout from preferred stream habitats. For overwintering, pools near cover from undercut banks and large woody debris are favored habitats of juvenile cutthroat (Bustard and Narver, 1975). Most anadromous cutthroat remain in freshwater for 2 to 4 years before smolting and migrating to saltwater, although the observed range is 1 to 6 years (Giger, 1972a; Lowery, 1975). Young cutthroat grow considerably during this period of freshwater residence, attaining lengths of about 150 to 300 mm before smoltification in streams from Oregon to Alaska as shown in Table D2-1 (Johnston and Mercer, 1976).

Coastal cutthroat trout are opportunistic feeders and generalists during their period of stream residence, usually taking advantage of whatever prey is available (Trotter, 1997). For example, age-0 to age-2 cutthroat coexisting in a Bogachiel River tributary all ate the same diet and switched from aquatic to terrestrial insects as the latter prey became more abundant (Martin, 1984). Aquatic insects are often the most available and therefore the dominant food item in streams (Pauley, et al., 1989; Trotter, 1997); however, age-1 and older cutthroat may eat coho fry less than 50 to 60 mm in length when available (Fransen, et al., 1993). Stream dwelling cutthroats may also feed on salmon eggs at times (Johnston, 1982), although this resource may more often be exploited by Dolly Varden/bull trout (Johnston, pers. comm., 2001).

Table D2-1: Freshwater Growth of Juvenile Sea-Run Cutthroat Trout

Location	Age in Years I	II	III	IV	V
Oregon	107	132	175-234	211-253	280
British Columbia	49-89	84-112	156-183		
Washington			163-189	200	

Source: Johnston and Mercer (1976)

Note: Fork lengths are in millimeters and all data were from the spring of the year references.

Estuarine and marine residence

Emigration to saltwater occurs from March through July, and varies locally. For Washington and Oregon populations, outmigration begins as early as March, peaks in mid-May, and is complete in mid-June (Johnson, et al., 1999). Smolting appears to be more dependent on size than age (Trotter, 1997), and a relationship between age and size at smolting and severity of the saltwater environment that smolts will be entering has been suggested, but not confirmed (Johnston, 1982; Johnston, et al., 1999). In the protected waters of Puget Sound, smolts are mainly age-2 and average about 160 mm (Johnston, 1982). In less hospitable waters of the open coast, smolts are often older and larger. Fuss (1982) found that smolts from Washington coastal streams were predominantly age-3 and age-4, and measured over 200 mm in length. There is some variation in the age at which Columbia River sea-run cutthroat smolts enter the estuary and ocean plume. Chilcote (1980) and Tipping (1981) reported that wild smolts from two lower Columbia tributaries (Kalama and Cowlitz Rivers) were about 65 percent age-2, 35 percent age-3, and a small fraction age-4, with an average length of about 160 mm. From sampling in saltwater, Loch and Miller (1988) and Pearcy, et al. (1990) concluded that most hatchery origin sea-run cutthroat migrated to the Columbia River estuary and ocean plume at one year of age, whereas all wild smolts first entered salt these environments at age-2 or age-3 (Table D2-2).

Table D2-2: Age and Length of Hatchery and Wild Cutthroat Trout Sampled in the Columbia River Estuary and Ocean Plume

Location	Stock	Age	Sample Size	Mean Fork Length (mm)	SD	% Total
Estuary	Hatchery	1.+	88	290.6	28.5	85%
"	"	1.+F+	10	362.9	44.7	10%
"	"	1.+S+	4	393.3	29.6	4%
"	"	1.+F+S+	1	389	-	1%
"	"	Total	103			100%
"	Wild	2.+	6	294.2	45.6	30%
"	"	2.+F+	2	364.5	3.5	10%
"	"	2.+S+	3	387.3	2.5	15%
"	"	2.+S+S+	1	466	-	5%
"	"	2.+F+S+S+S+	1	445	-	5%
"	"	3.+F+	1	410	-	5%
"	"	3.+S+	3	375.3	21.1	15%
"	"	3.+F+S+	2	410	14.1	10%
"	"	3.+F+S+S+S+	1	520	-	5%
	"	Total	20			100%

Plume	Hatchery	1.+	7	260.3	18.9	78%
"	"	1.+F+	2	298	25.5	22%
"	"	Total	9			100%
"	Wild	2.+	6	287.7	41.4	67%
"	"	2.+S+	1	365	-	11%
"	"	2.+F+S+	1	415	-	11%
"	"	3.+S+S+S+	1	470	-	11%
"	"	Total	9			100%

Source: June to September 1980, from Loch, 1982.

Note: Age designation: Number left of decimal is winters in freshwater before smolting; to the right of the decimal each letter indicates one additional season of growth in freshwater (+F) or in the estuary or plume (+S)

The amount of time spent in salt water and distance migrated from the home stream varies among populations. At the extremes, cutthroats spend from 2 to 8 months in salt water before returning to freshwater (Thorpe, 1994). Some populations seldom venture into salt water farther than the estuary of their home stream (Tomasson, 1978; Northcote, 1997). Tipping (1981) thought that cutthroat smolts on their first seaward migration from the Cowlitz River moved no farther than the Columbia estuary. In most systems, cutthroat remain within a few kilometers of shore, do not cross large bodies of open water after reaching salt water, and migrate no more than about 70 km along shore from their home stream (Johnston, 1982; Trotter, 1997). In a few situations, most notably the Columbia River plume, cutthroats migrate to open marine waters with riverine influence over 50 km from shore (Loch and Miller, 1988; Pearcy, et al., 1990; Pearcy, 1997).

While in the estuary and at sea, cutthroats typically feed opportunistically on a variety fish and invertebrates (Pauley, et al., 1989; Trotter, 1997), often foraging in waters no more than a few meters deep (Johnston, 1982), except for populations that use marine waters as noted above (Pearcy, 1997). In sheltered waters, cutthroats seek gammarid amphipods, isopods, shrimp, as well as small fish such as sticklebacks and baitfish in shallow habitats such as sand bars, gravel beaches, creek mouths, eel grass patches, and oyster beds (Giger, 1972; Simenstad and Eggers, 1981; Trotter, 1997). Cutthroats prey in open marine waters commonly includes crab megalops, mysids, euphausids, and small fish such as greenlings, cabezon, and anchovy (Loch and Miller, 1988; Pearcy, et al., 1990; Pearcy, 1997). Other salmonids, such as juvenile pink and chum salmon, are sometimes an important prey of cutthroats in saltwater (Trotter, 1997). Growth in salt water can be rapid. Sea-run cutthroats in the Columbia River plume grow at a rate of about 25 mm per month (Pearcy, et al., 1990). Over their range, sea-run cutthroats are typically about 300 to 330 mm in length on their first return to freshwater, and they reach a maximum length of about 500 mm after multiple migrations (Trotter, 1997).

Return migration to fresh water

Nearly all cutthroat trout overwinter in freshwater after feeding in marine or brackish waters for several months (Trotter, 1997; Johnson, et al., 1999). An exception to this rule occurred in the Squamish River estuary (British Columbia) where Levy and Levings (1978) captured cutthroats in all months except April and May. In most systems, not all fish spawn on their first return because few anadromous cutthroats are sexually mature until their fourth or fifth year of age (Trotter, 1997). In the Cowlitz River, at first return from salt water hatchery and wild females were 62.5 percent and zero percent mature, respectively (Tipping, 1981). The return time of fish to fresh water appears to vary by type of river. Coastal streams with appreciable estuaries, large Puget Sound rivers, and the Columbia River typically have early-entry stocks that return to freshwater July through October, often with peak migrations in September and October (Trotter, 1997). Small streams draining directly into marine waters often have late-entry stocks, which remain in salt water until mid winter (Johnston, 1982). In some systems, anadromous cutthroat feed actively on their return migration to freshwater (Johnston, 1982), while other populations appear to feed little in tidewater areas in the summer and fall, despite abundant food sources Giger (1972). Columbia river cutthroat feed actively on their return to the estuary and tidewater (Loch, 1982).

The published literature contains no data about the overwintering period of sea-run fish in fresh water. Trotter (1997) speculates that instream behavior, habitat choice, and foraging may be similar to that of older pre-migrant juveniles, with fish holding in sheltered habitats such as deep pools with cover. In the Fraser River, a British Columbia stream nearly as large as the Columbia River, many coastal cutthroats greater than 200 mm in length overwinter in lower river freshwater back-channels that they do not typically occupy in the summer (Rempel, 2001a). These are protected pockets during winter low flows that convey high flows during spring freshet. Stomachs from 5 such fish sampled in February and March 2000 contained as a percentage of total stomach volume, plant material (28 percent), Trichoptera nymphs (22 percent), Chironomidae pupae (7 percent), Ephemeroptera nymphs (5 percent), plus other assorted insects and invertebrates (Rempel, 2001b).

2.3 Findings on Selected Key Topics Relative to the Study Area

2.3.1 Occurrence of Cutthroat Trout by Location and Time

Knowledge of where and when cutthroat trout occur in the study area is essential to a basic understanding of their migrations, life history, and living requirements. Additional information about abundance, age, and size of cutthroats is also important for informed management decisions. What is known of these subjects from studies conducted in the area of interest is presented below.

Studies of Columbia River tributaries in Washington show that age-1 juvenile cutthroats migrate downstream from March to June, with peak movement typically occurring in May (Chilcote, 1980; Chilcote, et al., 1980; Blakely, 2000). However, available information does not clearly indicate whether any of these fish rear for any appreciable time in the upper riverine reach of the Columbia River (Figure D2-1) prior to smolting, or if it is used mainly as a migratory corridor. Some cutthroats clearly do not stay in the river for long, as a large fraction of hatchery origin sea-run cutthroat captured in the estuary and ocean plume had reached salt water at age-1, as shown in Table D2-2 (Loch and Miller, 1988; Pearcy, et al., 1990). Wild fish captured in the salt water had spent at least two winters in freshwater, so they may have reared for a time in the upper riverine reach. Loch (pers. comm., 2001) believes that the downstream portion of the upper riverine reach, from about Longview to Jones Beach, may be a transitional zone between river and estuary, where juvenile salmonids feed and complete their adaptation to salt water. Length of stay varies: some do not complete the transition and remain in the river, while others move into the estuary or migrate to sea (ibid.). Out-migrant cutthroat often feed for an extended period in this transitional zone, and many hatchery cutthroats residualize there (ibid.). This behavior has been well documented at Jones Beach were sampling was extensive (Loch, 1982), but data for areas farther upstream are fragmentary and only suggestive. Loch (pers. comm., 2001) believes that portions of the upper riverine reach above Longview may be generally less hospitable to juvenile cutthroat in terms of food and habitat, and may therefore serve more as a migratory corridor than as a long-term rearing area.

Sport fishery catch records show that adult and immature fish returning from the estuary and the sea are captured in the upper and lower riverine reaches, mainly from Jones Beach to the Cowlitz River, mostly from July through September (Schuck, 1980; Melcher and Watts, 1995; Melcher, 1996; Trotter, 1997). The implication of declining catches after September is that the fish have moved to other locations, probably into the tributaries to overwinter and, if mature, to spawn. It is possible that some cutthroats may overwinter in the riverine reaches of the Columbia or in the estuary. Lucas (1997) states that immature sea-run cutthroat trout from lower Columbia tributaries may overwinter in deep tributary pools or in the estuary, but no substantiating data were presented. Dawley, et al. (1985) collected few cutthroats in the lower riverine reach and the estuary during the winter, suggesting that few cutthroats overwintered in those areas. This conclusion is open to question, however, because sampling was scant during this period and did not include all habitats that cutthroats may have used (see sections below). As mentioned previously, in the Fraser River many smolt-size and larger coastal cutthroats overwinter in lower river freshwater back-channels (Rempel, 2001a).

Based on sampling at Jones Beach at the upstream end of the lower riverine reach (Figure D2-1) from 1977 to 1983, Dawley, et al. (1985) reported that coastal cutthroat were in the area March through November, with peak abundance occurring in April through June and in August through September; few fish were present in the winter. These authors did not present age and size information for cutthroat, but they state that the migration of spawned out adults peaked in May (Dawley, et al., 1979 and 1980). An extensive sampling program for sea-run cutthroat and steelhead trout was conducted at Jones Beach as well as several sites in the estuary in 1980 (Loch, 1982). The few cutthroat smolts that were captured during this program were taken in the lower and central estuary from April through June. Adult cutthroat were sampled at Jones Beach and in the estuary from July 8 through the end of August. Catches of adults peaked during the last week of July in the estuary and during the first week of August at Jones Beach, indicating that the fish were migrating riverward. The size of adult fish in the estuary was largest in July, and decreased thereafter, following the often-observed pattern that the largest cutthroat migrate streamward first (Trotter, 1997). At Jones Beach, the size of cutthroat increased over time, however. Loch (1982) determined from scale characteristics that 90 percent of the fish at Jones Beach were age-1+ hatchery stock, and he concluded that they remained in the area and grew throughout the summer (Table D2-2). Age-1+ hatchery fish were also found throughout the estuary, whereas all wild fish examined were older and had spent at least 2 winters in freshwater (Loch, 1982).

Appendix D-3 of this BA is an analysis of beach and purse seine data collected by NMFS between 1967 and 1980 to determine spatial and temporal trends in size and abundance of coastal cutthroat trout in the estuary. Sampling coverage varied greatly from year to year, but some general patterns were suggested by results. In four of five years, cutthroats were captured along the shoreline (beach seine) only in August and September in the lower two-thirds of the estuary (mouth and estuarine reach, Figure D2-1), and from February through September in the upper one-third of the estuary (lower riverine reach). Cutthroats were commonly taken in the deeper channel (purse seine) throughout the estuary from April through August, the whole sampling season for this gear. Somewhat higher catch rates in the middle and upper estuary suggest that cutthroats were more abundant there than in the lower estuary where catch rates tended to be lower. Frequent catches of more than one cutthroat per set, when any were caught at all, indicated that some schooling occurred, but most multiple fish catches were only two to three fish. Trends in size of cutthroat by time of year and portion of the estuary were not clear. The over all mean fork length was 283 mm for beach-seined fish and 285 mm for purse-seined fish, with a range of about 120-530 mm for both gears.

Nearly all sea-run cutthroat that have been captured in marine waters off the Washington and Oregon coasts occurred within the bounds of the Columbia River plume, 10 to 50 km offshore and 55 km up or down coast from the river mouth (Loch, 1982; Loch and Miller, 1988; Pearcy, 1997). These fish tended to drift southward in the plume with prevailing currents, and limited data suggest that they were only present in marine waters from May through August, presumably returning to the estuary afterwards (the last catches of cutthroats were in August, but sampling in the plume was not performed after early September). While in the plume they fed intensively and grew rapidly, about 1 mm per day, and they showed no tendency toward schooling (Pearcy, 1997). Cutthroat trout in the plume were found in waters with a depth of 30 to 134 meters and did not frequent shallower shoreline waters (Dawley, et al., 1985; Pearcy, and Fisher, 1990). Their depth distribution within the water column was not determined, but the nets used over the years fished from the surface to depths ranging from 20 to 60 meters (Pearcy and Fisher, 1990).

2.3.2 Habitat Use and Preferences

Understanding the habitat requirements and preferences of coastal cutthroat trout is important for their preservation and management. Given the complex life history of coastal cutthroat trout and the high degree of scientific uncertainty associated with it, defining specific habitat requirements for this species is difficult (NMFS and USFWS, 1999). Potential cutthroat habitat within the study area constitutes rearing and foraging habitat, and a migratory pathway. Considering the strict requirements of the species for spawning and age-0 rearing, these activities are probably restricted to tributary streams and are very unlikely in the study area.

Information about coastal cutthroat trout habitat use and preferences in upper riverine reach (Figure D2-1) of the Columbia is very limited. Trotter (1987) states that in many streams, returning sea-run cutthroat favor quieter pools, where the water deepens and slows, and that places of this type with added habitat complexity and cover from boulders, log jams, or overhanging brush often attract cutthroats. Available information for the Columbia does not clearly indicate migration path preferences or whether age-1 or older cutthroat rear for extended periods in the upper riverine reach (also see discussion of occurrence by location in previous section). Near the upper end of this area, Ellis (2000) reported a limited catch of cutthroat trout (three fish) in shallow water of the Willamette River near Portland. Loch (pers. comm., 2001) believes that both out-migrant and returning cutthroat trout in the upper riverine reach prefer shoreline areas where food is available and where in-water structure offers protection from rapid flows and cover from predation. He also believes that tributary mouths are important holding areas. In the lower Chehalis River, another large SW Washington/Columbia River cutthroat ESU stream, the reach immediately below one major tributary confluence (Satsop River) was found to be an important area for juvenile and adult cutthroats alike (Wright, 1973). Sea-run cutthroats returning from the estuary held there, apparently awaiting flows and temperatures favorable for continued upstream migration, and age-0 trout, presumed to include both rainbow and cutthroat juveniles, reared there during the growing season (ibid.). In the upper riverine reach, sea-run cutthroat are captured by the sport fishery from July through October, mainly below the Cowlitz confluence. Fishing takes place along relatively shallow bars where cutthroats forage.

Seining at Jones Beach, near the upper extreme of the estuary, at times captured many cutthroat trout, both offshore in the main channel and along the featureless, sandy beach (Dawley, et al., 1985). In both habitats, most cutthroats were captured during the peak seaward (April to May) and upstream (August to September) migrations. Limited sampling from November through March suggests that few cutthroats overwintered at Jones Beach (ibid.). Little information was given about age or size of the cutthroats, except to say that the migration of spawned out adults peaked in May (Dawley, et al., 1979 and 1980). Dawley, et al. (1985) reported that cutthroat catches in the main channel declined during mid-summer months, while shoreline catches remained relatively high, suggesting that cutthroats reared in shallow littoral habitats at Jones Beach during the summer. Results of beach and purse seine sampling at other sites throughout the estuary, reported in Appendix D-3 of this BA, indicated that cutthroats occurred in the channel throughout the estuary during spring and summer. In the shallows, they were present in the upper estuary spring through summer, but were seldom found in the lower two-thirds of the estuary until August and September (ibid.). Loch (pers. comm., 2001) believes that cutthroat smolts and returning adults favor shallow, nearshore habitats of the estuary where they prey opportunistically on invertebrates and small fish. Ledgerwood (pers. comm., 2001) points out that cutthroats were seldom the target species of the aforementioned studies, and that no study in the Columbia estuary to date has attempted to sample all of the shallow habitat types that cutthroats may commonly use. Ledgerwood (ibid.) believes that cutthroats often occur in shallow habitats more structurally complex than can be sampled with beach seines typically used in the estuary. It therefore appears that studies conducted to date do not clearly describe habitat use by adult or juvenile cutthroat trout in the lower Columbia river and estuary (see Recommended Studies and Methods sections for alternatives).

Within the Columbia River plume, most sea-run cutthroat were captured 10 to 50 km off the Washington and Oregon coasts, in waters with an average surface temperature of 13.4 degrees C and a surface salinity of 28.6 psu (Loch and Miller, 1988; Pearcy, et al., 1990). Sea-run cutthroat in protected waters typically remain within a few kilometers of shore (Johnston, 1982), but they were absent from this zone near the Columbia River mouth, for no apparent reason (Dawley, et al., 1985; Pearcy and Fisher, 1990). No cutthroats were captured near shore off the river mouth where the water was less than 30 meters deep, although they were captured in the estuary and in offshore waters of the plume during concurrent sampling (Dawley, et al., 1985; Loch and Miller, 1988; Pearcy, et al., 1990). Their depth distribution within the water column was not determined, but the nets used over the years fished from the surface to depths ranging from 20 to 60 meters (Pearcy and Fisher, 1990).

2.3.3 Food and Feeding

Coastal cutthroat trout are opportunistic feeders throughout their lives, both in streams and in salt water, taking advantage of what ever prey is most abundant, commonly aquatic insects and other invertebrates as well as small fish when available (Loch and Miller, 1988; Trotter, 1997). No information was found in the literature describing cutthroat feeding habits or diet in the upper riverine reach per se (Figure D2-1). However, Tipping (1981) reported that adult cutthroat trout in the mainstem Cowlitz River fed mainly on terrestrial and aquatic insects. At Jones Beach, near the boundary of the lower and upper riverine reaches, the diet of cutthroats varied seasonally (Loch, 1982). In August, cutthroats (mean fork length 291 mm) consumed mainly fish, gammerid amphipods, and insects, and small shad were the dominant prey (89 percent of stomach contents by weight and 29 percent by numbers, ibid.). In September, cutthroats (mean fork length 304 mm) preyed on cladocerans, mysids, fish, and insects, and shad were again the dominant food item (85 percent of stomach contents by weight and 41 percent by numbers, ibid.). Loch (pers. comm., 2001) believes that, in general, outmigrant juvenile cutthroat in the lower Columbia River favor shallow, nearshore habitats where they prey on invertebrates and small fish, as available. As they progress downstream toward the estuary, aquatic and terrestrial insects give way to gammerid amphipods in dietary importance, and gammerids are especially abundant in mudflats and shallow habitats of the lower river.

In most estuaries, smolts and older cutthroats typically travel in small schools, feeding opportunistically on fish and invertebrates, often in waters no more than a few meters deep (Trotter, 1997). The only detailed description of cutthroat food habits available for the Columbia River estuary comes from sampling conducted throughout the estuary in 1980 with beach seine, purse seine, and fyke nets (Loch, 1982). On their seaward migration through the estuary, sea-run smolts fed chiefly on insects and gammerid amphipods (Loch, 1982; McCabe, et al., 1983; Bottom et al., 1984). Adults returning to the lower estuary fed mainly on Pacific herring, threespine stickleback, and bay shrimp (Loch, 1982). Loch (pers. comm., 2001) believes that cutthroat feed extensively in estuarine habitats that support high food production, such as mudflats for amphipods, and on certain bars were fish such as sand lance are abundant. Simenstad and Eggers (1981) collected five cutthroats averaging 260 mm in fork length (standard deviation = 116 mm) from shallow waters of Grays Harbor, the northwest extreme of the Southwest Washington/Columbia River coastal cutthroat ESU. Stomachs of these fish contained pelagic larvae of *Cancer* sp. crabs (44 percent of total IRI), juvenile smelt (34.4 percent), juvenile salmonids (8.3 percent), greenling (5.1 percent), and unidentified fish (7.9 percent).

In marine waters of the Columbia plume, sea-run cutthroat consumed primarily fish and crustaceans (Brodeur, et al., 1987; Loch and Miller, 1988; Pearcy, et al., 1990). Mysids and euphausids (crustaceans) were dominant in numbers in some places at some times, but fish dominated in biomass (Pearcy, et al., 1990). Northern anchovy, kelp greenling, cabezon, and rockfishes were the predominant fish species eaten and other juvenile salmonids were infrequently preyed on by cutthroats (ibid.).

2.3.4 Interspecific Competition

Competition for food and habitat between coastal cutthroat trout and other fish in the study area is likely, although supporting evidence is circumstantial. Coastal cutthroat trout are fairly unspecialized and adaptable in their feeding habits throughout their life history, making them capable of exploiting the prey items most abundant or desirable at a particular time and location (Loch and Miller, 1988; Trotter, 1997). Johnston (1982) describes coastal cutthroat trout as generalists that spend their lives migrating and filling niches other salmonids least prefer. However, when diet and habitat use by cutthroat trout overlap use by other salmonid and non-salmonid species, as they commonly do in the area of interest (Emmett and Stone, 1991), competition is likely if resources are limited. Releases of hatchery-reared salmonids are recognized as a major potential source of competition for lower Columbia River cutthroat trout in all habitats that cutthroat occupy throughout their life history (Lichatowich and McIntyre, 1987; Johnson, et al., 1999).

Although outside the study area, competitive interactions with hatchery fish in tributary streams have undoubtedly affected cutthroat trout in the study area and should therefore be mentioned here (Hooten, 1997; Leider, 1997). In natal streams, cutthroat fry are displaced from preferred habitats by steelhead and coho salmon of similar size, so cutthroat typically avoid competition by spawning and rearing upstream from the coho zone (Johnston, 1982). The formerly common practice of indiscriminately planting juvenile coho into cutthroat rearing areas of natal streams therefore had a strong negative impact on wild cutthroat trout in the lower Columbia watershed (Leider, 1997; Johnston, pers. comm., 2001). Introductions of hatchery-reared rainbow trout have also impacted wild cutthroat populations in spawning and rearing areas through competition for food and space, as well as through interbreeding (Behnke, 1992). Behnke (1992) considers that the lack of basibranchial teeth in some wild coastal cutthroats of Washington and Oregon streams where rainbow trout have been heavily stocked is evidence of hybridization between these species.

Many potential competitors (and predators) of cutthroat are also found in the upper riverine reach of the study area (Figure D2-1). In a fisheries study near Portland, Ellis (2000) sampled cutthroat trout in shallow water habitat along with largemouth and smallmouth bass, yellow perch, American shad, northern pike minnow, and other species that may compete for resources such as food and habitat. Shad and northern pile minnow occur over the entire extent of the upper riverine reach, and both species were seasonally abundant at Jones Beach (Dawley, et al., 1986). As non-native species, many of the fishes mentioned above have not co-evolved to partition resources with cutthroat trout, and are therefore likely to compete with coastal cutthroat trout for when resources are limited.

In the Columbia estuary, amphipods and insects are a dominant prey of juvenile shad (Hamman, 1981) and out-migrating cutthroat smolts (Loch, 1982) and Bottom and Jones (1990) concluded that the diets of juvenile shad and salmonids overlapped appreciably. Marine mammals and birds foraging on baitfish such as Pacific herring, smelt, and anchovy may also compete for these favored prey items with adult cutthroat trout returning from the sea. Cutthroat trout may also experience competition in marine waters. Off the Washington and Oregon coast, dietary overlap of sea-run cutthroat trout with juvenile chinook and coho salmon is sometimes as high as 60 percent (Brodeur and Pearcy 1992), suggesting that these species may sometimes compete for food. Large-scale hatchery releases of fry and fingerling salmon that are common in the Columbia River have the potential to overwhelm food production capacity and increase competition in estuaries and marine waters (Lichatowich and McIntyre 1987).

2.3.5 Predation on Cutthroat Trout

Predation on coastal cutthroat trout by other fish, birds, and marine mammals in the study area may be substantial, although documentation is rare. In portions of the Columbia River where prey and predator behavior has been disrupted by dams, most notably in impoundments and near the dams themselves, bass and northern pikeminnow are at times important predators on juvenile salmonids in general, with smaller fish likely most vulnerable (Beamesderfer, 2000). Juvenile salmonids can comprise one third of the diet of northern pikeminnow in such locations (ibid.) Birds such as cormorants, belted kingfishers, loons, common merganser, heron, grebes, and other piscivors are likely to be major predators of cutthroats in fresh and brackish waters (Palmisano, 1997). Alcid predators, including auklets, murres, murrelets, Guillemots, and puffins, likely feed on salmonids, which may include cutthroats, in nearshore marine waters (Manuwal, 1977). Collis, et al. (1999, 2000) have measure high levels of predation by terns, cormorants, and gulls on juvenile salmonids in the Columbia estuary in recent years. For example, they estimated that these birds consumed from 10 to 30 percent of all salmonid smolts that entered the estuary in 1998. Caspian terns accounted for nearly 60 percent of this consumption and predation was centered around rookeries on Rice and Sand Islands in the lower riverine reach, see Figure D2-1 (ibid.). Relative predation rates were highest on species with the largest smolts (steelhead and coho) in the riverine reach, and it was speculated that large smolt size, longer residence time in the estuary, and occurrence near the water surface may be factors leading to higher predation rates (ibid.). It was also noted that the number of terns and cormorants nesting in the Columbia estuary has been increasing rapidly since the mid 1980s (ibid.). Although no information was reported on predation by birds on cutthroat trout, all trends mentioned suggest the potential for significant predation on this species; for example, large smolt size and long residency in the estuary could lead to high predation rates on cutthroats. Since these fish-eating birds commonly consume steelhead smolts 200 mm in length, sea-run cutthroat smolts that typically average about 160 mm in length (Tipping 1981) are of a size vulnerable to bird predation (Ledgerwood, pers. comm., 2001).

Northwest pinneped populations have been increasing annually by 3 to 12 percent since passage of the Marine Mammal Protection Act in 1972 (NMFS, 1992), increasing the potential for predation on cutthroat trout. Scarring rates on other salmonids, indicative of attacks from marine mammals, have increased markedly at Columbia River dams where scarring incidence is monitored during fish passage (Harmon and Matthews, 1990; Palmisano, 1997). For Alsea River (Oregon) cutthroat trout in the marine environment, spiny dogfish, harbor seals, and adult salmon were identified as the most likely predators (Giger 1972). Giger reported that 58 percent of wild cutthroat trout, and 67 percent of hatchery trout taken from the Alsea River estuary in 1970 had scarring from predatory attacks. In his 1980 sampling of cutthroat trout in the Columbia River estuary, Loch (1982) captured one fish with a bite mark attributed to a seal. Neither Loch and Miller (1988) nor Pearcy (1997) report any predation or attacks on cutthroat trout in the Columbia River plume. Bryen (2000) reports that scarring from pinneped attacks on cutthroats returning to the Beaver Creek hatchery (lower Columbia River, Figure D2-1) was at a record high of 18 percent in 1997-1998, but was only 5 percent in 1998-1999. With steelhead, harbor seals and sea lions preferentially targeted gravid females (ibid.), and it may not be unreasonable to speculate that such behavior occurs toward cutthroats as well. Pearcy (1997) suggests that predation at sea might be intensified during warm ocean conditions. During warm summers when upwelling is weak, the inshore-offshore zone of cool temperatures for salmonids is compressed close to shore, concentrating both predators and prey. In addition, abundance of major Clupeid and Osmerid prey species is typically low during warm conditions with weak upwelling, perhaps intensifying predation on alternate species, such as salmonids.

Fisheries for Cutthroat Trout

There are no commercial fisheries that target coastal cutthroat trout in the study area, although the species is sometimes incidentally captured in commercial salmon fisheries (Blakely, 2000). The extent of this bycatch is unknown, but Tipping (1981) reported that a gillnet fishery in the lower Cowlitz River captured an estimated 230 cutthroat trout, mainly in 5- to 5-7/8 inch stretched mesh sizes, and the largest cutthroat in the population were most vulnerable to harvest.

Sport fisheries for sea-run cutthroat trout are a longstanding tradition in the lower Columbia River and its tributaries. The fishery traditionally begins about July 4 when fish appeared in the lower Columbia, and continues until about the end of October, when the migratory influx ceases (Trotter, pers. comm., 2001). In the riverine reach, nearly all angling effort and harvest are attributed to bank anglers fishing at river bars from Jones Beach to the Cowlitz River (Melcher and Watts, 1995; Melcher, 1996); few cutthroat anglers fish from boats or fish upstream or downstream of the segment described above (Schuck, 1980, Melcher and Watts, 1995; Melcher, 1996; Trotter, pers. comm., 2001). Angling for sea-run cutthroat is also popular in tributaries such as the Cowlitz River (Tipping and Springer, 1980; Tipping, 1981), the Elochoman River (Randolph 1986), and other tributaries (Lavier, 1963). Occasionally, cutthroat trout are captured by anglers trolling from boats in the estuarine reach, but this is believed to be infrequent (Sheehan, pers. comm., 2001).

The literature contains little quantitative information about sport fisheries for sea-run cutthroat trout in the study area. Lucas (1980) conducted a creel survey at two river bars between the Elochoman and Cowlitz Rivers on 14 days from July 19 to November 12, 1977. Over the course of the survey he checked 61 anglers targeting cutthroat trout who had fished 190 angler-hours, with a total catch of zero cutthroat trout. Schuck (1980) surveyed the mainstem sport fishery at several locations (location codes not defined) from July to November and reported fish sizes, but not effort levels. In general, mainstem and tributary fisheries were very productive into the 1980s, after which they declined drastically (Melcher and Watts, 1995, 1996; Hooten, 1997; Leider, 1997). The annual cutthroat harvest in the lower Columbia River for Washington and Oregon anglers combined ranged from 1,405-13,617 fish from 1969-1985 (1975-1985 mean = 4,200), compared with 69 to 503 fish from 1986-1995 (Melcher and Watts, 1995, 1996). This decline in harvest reflects increasingly restrictive harvest regulations as well as decreasing stock abundance (Hooten 1997, Leider 1997). Tipping (1981) reports that a sample of 32 cutthroat trout from the 1980 Cowlitz River sport fishery averaged 34.1 cm in length (range approximately 26 to 40 cm), and that these fish were on average larger and older than cutthroats from a concurrent fishery in the lower Columbia River. Additional unanalyzed sport fishery data exists in agency archives (Sheehan, pers. comm., 2001).

2.3.6 Natural versus Hatchery Stock Composition

Hatcheries have been used to augment wild production of cutthroat trout in the lower Columbia River and its tributaries for many years (Hooten, 1997; Leider, 1997; Johnson, et al., 1999). The main intent of hatchery programs has been to improve recreational fishing opportunities (Hooten, 1997; Leider, 1997). Hatchery supplementation programs in Oregon tributaries of the lower Columbia were discontinued in 1994, but supplementation continues in Washington, with most production from the Cowlitz River facility (Hooten, 1997; Leider, 1997). In 1997, about 200,000 hatchery cutthroat were released into Abernathy and Beaver Creeks and the Coweeman, Cowlitz, and Lewis Rivers (WDFW, 1997).

Despite the many fisheries studies conducted over the years, estimated proportions of hatchery and wild cutthroats in the study area per se were found in only one report. Loch (1982) described stock proportions from fish sampled in the Columbia River estuary and plume for June-September 1980 (Table D2-2). These data indicate that 84 percent of fish sampled in the estuary (103 of 123) were hatchery fish, whereas 50 percent of fish sampled in the plume (9 of 18) were hatchery fish. Similarly, Tipping and Springer (1980) reported that 60 percent of the cutthroat catch in the Cowlitz River was of hatchery origin in 1979.

2.3.7 Data Deficiencies

Many gaps and deficiencies exist in available data about Columbia River coastal cutthroat trout in the various parts of the study area. In general, long-term data sets that quantitatively describe changes in abundance and stock characteristics such as population age and size structure are lacking. Knowledge of cutthroat migrations within the area of interest is also sketchy. Much of the available information about cutthroats in the study area is dated and in some cases may not accurately describe current conditions. These deficiencies are described in greater detail below.

Very little information exists in both published and unpublished literature about cutthroat in the upper riverine reach (Portland to Jones Beach). Results from creel surveys are scant and mainly useful as an indicator of presence/absence and migration timing in the lower portion of this area. Information about cutthroats in the Columbia above the Cowlitz confluence is almost nonexistent. Quantitative data about subjects such as seasonal use by cutthroat, age groups involved, and habitat preferences in this unique large river environment are apparently unavailable, and results from studies conducted in smaller streams may be inapplicable. Some useful unanalyzed and unpublished data may exist in agency archives from tagging and creel surveys (Loch and Sheehan, pers. comm., 2001).

Considerable fisheries work has taken place in the lower riverine reach and the estuary (Jones Beach to the river mouth) since the 1960s. Much of this work appears in the literature with peripheral mention of cutthroat trout as a non-target species, and additional unanalyzed data on cutthroats exists in agency archives (Ledgerwood, pers. comm., 2001). Several published studies (e.g., Dawley, et al., 1980; Loch, 1982; Bottom, et al., 1984) indicate the presence or absence and timing of cutthroat trout in this area, and Loch's work also describes age at smolting, size, and diet. Some available habitats were not sampled in these studies, most notably complex, shallow-water habitats that may be preferred by cutthroat trout, so this work does not accurately portray habitat preferences of this species in the study area (Ledgerwood, pers. comm., 2001). Tagging and tracking studies would offer more direct measures of habitat use and preferences. Predation on cutthroats in the estuary by rapidly increasing populations of birds and marine mammals is a subject of concern that has yet to be studied.

Purse and beach seining in the ocean plume have provided important basic information about use of this habitat by sea-run cutthroat, as well as basic biological information about the species (e.g., size, age, growth, diet, hatchery/wild composition). Studies were conducted according to a design that appeared to sample the whole distribution of cutthroat in the plume for at least most of the time that they were present in the marine environment, and several years of data were collected to evaluate inter-annual variability. Some uncertainty remains about whether any cutthroats overwintered at sea because sampling was only conducted from May through September (absence of cutthroats from the plume in winter months was presumed due to their disappearance from catches after August coupled with other knowledge of cutthroat life history). Other noteworthy questions, such as the effects of changing ocean conditions on cutthroats, may at some time need to be addressed in future studies.

This appendix collects and synthesizes the available scientific and commercial data on cutthroat trout presence in and use of the lower Columbia River, estuary, and ocean plume. In order to make final listing decisions or develop recovery plans for cutthroat trout, it may be necessary to address the data deficiencies and suggested studies identified above. However, the available data collected and reported here provide sufficient information on cutthroat trout's presence in and use of the project area to support the Biological Assessment's analysis of the potential effects of channel improvement on the species.

2.3.8 Suggested Studies and Methods

Marvin Rosenau (BC Ministry of the Environment, Surrey, BC):
Study cutthroat trout migrations in the lower river and estuary using combination radio/sonic tags and strontium analysis of scales or otoliths. Combination tags would be effective in both salt and fresh water.

Richard Ledgerwood (NMFS, Hammond Lab, Oregon):
Use Passive Integrated Transponders (PIT) to tag cutthroats to evaluate their use of side channels and other shallow water habitats in the estuary. Ed Casillas at NMFS is spearheading a program to develop such methods for other salmonids. PIT tags could also be used to assess mortality from predatory birds. This is presently working well for other salmonids, and NMFS has discovered high mortality of steelhead smolts (200 mm and larger fish) this way. Currently, no cutthroat trout are being PIT tagged. Ledgerwood also recommends sonic tags to study migrations in the estuary. This could be piggybacked with methods under development for salmon; e.g., development of a buoy-based monitoring system.

Much useful data resides on paper forms only at the Hammond Lab, and some of it pertains to cutthroat trout. It should be entered to a computer database before people who know the data have retired. The entire task for all species could likely be done in about six months. Ledgerwood might be able to provide some guidance if this task is attempted. Some of this data was entered to computer during a visit to the Hammond Lab by a team led by Doug Young (USFWS) on March 7 and 8, 2001.

John Loch (WDFW):
A basic habitat inventory is needed in the study area and tributaries to identify important habitats such as main food producing areas. Examples would be flats and bars in the estuary where cutthroats feed on amphipods and sand lance, respectively. From this type of basic information more focused questions about the needs of cutthroats could be developed.

Involve universities in the design and execution of the work to keep scientific standards high and for cost effectiveness

Dr. Jim Hall at OSU would be a source of other recommendations for work that is needed.

Mario Solazzi (ODFW):
More work is needed to better define distribution, environmental preferences, and diet of cutthroats in marine waters.

More studies are also needed to determine where cutthroats go, what they are doing, habitat preferences, and critical areas in estuaries. He suggests radio and acoustic tags.

William Pearcy (from the conclusion of his article, "The Sea-Run and the Sea,". Pearcy, 1997). Some key studies and data are needed:
Population estimates are necessary to evaluate the plight of trout in regions of decline.

Sampling should include taking scales so age and size structure and survival rates can be evaluated.

Long-term sampling programs should be maintained so time trends can be recognized.

Some careful comparisons of resident and anadromous cutthroat populations should be made to determine if recent declines in cutthroat populations stem from the freshwater or marine environment.

2.4 References

Beamesderfer, R.C.P. 2000. Managing Fish Predators and Competitors: Deciding when Intervention is Effective and Appropriate. *Fisheries* 25:18-23.

Behnke, R.J. 1992. Native Trout of Western North America. AFS Monograph 6, American Fisheries Society, Bethesda, Maryland.

Bisson, P.A., and J.R. Sedell. 1984. Salmonid Populations in Streams in Clearcut vs. Old-Growth Forests of Eastern Washington. In: Fish and Wildlife Relationships in Old-Growth Forests. W.R. Meehan, Jr., T.R. Merrell and T.A. Hanley, editors. Institute of Fisheries Research Biologists, Morehead City, North Carolina. Pp. 121-129.

Bisson, P.A., K. Sullivan, and J.L. Nielsen. 1988. Channel Hydraulics, Habitat Use, and Body Form of Juvenile Coho Salmon, Steelhead, and Cutthroat Trout in Streams. *Transactions of the American Fisheries Society* 117:262-273.

Blakely, A., B. Leland, and J. Ames (eds.). 2000. 2000 Washington Salmonid Stock Inventory. Coastal Cutthroat Trout. Washington Department of Fish and Wildlife, Olympia, Washington.

Bottom, D.L., and K.K. Jones. 1990. Species Composition, Distribution, and Invertebrate Prey of Fish Assemblages in the Columbia River Estuary. *Progress in Oceanography* 25(1-4) 243-270.

Bottom, D.L., K.K. Jones, and M.J. Herring. 1984. Fishes of the Columbia River Estuary. Final Report on the Fish Work Unit of the Columbia River Data Development Program submitted to Oregon Department of Fish and Wildlife, Portland, Oregon.

Boule, M.E., and K.F. Bierly. 1987. History of Estuarine Development and Alteration: What Have We Wrought? *Northwest Environmental Journal* 3:43-61.

Brodeur, R.D., G.W. Boehlert, E. Casillas, M.B. Eldridge, J.H. Helle, W.T. Peterson, W.R. Heard, S.T. Lindley, and M.H. Schiewe. 2000. A Coordinated Research Plan for Estuarine and Ocean Research on Pacific Salmon. *Fisheries* 25:7-16.

Brodeur, R.D., and W.G. Pearcy. 1992. Effects of Environmental Variability on the Trophic Interactions and Food Web Structure in a Pelagic Upwelling Ecosystem. *Marine Ecology, Progress Series* 84:101-119.

Brodeur, R.D., H.V. Lorz, and W.G. Pearcy. 1987. Food Habits and Diet Variation of Pelagic Nekton Off Oregon and Washington, 1979-1984. NOAA Tech Report NMFS 57.

Bryant, F.G. 1949. A Survey of Columbia River and its Tributaries with Special Reference to its Fishery Resources – Part II. Washington Streams from the Mouth of the Columbia to and Including the Klickitat River (Area I). U.S. Fish and Wildlife Service Special Scientific Report 62.

Bulkley, R.V. 1966. Catch of the 1965 Tidewater Cutthroat Sport Fishery and Notes on the Life History of the Coastal Cutthroat Trout in the Siuslaw River, Oregon. Corvallis, Oregon, Research Division, Oregon Game Commission.

Bustard, D.R., and D.W. Narver. 1975. Preferences of Juvenile Coho Salmon (*Onchorynchus kisutch*) and Cutthroat Trout (Salmo clarki) Relative to Simulated Alteration of Winter Habitat. Journal of the Fisheries Research Board of Canada 32:681-687.

Byren, J. 2000. Characteristics of Anadromous Steelhead and Sea-Run Cutthroat at Beaver Creek and Skamania Hatcheries. Washington State Department of Fish and Wildlife, Annual Report FPA00-02, 45 pp.

Campana, S.E., and S.R. Thorrold. 2001. Otoliths, Increments, and Elements: Keys to a Comprehensive Understanding of Fish Populations? *Canadian Journal of Fisheries and Aquatic Sciences* 58:30-38.

Campton, D.E., and F.M. Utter. 1987. Genetic Structure of Anadromous Cutthroat Trout (*Salmo clarki clarki*) Populations in the Puget Sound Area: Evidence for Restricted Gene Flow. *Canadian Journal of Fisheries and Aquatic Sciences* 44:573-582.

Chilcote, M.W. 1980. Kalama Sea-Run Cutthroat. Washington State Game Department, Fish Management Division Report 80-14, pp. 2-168.

Chilcote, M.W., S.A. Leider, and B.A. Crawford. 1980. Kalama River Salmonid Studies 1980. Washington State Game Department, Fish Management 37 pp.

Chilcote, M.W., S.A. Leider, and R.P. Jones. 1980. Kalama River Salmonid Studies 1980, Washington State Game Department, Fish Management Division Report No. 81-11, 97 pp.

Collis, K., D.D. Roby, D.E. Lyons, and D.P. Craig. 2000. Draft 2000 Season Summary: Columbia Bird Research Update. (Available at the Web Site: www.columbiabirdresearch.org).

Collis, K., S.L. Adamany, D.D. Roby, D.P. Craig, and D.E. Lyons. 1999. Avian Predation on Juvenile Salmonids in the Lower Columbia River. 1998 Annual Report to Bonneville Power Administration and U.S. Army Corps of Engineers, Portland, Oregon.

Crawford, B.A., R. Lucas, J.M. Tipping, S. Springer, M.L. Schuck, L. LaVoy, and H. Fischer-Benzon. 1980. Cutthroat Status Report for Southwest Washington 1979. In: Sea-Run Cutthroat Status Report, pp. 99-105, Washington State Game Department, Fisheries Management Division, 80-14.

Dahl, T.E. 1990. Wetlands Losses in the United States 1780s to 1980s. U.S. Department of the Interior, Fish and Wildlife Service, Washington D.C., 13 pp.

Dawley, E.M., R.D. Ledgerwood, T.H. Blahm, C.W. Sims, J.T. Durkin, R.A. Kim, A.E. Rankin, G.E. Monan, and F.J. Ossiander. 1986. Migrational Characteristics, Biological Observations, and Relative Survival of Juvenile Salmonids Entering the Columbia River Estuary, 1966-1983. Unpublished Report to Bonneville Power Administration, Contract DE-A179-848BP39652, by Coastal Zone and Estuarine Studies Division, National Marine Fisheries Service, Seattle, Washington. 256 pp.

Dawley, E.M., R.D. Ledgerwood, and A.L. Jensen. 1985. Beach and Purse Seine Sampling of Juvenile Salmonids in the Columbia River Estuary and Ocean Plume, 1977-1983. NMFS report F/NWC-75, MNFS, Seattle, Washington.

Dawley, E.M., R.D. Ledgerwood, and T.H. Blahm. 1985. Migrational Characteristics, Biological Observations, and Relative Survival of Juvenile Salmonids Entering the Columbia River Estuary, 1977-1983. Unpublished manuscript. Northwest and Alaska Fisheries Center, NMFS, NOAA, Seattle, Washington.

Dawley, E.M., C.W. Sims, R.D. Ledgerwood, D.R. Miller, and J.G. Williams. 1981. A Study to Define the Migrational Characteristics of Chinook and Coho Salmon and Steelhead Trout in the Columbia River Estuary. 1980 Annual Report to Pacific Northwest Regional Commission, 53 pp.

Dawley, E.M., C.W. Sims, R.D. Ledgerwood, D.R. Miller, and F.P. Thrower. 1980. A Study to Define the Migrational Characteristics of Chinook and Coho Salmon and Steelhead Trout in the Columbia River Estuary. 1979 Annual Report to Pacific Northwest Regional Commission, 90 pp.

Dawley E.M., C.W. Sims, and R.D. Ledgerwood. 1979. A Study to Define the Migrational Characteristics of Chinook and Coho Salmon and Steelhead Trout in the Columbia River Estuary. 1978 Annual Report to Pacific Northwest Regional Commission, 23 pp.

DeShazo, J.J. 1980. Sea-Run Cutthroat Trout Management in Washington, an Overview. In: Sea-Run Cutthroat Status Report, pp. 1-17, Washington State Game Department, Fisheries Management Division, 80-14.

Duff, R.L. 1972. The 1969-70 and 1970-71 Sea-Run Cutthroat Tagging and Evaluation Study at the Cowlitz Trout Hatchery. Washington Department of Game, Fisheries Management Division Report, 26 pp.

Durkin, J.T. 1982. Migration Characteristics of Coho Salmon Smolts in the Columbia River Estuary. In: Estuarine Comparisons, Kennedy. Academic Press. Pp. 365-375.

Edie, B.G. 1975. A Census of the Juvenile Salmonids of the Clearwater River Basin, Jefferson County, Washington, in Relation to Logging. Master Thesis, University of Washington. 86 pp.

Ellis, R.H. 2000. Biological Assessment for Listed and Proposed Species Threatened and Endangered Species, West Hayden Island Port Facilities Development, Port of Portland, Oregon. Draft Report to U.S. Army Corps of Engineers and Federal Highway Administration, Portland, Oregon.

Emmett, R.L., and S.L. Stone. 1991. Distribution and Abundance of Fishes and Invertebrates in West Coast Estuaries. Volume II: Species Life History Summaries. Estuarine Living Marine Resources Report Number 8. NOAA, National Ocean Service, Strategic Environmental Assessment Division, Rockville, Maryland.

Fuss, H.J. 1982. Age, Growth, and Instream of Olympic Peninsula Coastal Cutthroat Trout. In: Proceedings of Olympic Wild Fish Conference. J.M. Walton and D.B. Houston, editors. U.S. Park Service and Peninsula College, Port Angeles, Washington. Pp. 125-134.

Gaumer, T., D. Demory, and L. Osis. 1973. Nestucca River Estuary Resource Use Study. NOAA N208-0073-72(N), DACW 57-72-C-0138.

Giger, R.D. 1972a. Ecology and Management of Coastal Cutthroat Trout in Oregon. Fishery Research Report No. 6, Corvallis Oregon. Federal Aid to Fish Restoration Project F-72-R, Final Report.

Giger, R.D. 1972b. Some Estuarine Factors Influencing Ascent of Anadromous Cutthroat Trout in Oregon. Second Annual Technical Conference on Estuaries of the Pacific Northwest, Oregon State University, Corvallis, Oregon.

Glova, G.J. 1987. Comparison of Allopatric Cutthroat Trout Stocks with those Sympatric with Coho Salmon and Sculpins in Small Streams. *Environmental Biology Fishes* 20:275-284.

Glova, G.J. 1986. Interaction for Food and space Between Experimental Populations of Juvenile Coho Salmon (*Oncorhynchus kisutch*) and Coastal Cutthroat Trout (*Oncorhynchus clarki clarki*) in a Laboratory Stream. *Hydrobiolgia* 132:155-168.

Glova, G.J. 1984. Management Implications of the Distribution and Diet of Sympatric Populations of Juvenile Coho Salmon and Coastal Cutthroat Trout in Small Streams in British Columbia, Canada. *Progress in Fish Culture* 46:269-277.

Glova, G.J. 1978. Pattern and Mechanism of Resource Partitioning Between Stream Populations of Juvenile Coho Salmon (*Oncorhynchus kisutch*) and Coastal Cutthroat Trout (*Oncorhynchus clarki clarki*). Ph.D. Dissertation, University of British Columbia, 185 pp.

Glova, G.J., and J.C. Mason. 1977. Interactions for Food and Space Between Sympatric Populations of Underyearling Coho Salmon and Coastal Cutthroat Trout in a Stream Simulator During Spring. Fisheries Research Board of Canada, Nanaimo, British Columbia. Manuscript Report Service 1428. 36 pp.

Glova, G.J., and J.C. Mason. 1976. Interactive Ecology of Juvenile Salmon and Tout in Streams. Fisheries Research Board of Canada, Pacific Biological Station, Nanaimo, British Columbia, Manuscript Report Service 1391. 24 pp.

Gonor, J.J., J.R. Sedell, and P.A. Benner. 1988. What We Know About Large Trees in Estuaries, in the Sea, and on Coastal Beaches. In: From the Forest to the Sea: A Story of Fallen Trees. C. Maser, R.F. Tarrant, J.M. Trappe and J.F. Franklin, editors. U.S. Forest Service, General Technical Report. PNW-GTR-229. Pp. 83-112.

Guiguet, T. 1980. An Annotated Bibliography on the Utilization of Estuarine Habitats by Cutthroat and Steelhead Trout and Dolly Varden Char. Habitat Protection Section, Fish and Wildlife Branch, British Columbia Ministry of the Environment.

Haertel, L., and C. Osterberg. 1976. Ecology of Zooplankton, Benthos, and Fishes in the Columbia River Estuary. *Ecology* 48:459-472.

Hall, J.D., P.A. Bisson, and R.E. Gresswell, editors. 1997. Sea-Run Cutthroat Trout: Biology, Management, and Future Conservation. American Fisheries Society. Corvallis, Oregon. 183 pp.

Hammann, M.G. 1981. Utilization of the Columbia River Estuary by American Shad, *Alosa Sapidissima* (Wilson). Master's Thesis, Oregon State University, Corvallis, Oregon.

Harmon, J., and G. Matthews. 1990. Evidence of Increase in Marine Mammal Damage to Adult Spring Chinook Salmon in the Columbia River. NMFS, Northwest and Alaska Fisheries Center Quarterly Report, April-May 1990.

Hartman, G.F., and C.A. Gill. 1968. Distribution of Juvenile Steelhead and Cutthroat Trout (*Salmo gairdneri and S. clarki clarki*) Within Streams in Southwestern British Columbia. *Journal of the Fisheries Resource Board of Canada* 25(1):33-48.

Harvey, J.T. 1987. Population dynamics, Annual Food Consumption, Movements, and Diving Behaviors of Harbor Seals in Oregon. Doctoral Dissertation. Oregon State University, Corvallis, Oregon.

Hawkins, S.W., and J.M. Tipping. 1999. Predation by Juvenile Hatchery Salmonids on Wild Fall Chinook Salmon Fry in the Lewis River, Washington. *California Fish and Game* 85:124-129.

Hess, S.S. 1982. Cutthroat Trout in Lower Columbia River Tributaries of Oregon. ODFW Fish Division Report 83-2.

Hooten, R. 1997. Status of Coastal Cutthroat Trout in Oregon. In: Sea-Run Cutthroat Trout: Biology, Management, and Future Conservation. J.D. Hall, P.A. Bisson, and R.E. Gresswell, editors. American Fisheries Society, Corvallis, Oregon. Pp. 57-67.

Howell, P., et al. 1985. Stock Assessment of Columbia River Anadromous Salmonids. Volume I (Chinook, Coho, Chum, and Sockeye Salmon Stock Summaries) and Volume II (Steelhead Stock Summaries, Stock Transfer Guidelines – Information Needs). Contract No. DE-A179-84BP12737 with U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife, Portland, Oregon.

Johnsen, R.C., and C.W. Sims. 1973. Purse Seining for Juvenile Salmon and Trout in the Columbia River Estuary. *Transactions of the American Fisheries Society* 102:341-345.

Johnson, O.W., M.H. Ruckelshaus, W.S. Grant, F.W. Waknitz, A.M. Garrett, G.J. Bryant, K. Neely, and J.J. Hard. 1999. Status Review of Coastal Cutthroat Trout from Washington, Oregon, and California. NOAA Technical Memorandum NMFS-NWFSC-37. National Marine Fisheries Service, Seattle, Washington.

Johnson, O.W., R.S. Waples, T.C. Wainwright, K.G. Neely, F.W. Waknitz, and L.T. Parker. 1994. Status Review for Oregon's Umpqua River Sea-Run Cutthroat Trout. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-15. 122 pp.

Johnston, J.M. 2001. Fisheries Biologist, Washington Department of Fish and Wildlife, Bellingham, Washington. Personal communication on February 28, 2001.

Johnston, J.M. 1982. Life Histories of Anadromous Cutthroat with Emphasis on Migratory Behavior. In: Proceedings of the Salmon and Trout Migratory Behavior Symposium. E.L. Brannon and E.O. Salo, editors. University of Washington, Seattle, Washington. Pp. 123-127.

Johnston, J.M., and S.P. Mercer. 1976. Sea-Run Cutthroat in Saltwater Pens – Broodstock Development and Extended Juvenile Rearing (with Life History Compendium). Washington Department of Game. Fisheries Resource Report, Project AFS-57-1. Olympia, Washington. 92 pp.

Jones, D.E. 1976. Steelhead and Sea-Run Cutthroat Trout Life History in Southeast Alaska. Annual Progress Report (AFS-42-4-B), Project AFS-42. Alaska Department of Fish and Game, 17:29-52.Kostow, K. 1995. Biennial Report on the Status of Wild Fish in Oregon. Internal Report Oregon Department of Fish and Wildlife.

Lavier, D. 1963. The Sea-Run Cutthroat. *Washington State Game Department Bulletin* 15(3):4.

LaVoy, L. 1980. Sea-Run Cutthroat. In: Sea-Run Cutthroat Trout Census Report. Washington State Game Department Report 80-14. Olympia, Washington. Pp. 140-151.

Lawson, P.W. 1993. Cycles in Ocean Productivity, Trends in Habitat Quality, and the Restoration of Salmon Runs in Oregon. *Fisheries* 18(8):6-10.

Ledgerwood, R. 2001. National Marine Fisheries Service, Astoria, Oregon. Personal communication on March 5, 2001.

Leider, S.A. 1997. Status of Sea-Run Cutthroat Trout in Washington. In: Sea-Run Cutthroat Trout: Biology, Management, and Future Conservation. J.D. Hall, P.A. Bisson, and R.E. Gresswell, editors. American Fisheries Society, Corvallis, Oregon. Pp. 68-76.

Levy, D.A., and C.D. Levings. 1994. A Description of the Fish Community of the Squamish River Estuary, British Columbia: Relative Abundance, Seasonal Changes and Feeding Habits of Salmonids. Canadian Fisheries Marine Services Manuscript Report 1475, 63 pp.

Lichatowich, J.A., and J.D. McIntyre. 1987. Use of Hatcheries in the Management of Pacific Anadromous Salmonids. In: American Fisheries Society Symposium. M.J. Dadswell, R.J. Klauda, C.M. Moffitt, R.L. Saunders, R.A. Rulifson, and J.E. Cooper, editors. Boston, Massachusetts. Pp. 131-136.

Lisle, T.E. 1987. Using "Residual Depths" to Monitor Pool Depths Independently of Discharge. U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station, Research Note PSW-394, Berkley, California.

Loch, J.J. 2001. Washington Department of Fish and Wildlife. Personal communication on July 24, 2001.

Loch, J.J. 1982. Juvenile and Adult Steelhead and Sea-Run Cutthroat Trout within the Columbia River Estuary 1980. Washington Department of Game, Fish Management Division Report 82-2.

Loch, J.J., and D.R. Miller. 1988. Distribution and Diet of Sea-Run Cutthroat Trout Captured in and Adjacent to the Columbia River Plume, May-July 1980. *Northwest Science* 62(1):41-48.

Lowery, G.R. 1975. The Alsea Watershed Study – Part 1: Biological Studies. Oregon Department of Fish and Wildlife, Fisheries Research Report No. 9. Portland, Oregon.

Lucas, R. 1980. Cutthroat Studies in Southwest Washington, 1979. In: Sea-Run Cutthroat Census Report. Washington State Department of Game Report No. 80-13. Pp. 1-23.

Manuwal, O. 1977. Feeding Ecology of the Common Murre, uria Algae, Off the Oregon Coast. Master's Thesis, University of Oregon, Eugene, Oregon.

Martin, D.J. 1984. Growth, Food Consumption, and Production of Cutthroat Trout in Relation to Food Supply and Water Temperature. In: Proceedings of the Olympic Wild Fish Conference, March 23-31, 1983. J.M. Walton and D.B. Houston, editors. Fisheries Technology Program, Peninsula College and Olympic National Park, Port Angeles, Washington. Pp. 135-144.

Maser, C., and J.R. Sedell. 1994. From the Forest to the Sea: The Ecology of Wood in Streams, Rivers, Estuaries, and Oceans. St. Lucie Press, Delray Beach, Florida, 200 pp.

McCabe, G.T.J., W.D. Muir, and others. 1983. Interrelationships Between Juvenile salmonids and Non-Salmonid Fish in the Columbia River Estuary. *Fishery Bulletin* 81:815-826.

McLain, D.R. 1984. Coastal Ocean Warming in the Northeast Pacific 1976-83. In: the Influence of Ocean Conditions on the Production of Salmonids in the North Pacific: A Workshop, November 8-10, 1983, Newport, Oregon. W.G. Pearcy, editor. Publ. ORESU-WO-83-001, Oregon Sea Grant Program, Oregon State University, Corvallis, Oregon. Pp. 61-86.

Melcher, C.E., and J.W. Watts. 1996. The 1995 Lower Columbia River and Buoy 10 Recreational Fisheries. Oregon Department of Fish and Wildlife, Fish Division, Columbia River Management, Portland, Oregon.

Melcher, C.E. and J.W. Watts. 1995. The 1994 Lower Columbia River and Buoy 10 Recreational Fisheries. Oregon Department of Fish and Wildlife, Fish Division, Columbia River Management, Portland, Oregon.

Mitchell, W.T. 1988. Microhabitat Utilization and Spatial Segregation of Juvenile Coastal Cutthroat and Steelhead Trout in the Smith River Drainage, California. Masters Thesis, Humboldt State University, Arcata, California.

Monoco, M.E., T.A. Lowery, and others. 1992. Assemblages of U.S. West Coast Estuaries Based on the Distribution of Fishes. *Journal of Biogeography* 19:251-267.

Moore, K.M.S., and S.V. Gregory. 1988. Summer Habitat Utilization and Ecology of Cutthroat (*Salmo clarki*) in Cascade Mountain Streams. *Canadian Journal of Fisheries and Aquatic Sciences* 45:1921-1930.

Moring, J.R., and R.L. Youker. 1979. Oregon Rainbow and Cutthroat Trout Evaluation. Department of Fish and Wildlife, Portland, Oregon.

National Marine Fisheries Service and U.S. Fish and Wildlife Service (NMFS and USFWS). 1999. Endangered and Threatened Species; Threatened Status for Southwest Washington/Columbia River Coastal Cutthroat Trout in Washington and Oregon, and Delisting of Umpqua River Cutthroat Trout in Oregon. Federal Register 64 (64) 16397-16414.

National Marine Fisheries Service (NMFS). 1992. Report to Congress on Washington State Marine Mammals. Department of Commerce, National Oceanic and Atmospheric Administration, Silver Springs, Maryland.

National Oceanic and Atmospheric Administration (NOAA). 1997. Impacts of California Sea Lions and Pacific Harbor Seals on Salmonids and the Coastal Ecosystems of Washington, Oregon, and California. NOAA Technical Memorandum NMFS-NW FSC-28.

Natural Resource Consultants (NRC). 1996. Artificial Propagation Anadromous Pacific Salmonids 1950 to Present. Cutthroat Trout. Report to U.S. Department of Commerce, NOAA and NMFS. January 1995.

Northcote, T.G. 1997. Why Sea-Run? An Exploration into the Migratory/Residency Spectrum of Coastal Cutthroat Trout. In: Sea-Run Cutthroat Trout: Biology, Management, and Future Conservation. J.D. Hall, P.A. Bisson, and R.E. Gresswell, editors. American Fisheries Society, Corvallis, Oregon. Pp. 20-26.

Northcote, T.G., and D.Y. Atagi. 1996. Pacific Salmon Abundance Trends in the Fraser River Watershed Compared with Other British Columbia Systems. In: Pacific Salmon Ecosystems: Status and Future Options. D.J. Strouder, P.A. Bisson, and R.N. Naiman, editors. Chapman and Hall, New York, New York.

Olesiuk, P., and M. Bigg. 1988. Seals and Sea Lions on the British Columbia Coast. Canada Department of Fisheries and Oceans, Pacific Biological Station, Nanaimo, British Columbia.

Oregon State Game Commission. 1949. Summary, Annual Report, Lower Umpqua River Study 1949.

Palmisano, J.F. 1997. Oregon's Umpqua Sea-Run Cutthroat: Review of Natural and Human Caused Factors of Decline. In: Sea-Run Cutthroat Trout: Biology, Management, and Future Conservation. J.D. Hall, P.A. Bisson, and R.E. Gresswell, editors. American Fisheries Society, Corvallis, Oregon. Pp. 103-118.

Pauley, G.B., and G.L. Thomas. 1993. Mortality of Anadromous Coastal Cutthroat Trout Caught with Artificial Lures and Natural Bait. *North American Journal of Fisheries Management* 13:337-345.

Pauley, G.B., K. Oshima, K.L. Gowers, and G.L. Thomas. 1989. Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Pacific Northwest): Sea-Run Cutthroat Trout. U.S. Fish and Wildlife Service Biological Report 82(11:86). 30 pp.

Pearcy, W.G. 1997. The Sea-Run and the Sea. In: Sea-Run Cutthroat Trout: Biology, Management, and Future Conservation. J.D. Hall, P.A. Bisson, and R.E. Gresswell, editors. American Fisheries Society, Corvallis, Oregon. Pp. 29-36.

Pearcy, W.G. 1992. Ocean Ecology of North Pacific Salmonids. University of Washington Press, Seattle, Washington. 179 pp.

Pearcy, W.G., and J.P. Fisher. 1990. Distribution and Abundance of Juvenile Salmonids Off Oregon and Washington, 1981-1985. NOAA Technical Report NMFS 93.

Pearcy, W.G., R.D. Brodeur, and J.P. Fisher. 1990. Distribution and Biology of Juvenile Cutthroat Trout *Oncorhynchus clarki clarki* and Steelhead *Oncorhynchus mykiss* in Coastal waters Off Washington and Oregon. *Fishery Bulletin* 88(4):697-711.

Pearcy, W.G., and J.P. Fisher. 1988. Migrations of Coho Salmon During Their First Summer in the Ocean. *Fishery Bulletin* 86:173-195.

Randolph, C. 986. Characteristics of Skamania and Beaver Creek Hatchery Anadromous Stocks. Washington Department of Game, Fishery Management Division, Olympia, Washington, 154 pp.

Refalt, W. 1985. Wetland in Extremis: A Nationwide Survey. Wilderness Winter 1985:28-41.

Rempel, L. 2001a. University of British Columbia. Personal communication on August 22, 2001.

Rempel, L. 2001b. Unpublished Data Regarding Coastal Cutthroat Trout. August 2001.

Rosenau, M. 2001. British Columbia Ministry of the Environment. Personal communication.

Schuck, M.L. 1980. The Incidence and Catch of Sea-Run Cutthroat Trout (*Salmo clarki*) in the Columbia and Washougal Rivers of Southwestern Washington. In: Sea-Run Cutthroat Trout Census Report. Washington State Game Department Report 80-14, Olympia, Washington. Pp. 127-136.

Scott, W.B., and E.J. Crossman. 1973. Freshwater Fishes of Canada. *Bulletin Fishery Resource Board Canada*, 966 pp.

Sheehan, J. 2001. Fisheries Biologist, Oregon Department of Fish and Wildlife. Personal communication.

Sherwood, C., D.A. Jay, R.B. Harvey, P. Hamilton, and C.A. Simensted. 1990. Historical Changes in the Columbia River Estuary. *Progress in Oceanography* 25:299-352.

Simenstad, C.A., and D.M. Eggers. 1981. Juvenile Salmonid and Baitfish Distribution, Abundance, and Prey Resources in Selected Areas of Grays Harbor, Washington. University of Washington Fisheries Research Institute. 205 pp.

Simenstad, C.A., L.F. Small, C.D. McIntire, D.A. Jay, and C.R. Sherwood. 1990. Columbia River Estuary Studies: An Introduction to the Estuary, a Brief History, and Prior Studies. *Progress in Oceanography* 25:1-14.

Simenstad, C.A., K.L. Fresh, and E.O. Salo. 1982. The Role of Puget Sound and Washington Coastal Estuaries in the Life History of Pacific Salmon: An Unappreciated Function. In: Estuarine Comparisons. V.S. Kennedy, editor. Academic Press, New York, New York. Pp. 343-364.

Sims, C.W., and R.H. Johnsen. 1974. Variable-Mesh Beach Seine for Sampling Juvenile Salmon in Columbia River Estuary. *Marine Fisheries Review* 36:23-26.

Solazzi, M. 2001. Fisheries Biologist, Oregon Department of Fish and Wildlife. Personal communication on July 27, 2001.

Sumner, F.H. 1953. Migration of Salmonids in Sand Creek, Oregon. *Transactions of the American Fisheries Society* 82:139-150.

Thorpe, J.E. 1994. Salmonid Fishes and the Estuarine Environment. *Estuaries* 7:76-93.

Tipping, J.M. 1986. Effect of Release Size on Return Rates of Hatchery Sea-Run Cutthroat Trout. *Progress in Fish Culture* 48:195-197.

Tipping, J.M. 1981. Cowlitz Sea-Run Cutthroat Study 1980-1981. Washington State Game Department, Fisheries Management Division Report 81-12, Olympia, Washington.

Tipping, J.M., and S.G. Springer. 1980. Cowlitz River Sea-Run Cutthroat Creel Census and Life History Study. In: Sea-Run Cutthroat Trout Census Report. Washington State Game Department Report 80-14, Olympia, Washington. Pp. 106-126.

Tomasson, T. 1978. Age and Growth of Cutthroat Trout, *Salmon clarki clarki Richardson*, in the rogue River, Oregon. Master's Thesis, Oregon State University, Corvallis, Oregon, 75 pp.

Trotter, P. 2001. Independent Fisheries Biologist, Longview, Washington. Personal communication on February 5, 2001.

Trotter, P.C. 1997. Sea-Run Cutthroat Trout: Life History Profile. In: Sea-Run Cutthroat Trout: Biology, Management, and Future Conservation. J.D. Hall, P.A. Bisson, and R.E. Gresswell, editors. American Fisheries Society, Corvallis, Oregon. Pp. 7-15.

Trotter, P.C. 1989. Coastal Cutthroat Trout: A Life History Compendium. *Transactions of the American Fisheries Society* 118:463-473.

Trotter, P.C. 1987. Cutthroat, Native Trout of the West. Colorado Associated University Press, Boulder, Colorado.

Waring, R.H., and J.F. Franklin. 1979. Evergreen Coniferous Forests of the Pacific Northwest. *Science* 204:1380-1386.

Wells, B.K., G.E. Bath, S.R. Thorrold, and C.M. Jones. 2000. Incorporation of Strontium, Cadmium, and Barium in Juvenile Spot (*Leiostomus xanthurus*) Scales Reflects Water Chemistry. *Canadian Journal of Fisheries and Aquatic Science* 57:2122-2129.

Williams, J.E., and W. Nehlsen. 1997. Status and Trends of Anadromous Salmonids in the Coastal Zone with Special Reference to Sea-Run Cutthroat Trout. In: Sea-Run Cutthroat Trout: Biology, Management, and Future Conservation. J.D. Hall, P.A. Bisson, and R.E. Gresswell, editors. American Fisheries Society, Corvallis, Oregon. Pp. 37-42.

Wright, S. 1973. Resident and Anadromous Fishes of the Chehalis and Satsop Rivers in the Vicinity of Washington Public Power Supply System's Proposed Nuclear Project No. 3. Washington Department of Fisheries Report, Olympia, Washington. 26 pp.

D-3 REVIEW OF COLUMBIA RIVER ESTUARY STUDIES INDICATING SIZE AND LOCATION OF COASTAL CUTTHROAT TROUT IN THE COLUMBIA RIVER ESTUARY 1967-1971 AND 1978-1980

3.1 Introduction

Since the 1960s, extensive sampling in the Columbia River estuary has produced a large amount of information about fish using the area. Much of this information has only been thoroughly analyzed for salmon species, and much of it has not been transferred from paper forms to computer files. This technical memo describes how a subset of data for coastal cutthroat trout (Oncorhynchus clarki clarki) was obtained from archival records and analyzed, and presents findings of this analysis. Objectives of the analysis were to:

- Examine occurrence of cutthroat trout in the estuary by month and location
- Examine catch patterns to determine whether cutthroat trout tended to school
- Examine size of cutthroat trout by month and location

3.2 Methods

In March 2001, a USFWS-led crew visited the NMFS Hammond Lab to transcribe data from paper forms to Excel spreadsheets. Only information about cutthroat trout was taken, and only a subset of what is available was obtained. Very little data from Jones Beach was transcribed, as this location has been reported on extensively by Loch (1982); Dawley, et al., (1985); and others. Data obtained included sampling dates, locations, and methods, and number and fork lengths of fish captured. A streamlined data entry format was used to summarize catch and effort by location-time cell (e.g., Puget Island on May 1): if no fish were captured in a cell, one record was entered showing a zero-catch and the total effort for the cell (number of net sets); if at least one fish was captured, one or more records were entered, each showing the catch of one or more net sets and the total effort for the cell. If fish were measured, there was one record per fish. If fish were not measured, a single record often represented the composite catch of more than one net set.

Data were obtained from trawling in 1966 and from beach and purse seine sampling in several years from 1967 to 1980 (Table D3-1). Trawl data were not analyzed due to difficulties identifying sampling location and because of analysis time constraints. Stations extended from the river mouth to Jones Beach at River Mile (RM) 45, including marine, estuarine mixing, and freshwater portions of the estuary (Figures D3-1a; salinity zones according to Bottom, et al.,1984). Data from nearshore and offshore areas of the ocean plume were not included in this analysis due to time constraints. Only lengths from catch cards were analyzed because of uncertainty about length data in "binders." Stations shown in Figures D3-1b and D3-1c closely approximate actual sampling sites. Beach seine locations changed slightly as bars and beaches moved over time (Ledgerwood, pers. comm., 2001). Purse seining sampled offshore areas in the main channel close to the stations indicated in Figure D3-1c. Raw data are included as Attachment D3-1.

In general, fish sampling methods were fairly standardized over the years. A 95- by 5-meter beach seine was used in most cases (Dawley, et al., 1985; Miller, pers. comm., 2001) and a smaller beach seine was occasionally used for exploration (Miller, pers. comm., 2001). For the data presented here, a 229- by 10.7-meter purse seine was used during the 1967-1978 period (Johnsen and Sims, 1973; Miller, pers. comm., 2001), and a larger 305- by 10.7-meter purse seine was used from 1979-1980 (Miller, pers. comm., 2001). Fish sampling methods are described in detail in Johnsen and Sims (1973), Sims and Johnsen (1974), Loch (1982), Dawley, et al. (1985), and others. Varying tides, river flow, and weather conditions were likely the most significant factors affecting gear efficiency (Ledgerwood, pers. comm., 2001). Dawley, et al. (1985), adjusted their salmon passage rates for varying environmental conditions, however, information for making such an adjustment was not available for our analysis. The level of sampling consistency inherent to our data reasonably justifies monthly comparisons between stations or areas for individual gears (Ledgerwood and Miller, pers. comm., 2001). Purse seine data from 1967-1971 and 1979-1980 periods should be compared with caution because of differing net size between the two periods.

Initial data entry and editing were done in MS Excel. Subsequent analysis was performed with Systat 10 and Surfer software.

3.3 Results and Discussion

Data were analyzed from a total of 1,250 beach seine sets from all years of sampling (Table D3-2a). Most data were from March through September, but locations and months sampled were inconsistent over the years; coverage of the whole estuary was best before 1978. Average monthly beach seine catch per unit effort (CPUE) is defined as catch per set and varied from zero to 16.67 over all years (Table D3-2b). Zero catches were quite common (64 percent of all month-area cells), even when an appreciable number of sets were made. CPUE did not exceed 0.5 near the river mouth (areas A-C). Most cutthroats were caught in this area in August and September, except in 1978 when all captures were in May and June (Table D3-2a). Catch rates were higher in the middle estuary (areas D-F), ranging from 0.3 to 2.0, for catches made June through September. In the upper estuary (areas G-J), CPUE was generally in the same range as the middle estuary. Cutthroats were captured in the upper estuary from February through August. In 1967 and 1968, the only years when this area was sampled over a range of months, appreciable catches were made from March through August. The highest catch rate on record (16.7) occurred in July of 1970 in area G.

Data were analyzed from 1,109 purse seine sets from all years sampled (Table D3-3a). Most data were from April through September. Locations and months sampled were inconsistent over the years, and seldom did beach and purse seine samples coincide in time and location. Purse seine coverage of the whole estuary was best in years before 1978. Monthly beach seine CPUE per set varied from zero to 8.33 over all years (Table D3-3b), and zero-catches were common (34 percent of all month-area cells), even when an appreciable number of sets were made. Near the river mouth (areas A-C), cutthroats were captured from April through September over the years. CPUE in this area ranged up to 2.63, and peak rates were seen in May, July, and August (Table D3-3b). Catch rates in the middle estuary (areas D-F) were similar to or higher than those in the lower estuary on comparable dates. Cutthroats were caught in the middle estuary from April through August. Cutthroats were captured in the upper estuary (areas G-J) from April through July at a rate similar to other areas on comparable dates, but no data are available outside that period. Peak catch rates typically occurred in the upper estuary in May, and the highest CPUE on record (8.33) was in May 1968 in area J.

Considering all available data, catch per individual set was available from 61 purse seine sets with non-zero catches. Over half of these sets captured only one cutthroat trout, while the remaining fraction captured 2 to 14 trout (Figure D3-2). These results indicate some schooling, but most multiple catches were only 2 to 3 fish. No beach seine results were available from individual sets.

Fork lengths were available from 154 and 427 cutthroat trout captured by beach and purse seine, respectively (Table D3-4a). A few area-month cells (e.g., beach seine in area H April 1968) accounted for a large proportion of the catch, and catches were small for most other cells. For both gears, fork length ranged from about 120 to 530 millimeters (mm), with distinct modes at about 200 mm, 300 mm, and 500 mm; modes between 300 and 500 mm were more ambiguous (Figure D3-3, Table D3-4b). The overall mean fork length was 283 mm for beach seined fish and 285 mm for purse seined fish, with a range of about 120 to 530 mm for both gears. Length data were pooled by early and late season (March-June, July-September) and by portion of the estuary (lower = areas A-C, middle = areas D-E, upper = areas F-J) to calculate mean and standard deviation of fork length for individual gears. In these comparisons, fork length differed little between gears, except during the March-June period in the middle estuary, when the beach seine caught much smaller fish than the purse seine (Figure D3-4). This difference might suggest that outmigrating smolts in the middle estuary favored nearshore habitats, whereas kelts (adults migrating to the ocean after spawning) or other larger cutthroats favored channel habitats. Alternatively, it may be an artifact of the very small beach seine sample size for this period and portion of the estuary (Table D3-4a). The spread of sizes overlapped considerably across zones and seasons, and trends in length relative to these factors are not clear.

Analysis of the Hammond data presented here suggests several spatial and temporal trends in abundance and size of coastal cutthroat trout in the Columbia River estuary. Cutthroats were taken in the shallows (beach seining) of the upper estuary (freshwater zone, Figure D3-1) and in the channel (purse seining) throughout the estuary for at least April through September, whereas they were seldom taken in the shallows of the lower two-thirds of the estuary (estuarine mixing and marine zones) until May or later. Somewhat higher catch rates in the middle and upper estuary suggest that cutthroats were more abundant there than in the lower estuary where catch rates tended to be lower. Frequent catches of more than one cutthroat per set, when any were caught at all, indicated that occasional schooling occurred. Trends in size of cutthroat by time of year and portion of the estuary were not clear.

These results are more suggestive than definitive. They were influenced by small sample sizes and by the lack of any data at all for many times of year and locations of interest. Also, they were not supported by statistical tests, which were beyond the scope of this memorandum. Statistical testing would certainly require pooling of data (e.g., as for length computations above) to reduce the number of empty cells. The USFWS crew was not able to compensate for weather, flow, and tidal conditions during sampling, which undoubtedly affected catch rates, especially for beach seining. Another potentia l source of error was uncertainty about differentiation of cutthroat trout and steelhead in early years. For this analysis it was assumed that all fish were identified correctly.

3.4 Acknowledgements

Jen Burke (Oregon Department of Fish and Wildlife), Dick Ledgerwood (NMFS), and Dave Miller (NMFS) provided important advice and guidance during data transcription and analysis. Darci Weber and Paula Morgan of Parametrix assisted with data gathering and entry.

3.5 References

Bottom, D.L., K.K. Jones, and M.J. Herring. 1984. Fishes of the Columbia River Estuary. Final Report on the Fish Work Unit of the Columbia River Data Development Program to the Oregon Department of Fish and Wildlife (ODFW). Portland, Oregon.

Dawley, E.M., R.D. Ledgerwood, and T.H. Blahm. 1985. Migrational Characteristics, Biological Observations, and Relative Survival of Juvenile Salmonids Entering the Columbia River Estuary, 1977-1983. Unpublished manuscript. Northwest and Alaska Fisheries Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Seattle, Washington.

Johnsen, R.H., and C.W. Sims. 1973. Purse Seining for Juvenile Salmon and Trout in the Columbia River Estuary. *Transactions of the American Fisheries Society* 102:341-345.

Ledgerwood, R.D. 2001. National Marine Fisheries Service. Personal communication on July 23, 2001.

Loch, J.J. 1982. Juvenile and Adult Steelhead and Sea-Run Cutthroat Trout within the Columbia River Estuary, 1980. Washington Department of Game, Fish Management Division Report 82-2.

Miller, D. 2001. National Marine Fisheries Service. Personal communication on July 24, 2001.

Sims, C.W., and R.H. Johnsen. 1974. Variable-Mesh Beach Seine for Sampling Juvenile Salmon in Columbia River Estuary. *Marine Fisheries Review* 36:23-26.

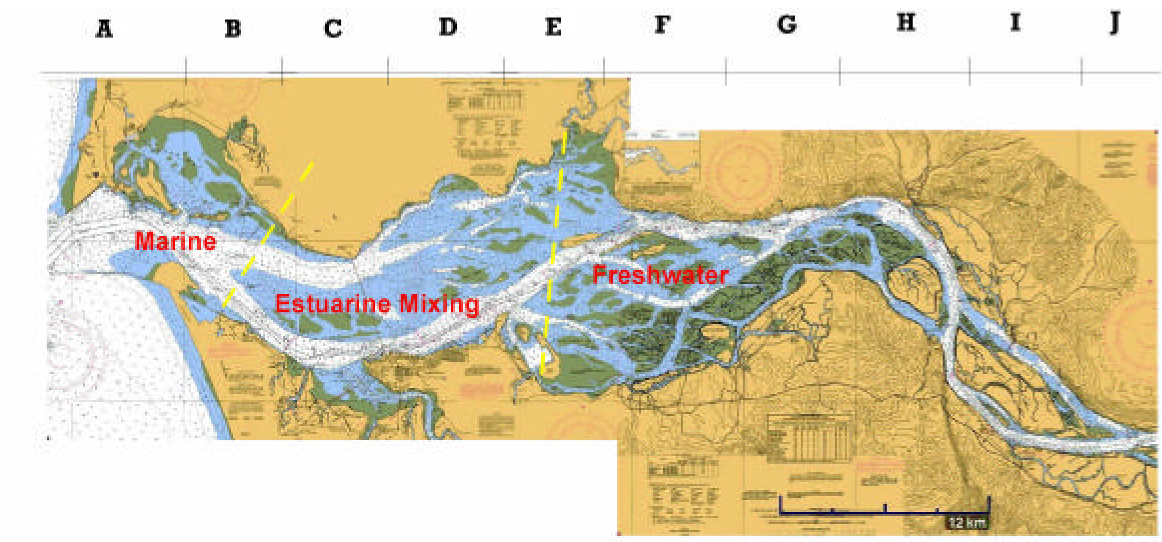
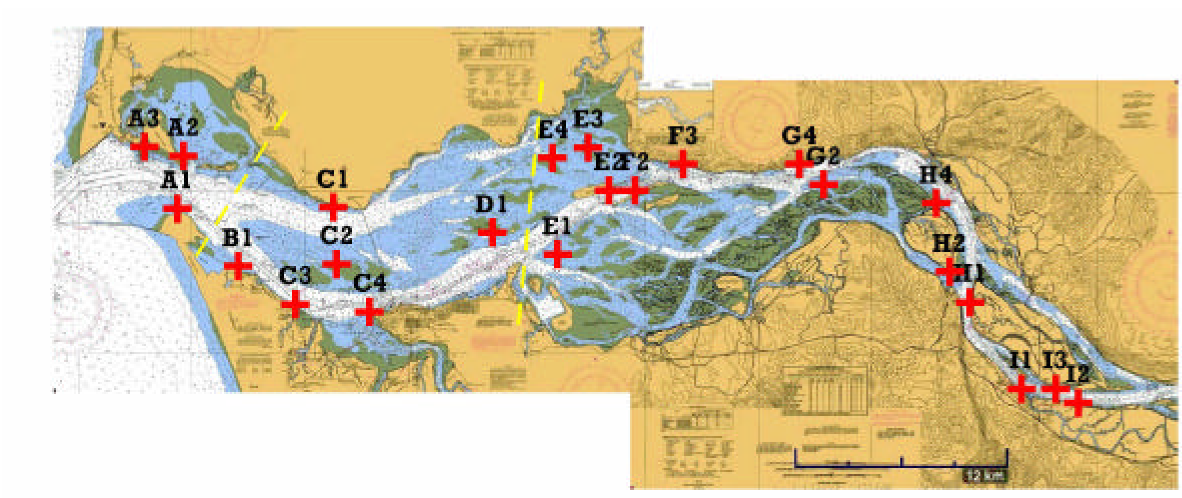


Figure D3-1a: The Columbia River Estuary, Showing Approximate Boundaries of Salinity Zones (from Bottom, et al., 1984) and East-West Analysis Areas A-J



D3-1b: Stations Sampled With Beach Seine, All Years

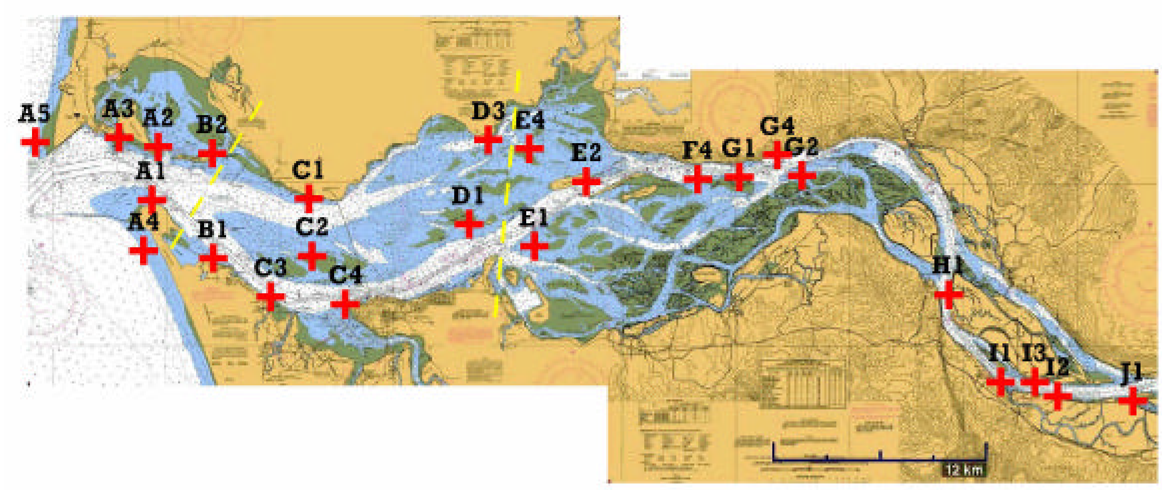


Figure D3-1c: Stations Sampled With Purse Seine, All Years

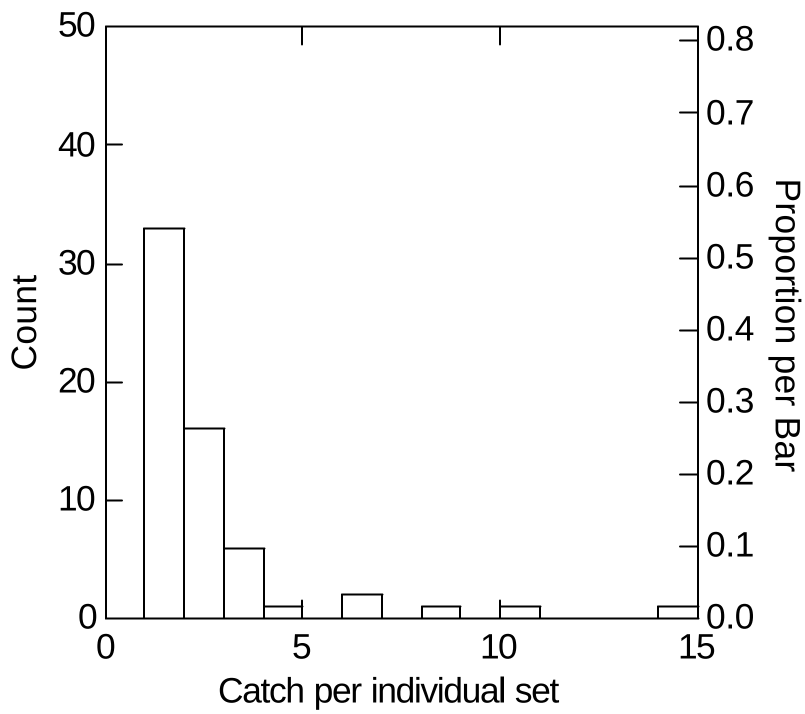


Figure D3-2: Frequency Distribution of Catch Per Purse Seine Set, For All Data Recorded By Individual Set

Note: Data were not available for beach seining

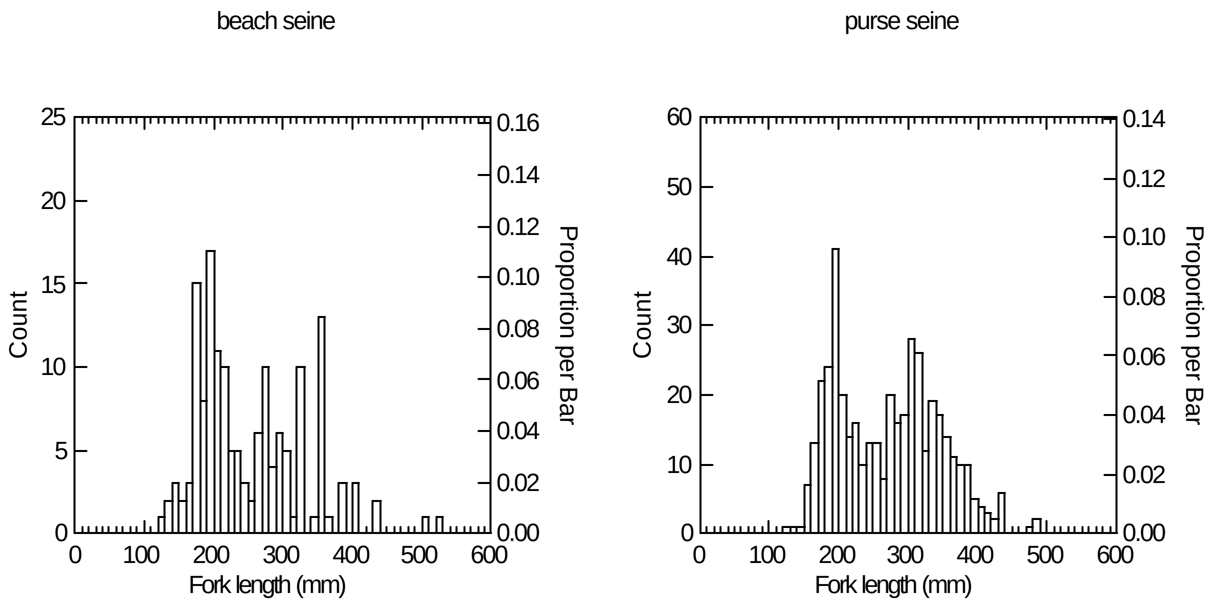


Figure D3-3 Length Frequency Distribution of All Cutthroat Sampled in the Columbia Estuary by Beach and Purse Seine, All Dates and Locations Combined

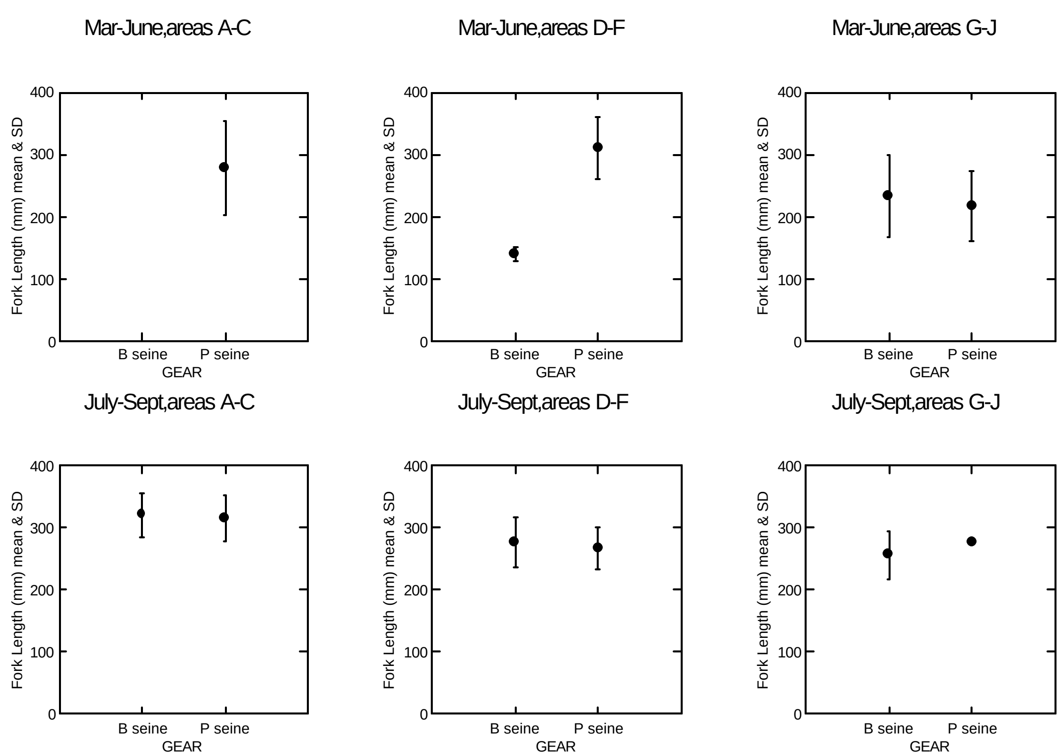


Figure D3-4. Fork Length (mm) of Cutthroat Trout in Beach and Purse Seine Catches in the Columbia River Estuary, Subdivided by Portion of the Estuary and Time of Year

Note: All years of data were pooled for these plots.

Table D3-1 Data About Cutthroat Trout in the Columbia River Estuary, by Year

	Data obtained		
Year	Beach seine	Purse seine	Trawl
1966			x
1967	x	x	
1968	x	x	
1969	x	x	
1970	x		
1971		x	
1972			
1973			
1974			
1975			
1976			
1977			
1978	x	x	
1979		x	
1980		x	

Obtained from Hammond Laboratory Records

Table D3-2a&b Beach Seine Sampling Effort (a) as Sets Per Area Per Month and CPUE (b) as Catch Per Set

Gear	Year	Month	Area A	B	C	D	E	F	G	H	I	J	Total
beach seine	67	Feb		4	2				7	34			47
"	"	Mar								64	13		77
"	"	Apr		1	4	4	3		5	63	12		92
"	"	Aug	42	4	39	11	32	2	4	66	13		213
"	"	Sept	3				3			24			30
"	"	Oct								15			15
"	"	Nov								2			2
"	"	Dec								3			3
"	68	Jan								2			2
"	"	Feb								6			6
"	"	Mar	6				9		5	18	7		45
"	"	Apr			3	4	10	2	4	103			126
"	"	May								11			11
"	"	Aug	14	7	7	2	12	2		8			52
"	"	Sept				2	2						4
"	69	Aug	13		8					10	16		47
"	"	Sept	9	4	7								20
"	"	Oct				9	16						25
"	70	May	13		2								15
"	"	June	119	6				10					135
"	"	July	28	43	3				6	9	4	7	100
"	"	Aug	2										2
"	"	Sept		2									2
"	78	Apr	48										48
"	"	May	61										61
"	"	June	54										54
"	"	July	9										9
"	"	Sept	7										7
		Total	428	71	75	32	87	16	31	438	65	7	1250

Gear	Year	Month	Area A	B	C	D	E	F	G	H	I	J	Mean
beach seine	67	Feb		0.00	0.00				0.00	0.03			0.01
"	"	Mar								0.00	0.00		0.00
"	"	Apr		0.00	0.00	0.00	0.00		0.00	0.22	0.33		0.08
"	"	Aug	0.02	0.00	0.00	0.00	0.31	0.00	0.25	0.35	0.00		0.10
"	"	Sept	0.00				0.00			0.00			0.00
"	"	Oct								0.00			0.00
"	"	Nov								0.00			0.00
"	"	Dec								0.00			0.00
"	68	Jan								0.00			0.00
"	"	Feb								0.00			0.00
"	"	Mar	0.00				0.00		1.00	0.00	0.57		0.31
"	"	Apr			0.00	0.00	0.00	0.00	0.00	0.68			0.11
"	"	May								1.82			1.82
"	"	Aug	0.07	0.00	0.14	0.00	0.67	0.50		0.00			0.20
"	"	Sept				2.00	1.50						1.75
"	69	Aug	0.31		0.50					0.80	0.44		0.51
"	"	Sept	0.00	0.00	0.14								0.05
"	"	Oct				0.00	0.00						0.00
"	70	May	0.00		0.00								0.00
"	"	June	0.00	0.00				0.60					0.20
"	"	July	0.00	0.00	0.00				16.67	0.00	2.00	0.00	2.67
"	"	Aug	0.00										0.00
"	"	Sept		0.00									0.00
"	78	Apr	0.00										0.00
"	"	May	0.18										0.18
"	"	June	0.04										0.04
"	"	July	0.00										0.00
"	"	Sept	0.00										0.00

Table D3-3a&b Purse Seine Sampling Effort (a) as Sets Per Area Per Month and CPUE (b) as Catch Per Set

Gear	Year	Month	A	B	C	D	E	F	G	H	I	J	Total
			Area										
purse seine	67	May							49				49
"	"	June							22				22
"	"	July	27	2	23	5	17		3	37	66		180
"	"	Aug				3							3
"	68	Apr							9	15			24
"	"	May							4	5		3	12
"	"	June							10				10
"	"	Aug			2	18	22						42
"	69	Feb				2							2
"	"	Mar				12							12
"	"	Apr				14			27	2	1		44
"	"	June			22	9			15				46
"	"	July	19		16	5			16				56
"	"	Aug	11										11
"	71	Mar				2	3						5
"	"	Apr			9	20	30		4				63
"	"	May		27	20				8				55
"	"	June		7	70								77
"	78	Apr			25								25
"	"	May			60								60
"	"	June			62								62
"	"	July			24			3					27
"	"	Aug			18								18
"	"	Sept			17								17
"	79	May			7								7
"	"	June			26								26
"	"	July			35								35
"	"	Aug			36	7							43
"	"	Sept			37								37
"	80	July			39								39
		Total	57	36	548	97	72	3	167	59	67	3	1109

Gear	Year	Month	A	B	C	D	E	F	G	H	I	J	Mean
			Area										
purse seine	67	May							2.78				2.78
"	"	June							0.05				0.05
"	"	July	0.00	0.00	0.00	0.00	0.06		0.00	0.00	0.02		0.01
"	"	Aug				0.00							0.00
"	68	Apr							0.22	0.27			0.24
"	"	May							0.75	1.60		8.33	3.56
"	"	June							0.20				0.20
"	"	Aug			0.00	0.44	0.18						0.21
"	69	Feb				0.00							0.00
"	"	Mar				0.00							0.00
"	"	Apr				0.07			0.26	0.00	0.00		0.08
"	"	June			0.09	0.33			0.33				0.25
"	"	July	1.47		0.00	0.00			0.00				0.37
"	"	Aug	0.36										0.36
"	71	Mar				0.00	0.33						0.17
"	"	Apr			0.67	0.70	0.83		0.00				0.55
"	"	May		1.59	1.35				1.50				1.48
"	"	June		0.57	0.59								0.58
"	78	Apr			0.04								0.04
"	"	May			0.37								0.37
"	"	June			0.24								0.24
"	"	July			0.00			0.00					0.00
"	"	Aug			1.00								1.00
"	"	Sept			0.47								0.47
"	79	May			0.00								0.00
"	"	June			0.15								0.15
"	"	July			2.63								2.63
"	"	Aug			2.42	2.14							2.28
"	"	Sept			0.95								0.95
"	80	July			0.44								0.44

Table D3-4a&b Sample Size (a) and Mean Fork Length (b) of Cutthroat Trout from Beach and Purse Seine Sets

Gear	Year	Month	Sample size by sampling area										
			A	B	C	D	E	F	G	H	I	J	Total
beach seine	67	Apr								11	4		15
"	"	Aug	1				10		1	7			19
"	68	Mar							5		4		9
"	"	Apr								61			61
"	"	May								20			20
"	"	Aug	1		2		8	1					12
"	"	Sept				4							4
"	69	Aug	3		4								7
"	"	Sept			1								1
"	70	June						6					6
"	Beach seine total		5		7	4	18	7	6	99	8		154
purse seine	67	May							136				136
"	"	June							1				1
"	"	July					1				1		2
"	68	Apr							2	4			6
"	"	May							3	8		25	36
"	"	June							2				2
"	"	July											2
"	"	Aug				5	4						11
"	69	Apr				1			7				8
"	"	June			2	3			5				10
"	"	July	23										23
"	"	Aug	2										2
"	71	Mar					1						1
"	"	Apr			6	14	25						47
"	"	May		4	1				12				19
"	78	June			2								2
"	"	Aug			9								9
"	"	Sept			8								8
"	79	June			2								2
"	"	July			6								6
"	"	Aug			67								67
"	"	Sept			12								12
"	80	July			14								14
"	Purse seine total		25	4	129	23	31		168	12	1	25	427

Gear	Year	Month	Mean fork length (mm) by sampling area										
			A	B	C	D	E	F	G	H	I	J	Total
beach seine	67	Apr								303	343		323
"	"	Aug	263				281		197	264			251
"	68	Mar							340		374		357
"	"	Apr								228			228
"	"	May								192			192
"	"	Aug	330		305		271	213					280
"	"	Sept				330							330
"	69	Aug	321		333								327
"	"	Sept			350								350
"	70	June						141					141
"	Beach seine total		305		329	330	276	177	269	247	358		283
purse seine	67	May							210				210
"	"	June							218				218
"	"	July					255				275		265
"	68	Apr							254	254			254
"	"	May							310	251		186	249
"	"	June							221				221
"	"	July											249
"	"	Aug				283	249						262
"	69	Apr				330			341				335
"	"	June			200	261			175				212
"	"	July	298										298
"	"	Aug	278										278
"	71	Mar					352						352
"	"	Apr			276	319	329						282
"	"	May		301	298				305				316
"	78	June			268								268
"	"	Aug			305								305
"	"	Sept			315								315
"	79	June			393								393
"	"	July			326								326
"	"	Aug			327								327
"	"	Sept			308								308
"	80	July			352								352
"	Purse seine total		288	301	306	298	296		254	252	275	186	285

Attachment D3-1: Raw Data

Data codes:
Gear types: 1=beach, 2=purse, 3=trawl; 4=unknown.
Missing values: -999 = missing (e.g. fish caught but no lengths recorded), blank = no data (e.g. no lengths from sets with no catch)

Area	StationLocatName	Lon	Lat	Month	Day	Year	Gear	TotSets	SetNum	Count	FkLenmm	LenSource
H	H1PUGET ISL	-123.42710	46.19366	2	7	67	1	8		0		cards
H	H1PUGET ISL	-123.42710	46.19366	2	7	67	1	-999		-999		cards
H	H1500 YDS UP FROM JETTY /PUGET ISL	-123.42710	46.19366	2	10	67	1	6		0		cards
H	H1PUGET ISL	-123.42710	46.19366	2	10	67	1	6		0		cards
H	H2noname	-123.44210	46.20923	2	10	67	1	2		0		cards
H	H2noname	-123.44210	46.20923	2	10	67	1	-999		-999		cards
H	H1PUGET ISL	-123.42710	46.19366	2	14	67	1	6	1	1		cards
H	H1PUGET ISL	-123.42710	46.19366	2	14	67	1	-999		-999		cards
B	B11000 YDS BELOW PNT ADAMS	-123.96482	46.21204	2	20	67	1	4		0		cards
B	B11000 YDS BELOW PNT ADAMS	-123.96482	46.21204	2	20	67	1	-999		-999		cards
C	C1200 YDS DOWN FROM OLD CHRUCH	-123.89520	46.24229	2	20	67	1	2		0		cards
C	C1200 YDS DOWN FROM OLD CHRUCH	-123.89520	46.24229	2	20	67	1	-999		-999		cards
G	G4JIM CROW PNT	-123.55249	46.26457	2	21	67	1	7		0		cards
G	G4JIM CROW PNT	-123.55249	46.26457	2	21	67	1	-999		-999		cards
H	H1PUGET ISL	-123.42710	46.19366	2	24	67	1	4		0		cards
H	H1PUGET ISL	-123.42710	46.19366	2	24	67	1	-999		-999		cards
H	H2BRADWOOD	-123.44210	46.20923	2	24	67	1	2		0		cards

H	H4BRADWOOD	-123.45208	46.24439	2	24	67	1	2		0		cards
I	I2JUST SO. OF WESTPORT SLOUGH ORE. SHORE	-123.34754	46.14202	3	1	67	1	8		0		cards
H	H1PUGET ISL	-123.42710	46.19366	3	2	67	1	4		0		cards
H	H1PUGET ISL	-123.42710	46.19366	3	6	67	1	6		0		cards
I	I2BETWEEN FIRST AND SECOND JETTY ABOVE WESTPORT SLOUGH	-123.34754	46.14202	3	8	67	1	5		0		cards
H	H1LOWER END OF PUGET ISL	-123.42710	46.19366	3	13	67	1	12		0		cards
H	H1PUGET ISL	-123.42710	46.19366	3	15	67	1	7		0		cards
H	H1PUGET ISL	-123.42710	46.19366	3	17	67	1	3		0		cards
H	H1PUGET ISL	-123.42710	46.19366	3	20	67	1	11		0		cards
H	H1LOWER END OF PUGET ISL	-123.42710	46.19366	3	21	67	1	4		0		cards
H	H1LOWER END OF PUGET ISL	-123.42710	46.19366	3	24	67	1	7		0		cards
H	H1PUGET ISL	-123.42710	46.19366	3	28	67	1	6		0		cards
H	H1PUGET ISL	-123.42710	46.19366	3	31	67	1	4		0		cards
G	G4JIM CROW PNT	-123.55249	46.26457	4	3	67	1	5		0		cards
H	H1PUGET ISL	-123.42710	46.19366	4	4	67	1	7		0		cards
B	B1PNT ADAMS	-123.96482	46.21204	4	5	67	1	1		0		cards
C	C1300 YDS DOWN FROM OLD CHRUCH AT MCGOWAN	-123.89520	46.24229	4	5	67	1	4		0		cards
D	D1SOUTH BEACH TAYLOR SANDS?	-123.77808	46.22935	4	6	67	1	4		0		cards
E	E1DOWN STREAM END	-123.73014	46.21813	4	6	67	1	3		0		cards
H	H1PUGET ISL	-123.42710	46.19366	4	7	67	1	3		0		cards
H	H1PUGET ISL	-123.42710	46.19366	4	11	67	1	-999	1	-999	-999	cards
H	H1PUGET ISL	-123.42710	46.19366	4	12	67	1	4	1	1	285	cards
H	H1PUGET ISL	-123.42710	46.19366	4	12	67	1	4	3	1	315	cards

H	H1PUGET ISL	-123.42710	46.19366	4	13	67	1	10		0		cards
H	H1PUGET ISL	-123.42710	46.19366	4	17	67	1	10		0		cards
I	I3UPPER END PUGET ISL SHIP CHANL	-123.36420	46.14923	4	19	67	1	10		0		cards
H	H1PUGET ISL	-123.42710	46.19366	4	20	67	1	9	4	1	406	cards
H	H1PUGET ISL	-123.42710	46.19366	4	20	67	1	9	7	1	355	cards
H	H1PUGET ISL	-123.42710	46.19366	4	20	67	1	9	9	1	355	cards
H	H1PUGET ISL	-123.42710	46.19366	4	20	67	1	9	9	1	355	cards
H	H1PUGET ISL	-123.42710	46.19366	4	21	67	1	3	2	1	355	cards
H	H1PUGET ISL	-123.42710	46.19366	4	21	67	1	3	2	1	305	cards
I	I1WESTPORT ISL	-123.38920	46.14924	4	24	67	1	2	1	1	305	cards
I	I1WESTPORT ISL	-123.38920	46.14924	4	24	67	1	2	1	1	305	cards
I	I1WESTPORT ISL	-123.38920	46.14924	4	24	67	1	2	1	1	355	cards
I	I1WESTPORT ISL	-123.38920	46.14924	4	24	67	1	2	1	1	406	cards
H	H1PUGET ISL	-123.42710	46.19366	4	26	67	1	8	1	1	178	cards
H	H1PUGET ISL	-123.42710	46.19366	4	26	67	1	8	1	1	209	cards
H	H1PUGET ISL	-123.42710	46.19366	4	26	67	1	8	6	1		cards
H	H1PUGET ISL	-123.42710	46.19366	4	26	67	1	8	7	1		cards
H	H1PUGET ISL	-123.42710	46.19366	4	26	67	1	8	8	1		cards
H	H1PUGET ISL	-123.42710	46.19366	4	27	67	1	3	3	1	210	cards
H	H1PUGET ISL	-123.42710	46.19366	4	28	67	1	6		0		cards
H	H1PUGET ISL	-123.42710	46.19366	8	3	67	1	6	5	1	260	cards
H	H2BRADWOOD	-123.44210	46.20923	8	3	67	1	3		0		cards
D	D1TAYLOR SANDS	-123.77808	46.22935	8	4	67	1	2		0		cards

E	E1BRUM BEACH	-123.73014	46.21813	8	4	67	1	7	0	cards
E	E2RICE ISL	-123.69220	46.25096	8	7	67	1	7	0	cards
A	A1SLOUGH	-124.00983	46.24173	8	8	67	1	2	0	cards
A	A1noname	-124.00983	46.24173	8	8	67	1	4	0	cards
A	A2noname	-124.00524	46.26876	8	8	67	1	2	0	cards
C	C1MCGOWAN	-123.89520	46.24229	8	8	67	1	3	0	cards
H	H1PUGET ISL	-123.42710	46.19366	8	8	67	1	3	0	cards
I	I2noname	-123.34754	46.14202	8	8	67	1	5	0	cards
H	H1PUGET ISL	-123.42710	46.19366	8	9	67	1	8	0	cards
A	A1above clatsop spit	-124.00983	46.24173	8	10	67	1	8	0	cards
A	A1SO JETTY BY ROAD	-124.00983	46.24173	8	10	67	1	1	0	cards
D	D1TAYLOR SANDS	-123.77808	46.22935	8	10	67	1	1	0	cards
D	D9TANNY PNT	-999.00000	-999.00000	8	10	67	1	2	0	cards
E	E5GOVT ISL	-999.00000	-999.00000	8	10	67	1	2	0	cards
D	D1TAYLOR SANDS	-123.77808	46.22935	8	11	67	1	2	0	cards
E	E2RICE ISL	-123.69220	46.25096	8	11	67	1	2	0	cards
E	E3NE END RICE ISL	-123.70762	46.27312	8	11	67	1	2	0	cards
E	E4GEORGE ROLLINGS MUD FLAT GRAYS BAY	-123.73388	46.26765	8	11	67	1	2	0	cards
H	H1PUGET ISL	-123.42710	46.19366	8	11	67	1	5	0	cards
A	A2SAND ISL	-124.00524	46.26876	8	14	67	1	2	0	cards
A	A3ILLWACO	-124.03401	46.27350	8	14	67	1	4	0	cards
C	C1MCGOWAN	-123.89520	46.24229	8	14	67	1	2	0	cards
A	A1CLATSOP SPIT	-124.00983	46.24173	8	15	67	1	2	0	cards

B	B1ADAMS PNT	-123.96482	46.21204	8	15	67	1	4		0		cards
C	C1MCGOWAN	-123.89520	46.24229	8	15	67	1	4		0		cards
C	C2MID RIVER OFF BRIDGE	-123.89271	46.21321	8	15	67	1	2		0		cards
D	D1TAYLOR SANDS	-123.77808	46.22935	8	16	67	1	2		0		cards
E	E1BURNS BEACH	-123.73014	46.21813	8	16	67	1	2		0		cards
E	E2RICE ISL	-123.69220	46.25096	8	16	67	1	3	3	1	275	cards
E	E2RICE ISL	-123.69220	46.25096	8	16	67	1	3	3	1	276	cards
E	E2RICE ISL	-123.69220	46.25096	8	16	67	1	3	3	1	431	cards
E	E2RICE ISL	-123.69220	46.25096	8	16	67	1	3	3	1	278	cards
E	E2RICE ISL	-123.69220	46.25096	8	16	67	1	3	3	1	278	cards
E	E2RICE ISL	-123.69220	46.25096	8	16	67	1	3	3	1	281	cards
E	E2RICE ISL	-123.69220	46.25096	8	16	67	1	3	3	1	281	cards
E	E2RICE ISL	-123.69220	46.25096	8	16	67	1	3	3	1	237	cards
E	E2RICE ISL	-123.69220	46.25096	8	16	67	1	3	3	1	218	cards
E	E2RICE ISL	-123.69220	46.25096	8	16	67	1	3	3	1	253	cards
E	E5LITTLE RICE ISL OFF ALTOUNA	-999.00000	-999.00000	8	16	67	1	2		0		cards
H	H1PUGET ISL	-123.42710	46.19366	8	16	67	1	8		0		cards
A	A3ILLWACO ENTRANCE	-124.03401	46.27350	8	17	67	1	8		0		cards
C	C2MID RIVER OFF BRIDGE	-123.89271	46.21321	8	17	67	1	2		0		cards
C	C3WARENTON ENTRANCE	-123.92314	46.19246	8	18	67	1	5		0		cards
C	C4MOUTH OF YOUNG RIVER	-123.86854	46.18872	8	18	67	1	3		0		cards
C	C5DESDEONIA SANDS	-999.00000	-999.00000	8	18	67	1	4		0		cards
A	A1CLATSOP SPIT	-124.00983	46.24173	8	21	67	1	3		0		cards

A	A2ILLWACO CHNL	-124.00524	46.26876	8	21	67	1	2	1	1	263	cards
C	C3WARENTON MOUTH OF SKIPANON RV	-123.92314	46.19246	8	21	67	1	5		0		cards
H	H1PUGET ISL	-123.42710	46.19366	8	21	67	1	11	6	4	-999	cards
H	H1PUGET ISL	-123.42710	46.19366	8	21	67	1	11	6	4	-999	cards
H	H1PUGET ISL	-123.42710	46.19366	8	21	67	1	11	6	4	-999	cards
H	H1PUGET ISL	-123.42710	46.19366	8	21	67	1	11	6	4	-999	cards
C	C1BURNS BEACH	-123.89520	46.24229	8	22	67	1	5		0		cards
D	D1TAYLOR SANDS	-123.77808	46.22935	8	22	67	1	2		0		cards
I	I2noname	-123.34754	46.14202	8	22	67	1	8		0		cards
-999	-9991/4MILE BELOW PNT ELIS SAND BAR BELOW BRIDGE WASHINGTON SIDE	-999.00000	-999.00000	8	23	67	1	2		0		cards
C	C1MCGOWAN	-123.89520	46.24229	8	23	67	1	4		0		cards
F	F2ACROSS FROM ALTOONA	-123.67333	46.25106	8	23	67	1	2		0		cards
G	G4JIM CROW PNT	-123.55249	46.26457	8	23	67	1	2		0		cards
H	H1PUGET ISL	-123.42710	46.19366	8	23	67	1	9	6	1	254	cards
A	A2ILWACO	-124.00524	46.26876	8	24	67	1	6		0		cards
H	H1PUGET ISL	-123.42710	46.19366	8	28	67	1	11	1	1	278	cards
H	H1PUGET ISL	-123.42710	46.19366	8	28	67	1	11	1	1	291	cards
H	H1PUGET ISL	-123.42710	46.19366	8	28	67	1	11	4	1	289	cards
H	H1PUGET ISL	-123.42710	46.19366	8	30	67	1	2	1	1	271	cards
H	H1PUGET ISL	-123.42710	46.19366	8	30	67	1	2	1	1	207	cards
E	E1BURNS BEACH	-123.73014	46.21813	8	31	67	1	3		0		cards
G	G4JIM CROW PNT	-123.55249	46.26457	8	31	67	1	2	1	1	197	cards
H	H1PUGET ISL	-123.42710	46.19366	9	7	67	1	4		0		cards

H	H2BRADWOOD	-123.44210	46.20923	9	7	67	1	4		0		cards
H	H1PUGET ISL	-123.42710	46.19366	9	13	67	1	-999	4	-999	-999	cards
H	H1PUGET ISL	-123.42710	46.19366	9	13	67	1	-999	4	-999	-999	cards
H	H1PUGET ISL	-123.42710	46.19366	9	14	67	1	10		0		cards
A	A3ILWACO CHNL	-124.03401	46.27350	9	18	67	1	3		0		cards
E	E1BURNS BEACH	-123.73014	46.21813	9	18	67	1	3		0		cards
H	H1PUGET ISL	-123.42710	46.19366	9	26	67	1	6		0		cards
H	H1PUGET ISL	-123.42710	46.19366	10	11	67	1	5		0		cards
H	H1PUGET ISL	-123.42710	46.19366	10	19	67	1	5		0		cards
H	H1PUGET ISL	-123.42710	46.19366	10	30	67	1	5		0		cards
H	H1PUGET ISL	-123.42710	46.19366	11	9	67	1	-999	1	-999	-999	cards
H	H1PUGET ISL	-123.42710	46.19366	11	9	67	1	-999	1	-999	-999	cards
H	H1PUGET ISL	-123.42710	46.19366	11	15	67	1	2		0		cards
H	H1PUGET ISL	-123.42710	46.19366	12	1	67	1	3		0		cards
-999	-999NORTH CHNL JUST BEFORE LIGHT #3	-999.00000	-999.00000	4	20	67	2	-999	0	-999		cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	4	25	67	2	-999	0	-999		cards
G	G2noname	-123.53468	46.25398	4	27	67	2	-999	0	-999		cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	4	28	67	2	-999	0	-999		cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	2	67	2	-999	0	-999		cards
G	G2UPPER WOODY ISL CHNL	-123.53468	46.25398	5	3	67	2	2	1	1	174	cards
G	G2UPPER WOODY ISL CHNL	-123.53468	46.25398	5	4	67	2	4	1	1	482	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	5	67	2	3	1	1	240	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	5	67	2	3	2	1	355	cards

G	G2WOODY ISL CHNL	-123.53468	46.25398	5	5	67	2	3	2	1	381	cards
E	E2noname	-123.69220	46.25096	5	8	67	2	-999	0	-999		cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	9	67	2	4	?	1	192	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	9	67	2	4	?	1	194	cards
G	G2UPPER WOODY ISL CHNL	-123.53468	46.25398	5	10	67	2	3	?	1	200	cards
G	G2UPPER WOODY ISL CHNL	-123.53468	46.25398	5	10	67	2	3	?	1	210	cards
G	G2UPPER WOODY ISL CHNL	-123.53468	46.25398	5	10	67	2	3	?	1	124	cards
G	G2UPPER WOODY ISL CHNL	-123.53468	46.25398	5	10	67	2	3	?	1	232	cards
G	G2UPPER WOODY ISL CHNL	-123.53468	46.25398	5	10	67	2	3	?	1	350	cards
G	G2UPPER WOODY ISL CHNL	-123.53468	46.25398	5	10	67	2	3	?	1	350	cards
G	G2UPPER WOODY ISL CHNL	-123.53468	46.25398	5	10	67	2	3	?	1	365	cards
G	G2UPPER WOODY ISL CHNL	-123.53468	46.25398	5	10	67	2	3	?	1	209	cards
G	G2UPPER WOODY ISL CHNL	-123.53468	46.25398	5	11	67	2	2	?	1	220	cards
G	G2UPPER WOODY ISL CHNL	-123.53468	46.25398	5	11	67	2	2	?	1	230	cards
G	G2UPPER WOODY ISL CHNL	-123.53468	46.25398	5	11	67	2	2	?	1	235	cards
G	G2UPPER WOODY ISL CHNL	-123.53468	46.25398	5	11	67	2	2	?	1	225	cards
G	G2UPPER WOODY ISL CHNL	-123.53468	46.25398	5	11	67	2	2	?	1	220	cards
G	G2UPPER WOODY ISL CHNL	-123.53468	46.25398	5	11	67	2	2	?	1	240	cards
G	G2UPPER WOODY ISL CHNL	-123.53468	46.25398	5	11	67	2	2	?	1	210	cards
G	G2UPPER WOODY ISL CHNL	-123.53468	46.25398	5	12	67	2	3	1	1	200	cards
G	G2UPPER WOODY ISL CHNL	-123.53468	46.25398	5	12	67	2	3	1	1	200	cards
G	G2UPPER WOODY ISL CHNL	-123.53468	46.25398	5	12	67	2	3	1	1	190	cards
G	G2UPPER WOODY ISL CHNL	-123.53468	46.25398	5	12	67	2	3	1	1	195	cards

G	G2UPPER WOODY ISL CHNL	-123.53468	46.25398	5	12	67	2	3	1	1	173	cards
G	G2UPPER WOODY ISL CHNL	-123.53468	46.25398	5	12	67	2	3	1	1	215	cards
G	G2UPPER WOODY ISL CHNL	-123.53468	46.25398	5	12	67	2	3	1	1	183	cards
G	G2UPPER WOODY ISL CHNL	-123.53468	46.25398	5	12	67	2	3	1	1	195	cards
G	G2UPPER WOODY ISL CHNL	-123.53468	46.25398	5	12	67	2	3	1	1	190	cards
G	G2UPPER WOODY ISL CHNL	-123.53468	46.25398	5	12	67	2	3	1	1	185	cards
G	G2UPPER WOODY ISL CHNL	-123.53468	46.25398	5	12	67	2	3	1	1	190	cards
G	G2UPPER WOODY ISL CHNL	-123.53468	46.25398	5	12	67	2	3	1	1	165	cards
G	G2UPPER WOODY ISL CHNL	-123.53468	46.25398	5	12	67	2	3	1	1	200	cards
G	G2UPPER WOODY ISL CHNL	-123.53468	46.25398	5	12	67	2	3	1	1	245	cards
G	G2UPPER WOODY ISL CHNL	-123.53468	46.25398	5	12	67	2	3	2	1	190	cards
G	G2UPPER WOODY ISL CHNL	-123.53468	46.25398	5	15	67	2	2	1	1	215	cards
G	G2UPPER WOODY ISL CHNL	-123.53468	46.25398	5	15	67	2	2	1	1	190	cards
G	G2UPPER WOODY ISL CHNL	-123.53468	46.25398	5	15	67	2	2	1	1	188	cards
G	G2UPPER WOODY ISL CHNL	-123.53468	46.25398	5	15	67	2	2	1	1	190	cards
G	G2UPPER WOODY ISL CHNL	-123.53468	46.25398	5	15	67	2	2	1	1	210	cards
G	G2UPPER WOODY ISL CHNL	-123.53468	46.25398	5	15	67	2	2	1	1	175	cards
G	G2UPPER WOODY ISL CHNL	-123.53468	46.25398	5	15	67	2	2	1	1	205	cards
G	G2UPPER WOODY ISL CHNL	-123.53468	46.25398	5	15	67	2	2	1	1	175	cards
G	G2UPPER WOODY ISL CHNL	-123.53468	46.25398	5	15	67	2	2	1	1	178	cards
G	G2UPPER WOODY ISL CHNL	-123.53468	46.25398	5	15	67	2	2	1	1	305	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	16	67	2	3	?	1	355	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	16	67	2	3	?	1	180	cards

G	G2WOODY ISL CHNL	-123.53468	46.25398	5	16	67	2	3	?	1	170	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	16	67	2	3	?	1	210	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	16	67	2	3	?	1	165	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	16	67	2	3	?	1	180	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	16	67	2	3	?	1	210	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	16	67	2	3	?	1	190	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	16	67	2	3	?	1	163	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	16	67	2	3	?	1	175	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	16	67	2	3	?	1	180	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	16	67	2	3	?	1	200	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	16	67	2	3	?	1	180	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	16	67	2	3	?	1	160	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	16	67	2	3	?	1	215	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	16	67	2	3	?	1	190	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	17	67	2	2	?	1	185	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	17	67	2	2	?	1	160	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	17	67	2	2	?	1	203	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	17	67	2	2	?	1	195	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	17	67	2	2	?	1	230	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	17	67	2	2	?	1	221	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	17	67	2	2	?	1	250	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	17	67	2	2	?	1	195	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	17	67	2	2	?	1	205	cards

G	G2WOODY ISL CHNL	-123.53468	46.25398	5	17	67	2	2	?	1	192	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	17	67	2	2	?	1	168	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	17	67	2	2	?	1	204	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	17	67	2	2	?	1	194	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	17	67	2	2	?	1	190	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	17	67	2	2	?	1	190	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	17	67	2	2	?	1	220	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	17	67	2	2	?	1	215	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	17	67	2	2	?	1	260	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	17	67	2	2	?	1	150	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	17	67	2	2	?	1	224	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	17	67	2	2	?	1	200	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	17	67	2	2	?	1	270	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	17	67	2	2	?	1	190	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	17	67	2	2	?	1	273	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	17	67	2	2	?	1	232	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	17	67	2	2	?	1	304	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	17	67	2	2	?	1	176	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	17	67	2	2	?	1	196	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	17	67	2	2	?	1	160	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	17	67	2	2	?	1	250	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	17	67	2	2	?	1	175	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	17	67	2	2	?	1	245	cards

G	G2WOODY ISL CHNL	-123.53468	46.25398	5	18	67	2	3	?	1	190	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	18	67	2	3	?	1	190	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	18	67	2	3	?	1	190	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	18	67	2	3	?	1	210	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	18	67	2	3	?	1	185	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	18	67	2	3	?	1	180	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	18	67	2	3	?	1	188	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	18	67	2	3	?	1	210	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	19	67	2	5	?	1	201	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	19	67	2	5	?	1	204	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	19	67	2	5	?	1	174	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	19	67	2	5	?	1	260	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	19	67	2	5	?	1	222	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	22	67	2	3	?	1	305	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	22	67	2	3	?	1	330	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	22	67	2	3	?	1	195	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	22	67	2	3	?	1	240	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	22	67	2	3	?	1	180	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	22	67	2	3	?	1	170	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	22	67	2	3	?	1	165	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	22	67	2	3	?	1	162	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	22	67	2	3	?	1	181	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	22	67	2	3	?	1	220	cards

G	G2WOODY ISL CHNL	-123.53468	46.25398	5	22	67	2	3	?	1	195	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	22	67	2	3	?	1	175	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	22	67	2	3	?	1	150	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	22	67	2	3	?	1	230	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	22	67	2	3	?	1	170	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	22	67	2	3	?	1	190	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	22	67	2	3	?	1	170	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	23	67	2	3	?	1	155	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	23	67	2	3	?	1	192	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	23	67	2	3	?	1	183	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	23	67	2	3	?	1	201	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	24	67	2	2	?	1	194	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	24	67	2	2	?	1	200	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	24	67	2	2	?	1	207	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	24	67	2	2	?	1	220	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	24	67	2	2	?	1	178	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	25	67	2	4	?	1	225	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	5	26	67	2	1	1	1	205	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	6	7	67	2	5		0		cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	6	8	67	2	1		0		cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	6	8	67	2	4		0		cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	6	9	67	2	4	?	1	218	cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	6	12	67	2	2		0		cards

G	G2WOODY ISL CHNL	-123.53468	46.25398	6	13	67	2	3		0		cards
G	G2WOODY ISL CHNL	-123.53468	46.25398	6	27	67	2	4		0		cards
H	H1PUGET ISL	-123.42710	46.19366	7	5	67	2	12		0		cards
I	I2HALF MILE UP WESTPORT SLOUGH	-123.34754	46.14202	7	5	67	2	6		0		cards
D	D1noname	-123.77808	46.22935	7	6	67	2	3		0		cards
E	E1noname	-123.73014	46.21813	7	6	67	2	5		0		cards
A	A1CLATSOP SPIT	-124.00983	46.24173	7	7	67	2	5		0		cards
I	I1WESTPORT SLOUGH	-123.38920	46.14924	7	7	67	2	1		0		cards
I	I1WESTPORT SLOUGH	-123.38920	46.14924	7	7	67	2	9		0		cards
I	I2WESTPORT BEACH	-123.34754	46.14202	7	10	67	2	8	?	1	275	cards
I	I3UPPER PUGET ISL ACROSS FROM LIGHT 62	-123.36420	46.14923	7	10	67	2	2		0		cards
H	H1PUGET ISL	-123.42710	46.19366	7	11	67	2	3		0		cards
I	I2HALF MILE UP WESTPORT SLOUGH	-123.34754	46.14202	7	11	67	2	10		0		cards
A	A1CLATSOP SPIT	-124.00983	46.24173	7	12	67	2	4		0		cards
A	A2SAND ISL	-124.00524	46.26876	7	12	67	2	2		0		cards
B	B2PNT ADAMS	-123.96565	46.26531	7	12	67	2	2		0		cards
C	C3WARRENTON ENTRANCE DN RIVER FROM SKIPANON	-123.92314	46.19246	7	12	67	2	2		0		cards
I	I2HALF MILE UP WESTPORT SLOUGH	-123.34754	46.14202	7	12	67	2	10		0		cards
E	E1BURNS BEACH	-123.73014	46.21813	7	13	67	2	5		0		cards
E	E2MILLER SANDS	-123.69220	46.25096	7	13	67	2	4		0		cards
H	H1PUGET ISL	-123.42710	46.19366	7	13	67	2	6		0		cards
C	C1MCGOWAN	-123.89520	46.24229	7	14	67	2	8		0		cards
A	A3ILWACO CHNL	-124.03401	46.27350	7	17	67	2	4		0		cards

I	I21/4 MILE ABOVE WESTPORT SLOUGH	-123.34754	46.14202	7	17	67	2	6		0		cards
H	H1LOWER PUGET ISL	-123.42710	46.19366	7	18	67	2	2		0		cards
I	I2WESTPORT	-123.34754	46.14202	7	18	67	2	10		0		cards
I	I2WESTPORT	-123.34754	46.14202	7	19	67	2	3		0		cards
A	A2SAND ISL	-124.00524	46.26876	7	21	67	2	1		0		cards
C	C1MCGOWAN	-123.89520	46.24229	7	21	67	2	3		0		cards
G	G4JIM CROW PNT	-123.55249	46.26457	7	24	67	2	3		0		cards
A	A1PUGET ISL	-124.00983	46.24173	7	25	67	2	5		0		cards
C	C2MID COLUMBIA ON ISL BEFORE BRIDGE	-123.89271	46.21321	7	25	67	2	2		0		cards
C	C3WARRENTON INLET	-123.92314	46.19246	7	25	67	2	4		0		cards
C	C4LONG SHORE WAREHOUSE	-123.86854	46.18872	7	25	67	2	2		0		cards
H	H1LOWER PUGET ISL	-123.42710	46.19366	7	25	67	2	2		0		cards
D	D1TAYLOR SANDS	-123.77808	46.22935	7	26	67	2	2		0		cards
E	E2RICE ISL	-123.69220	46.25096	7	26	67	2	3	?	1	255	cards
H	H1PUGET ISL ACROSS FROM BRADWOOD	-123.42710	46.19366	7	27	67	2	5		0		cards
A	A1CLATSOP SPIT	-124.00983	46.24173	7	31	67	2	2		0		cards
A	A2SAND ISL	-124.00524	46.26876	7	31	67	2	2		0		cards
A	A3ILWACO CHNL	-124.03401	46.27350	7	31	67	2	2		0		cards
C	C1MCGOWAN BEACH	-123.89520	46.24229	7	31	67	2	2		0		cards
H	H1PUGET ISL	-123.42710	46.19366	7	31	67	2	7		0		cards
I	I2WESTPORT BEACH	-123.34754	46.14202	7	31	67	2	2		0		cards
D	D1TONGUE PNT PIER 3	-123.77808	46.22935	8	1	67	2	1		0		cards
D	D1TONGUE PNT PIER 3	-123.77808	46.22935	8	10	67	2	2		0		cards

H	H1Puget Island	-123.42710	46.19366	1	23	68	1	2		0		cards
H	H1Puget Island	-123.42710	46.19366	2	12	68	1	3		0		cards
H	H1Lower End Puget Island	-123.42710	46.19366	2	29	68	1	3		0		cards
I	I21/4 mi. upriver from Westport Slough	-123.34754	46.14202	3	8	68	1	3	3	0		cards
H	H1W. end Puget Is.	-123.42710	46.19366	3	22	68	1	5		0		cards
I	I2Btwn 1st & 2nd Jetty at Westport	-123.34754	46.14202	3	22	68	1	4	2	1	343	cards
I	I2Btwn 1st & 2nd Jetty at Westport	-123.34754	46.14202	3	22	68	1	4	2	1	368	cards
I	I2Btwn 1st & 2nd Jetty at Westport	-123.34754	46.14202	3	22	68	1	4	2	1	521	cards
I	I2Btwn 1st & 2nd Jetty at Westport	-123.34754	46.14202	3	22	68	1	4	4	1	263	cards
E	E1W. end Burns Beach	-123.73014	46.21813	3	25	68	1	3		0		cards
G	G4Jim Crow Point	-123.55249	46.26457	3	26	68	1	5	1	1	305	cards
G	G4Jim Crow Point	-123.55249	46.26457	3	26	68	1	5	?	1	431	cards
G	G4Jim Crow Point	-123.55249	46.26457	3	26	68	1	5	?	1	266	cards
G	G4Jim Crow Point	-123.55249	46.26457	3	26	68	1	5	?	1	292	cards
G	G4Jim Crow Point	-123.55249	46.26457	3	26	68	1	5	?	1	406	cards
H	H1Puget Island	-123.42710	46.19366	3	27	68	1	8		0		cards
A	A1East of Jetty	-124.00983	46.24173	3	28	68	1	3		0		cards
A	A2Sand Is.	-124.00524	46.26876	3	28	68	1	3		0		cards
E	E1Burns Is. West end	-123.73014	46.21813	3	28	68	1	4		0		cards
E	E2SE Rice Is.	-123.69220	46.25096	3	28	68	1	2		0		cards
H	H1Puget Island West end	-123.42710	46.19366	3	29	68	1	5		0		cards
G	G4Jim Crow Point	-123.55249	46.26457	4	2	68	1	4		0		cards
H	H1Puget Island West end	-123.42710	46.19366	4	2	68	1	5		0		cards

D	D1Taylor Sands East	-123.77808	46.22935	4	3	68	1	4		0		cards
E	E1E. Side Burns Is.	-123.73014	46.21813	4	3	68	1	2		0		cards
E	E2Lone Is. At west end of Rice Is.	-123.69220	46.25096	4	3	68	1	4		0		cards
F	F2Miller Sands	-123.67333	46.25106	4	3	68	1	2		0		cards
C	C3Warrington entrance	-123.92314	46.19246	4	5	68	1	3		0		cards
E	E1Burns Beach	-123.73014	46.21813	4	5	68	1	4		0		cards
H	H1Puget Island	-123.42710	46.19366	4	11	68	1	3		0		cards
H	H2Bradwood Beach	-123.44210	46.20923	4	11	68	1	4		0		cards
H	H1Puget Island	-123.42710	46.19366	4	16	68	1	4	3	1	305	cards
H	H1West End Puget Is.	-123.42710	46.19366	4	17	68	1	4		0		cards
H	H1West End Puget Is.	-123.42710	46.19366	4	19	68	1	5		0		cards
H	H1West End Puget Is.	-123.42710	46.19366	4	22	68	1	6	4	1	209	cards
H	H1West End Puget Is.	-123.42710	46.19366	4	23	68	1	12	2	1	186	cards
H	H1West End Puget Is.	-123.42710	46.19366	4	23	68	1	12	2	1	178	cards
H	H1West End Puget Is.	-123.42710	46.19366	4	23	68	1	12	2	1	198	cards
H	H1West End Puget Is.	-123.42710	46.19366	4	23	68	1	12	2	1	178	cards
H	H1West End Puget Is.	-123.42710	46.19366	4	23	68	1	12	2	1	178	cards
H	H1West End Puget Is.	-123.42710	46.19366	4	23	68	1	12	2	1	200	cards
H	H1West End Puget Is.	-123.42710	46.19366	4	23	68	1	12	2	1	190	cards
H	H1West End Puget Is.	-123.42710	46.19366	4	24	68	1	10	?	1	381	cards
H	H1West End Puget Is.	-123.42710	46.19366	4	24	68	1	10	?	1	381	cards
H	H1West End Puget Is.	-123.42710	46.19366	4	24	68	1	10	?	1	381	cards
H	H1West End Puget Is.	-123.42710	46.19366	4	24	68	1	10	?	1	355	cards

H	H1West End Puget Is.	-123.42710	46.19366	4	24	68	1	10	?	1	355	cards
H	H1West End Puget Is.	-123.42710	46.19366	4	24	68	1	10	?	1	206	cards
H	H1West End Puget Is.	-123.42710	46.19366	4	24	68	1	10	?	1	210	cards
H	H1West End Puget Is.	-123.42710	46.19366	4	24	68	1	10	?	1	209	cards
H	H1West End Puget Is.	-123.42710	46.19366	4	24	68	1	10	?	1	156	cards
H	H1West End Puget Is.	-123.42710	46.19366	4	24	68	1	10	?	1	179	cards
H	H1West End Puget Is.	-123.42710	46.19366	4	24	68	1	10	?	1	198	cards
H	H1West End Puget Is.	-123.42710	46.19366	4	24	68	1	10	?	1	195	cards
H	H1West End Puget Is.	-123.42710	46.19366	4	25	68	1	16	?	1	223	cards
H	H1West End Puget Is.	-123.42710	46.19366	4	25	68	1	16	?	1	170	cards
H	H1West End Puget Is.	-123.42710	46.19366	4	25	68	1	16	?	1	196	cards
H	H1West End Puget Is.	-123.42710	46.19366	4	25	68	1	16	?	1	180	cards
H	H1West End Puget Is.	-123.42710	46.19366	4	25	68	1	16	?	1	279	cards
H	H1West End Puget Is.	-123.42710	46.19366	4	25	68	1	16	?	1	355	cards
H	H1West End Puget Is.	-123.42710	46.19366	4	25	68	1	16	?	1	508	cards
H	H1West End Puget Is.	-123.42710	46.19366	4	25	68	1	16	?	1	208	cards
H	H1West End Puget Is.	-123.42710	46.19366	4	25	68	1	16	?	1	127	cards
H	H1West End Puget Is.	-123.42710	46.19366	4	25	68	1	16	?	1	211	cards
H	H1West End Puget Is.	-123.42710	46.19366	4	25	68	1	16	?	1	208	cards
H	H1West End Puget Is.	-123.42710	46.19366	4	25	68	1	16	?	1	196	cards
H	H1West End Puget Is.	-123.42710	46.19366	4	25	68	1	16	?	1	193	cards
H	H1West End Puget Is.	-123.42710	46.19366	4	26	68	1	12	?	1	330	cards
H	H1West End Puget Is.	-123.42710	46.19366	4	26	68	1	12	?	1	240	cards

H	H1West End Puget Is.	-123.42710	46.19366	4	26	68	1	12	?	1	219	cards
H	H1West End Puget Is.	-123.42710	46.19366	4	26	68	1	12		9		cards
H	H1West End Puget Is.	-123.42710	46.19366	4	29	68	1	11	?	1	238	cards
H	H1West End Puget Is.	-123.42710	46.19366	4	29	68	1	11	?	1	230	cards
H	H1West End Puget Is.	-123.42710	46.19366	4	29	68	1	11	?	1	355	cards
H	H1West End Puget Is.	-123.42710	46.19366	4	29	68	1	11	?	1	209	cards
H	H1West End Puget Is.	-123.42710	46.19366	4	29	68	1	11	?	1	220	cards
H	H1West End Puget Is.	-123.42710	46.19366	4	29	68	1	11	?	1	220	cards
H	H1West End Puget Is.	-123.42710	46.19366	4	29	68	1	11	?	1	210	cards
H	H1West End Puget Is.	-123.42710	46.19366	4	29	68	1	11	?	1	214	cards
H	H1West End Puget Is.	-123.42710	46.19366	4	29	68	1	11	?	1	197	cards
H	H1West End Puget Is.	-123.42710	46.19366	4	29	68	1	11	?	1	185	cards
H	H1West End Puget Is.	-123.42710	46.19366	4	29	68	1	11	?	1	220	cards
H	H1West End Puget Is.	-123.42710	46.19366	4	29	68	1	11	?	1	245	cards
H	H1Puget Island	-123.42710	46.19366	4	30	68	1	11	1	1	175	cards
H	H1Puget Island	-123.42710	46.19366	4	30	68	1	11	1	1	175	cards
H	H1Puget Island	-123.42710	46.19366	4	30	68	1	11	2	1	273	cards
H	H1Puget Island	-123.42710	46.19366	4	30	68	1	11	2	1	214	cards
H	H1Puget Island	-123.42710	46.19366	4	30	68	1	11	2	1	159	cards
H	H1Puget Island	-123.42710	46.19366	4	30	68	1	11	4	1	191	cards
H	H1Puget Island	-123.42710	46.19366	4	30	68	1	11	4	1	181	cards
H	H1Puget Island	-123.42710	46.19366	4	30	68	1	11	5	1	205	cards
H	H1Puget Island	-123.42710	46.19366	4	30	68	1	11	5	1	173	cards

H	H1Puget Island	-123.42710	46.19366	4	30	68	1	11	8	1	170	cards
H	H1Puget Island	-123.42710	46.19366	4	30	68	1	11	11	1	194	cards
H	H1Puget Island	-123.42710	46.19366	4	30	68	1	11	11	1	175	cards
H	H1Puget Island	-123.42710	46.19366	5	1	68	1	11	1	1	211	cards
H	H1Puget Island	-123.42710	46.19366	5	1	68	1	11	2	1	185	cards
H	H1Puget Island	-123.42710	46.19366	5	1	68	1	11	2	1	190	cards
H	H1Puget Island	-123.42710	46.19366	5	1	68	1	11	2	1	182	cards
H	H1Puget Island	-123.42710	46.19366	5	1	68	1	11	3	1	190	cards
H	H1Puget Island	-123.42710	46.19366	5	1	68	1	11	4	1	168	cards
H	H1Puget Island	-123.42710	46.19366	5	1	68	1	11	5	1	199	cards
H	H1Puget Island	-123.42710	46.19366	5	1	68	1	11	7	1	163	cards
H	H1Puget Island	-123.42710	46.19366	5	1	68	1	11	8	1	179	cards
H	H1Puget Island	-123.42710	46.19366	5	1	68	1	11	9	1	191	cards
H	H1Puget Island	-123.42710	46.19366	5	1	68	1	11	9	1	179	cards
H	H1Puget Island	-123.42710	46.19366	5	1	68	1	11	9	1	223	cards
H	H1Puget Island	-123.42710	46.19366	5	1	68	1	11	9	1	235	cards
H	H1Puget Island	-123.42710	46.19366	5	1	68	1	11	10	1	236	cards
H	H1Puget Island	-123.42710	46.19366	5	1	68	1	11	10	1	180	cards
H	H1Puget Island	-123.42710	46.19366	5	1	68	1	11	11	1	200	cards
H	H1Puget Island	-123.42710	46.19366	5	1	68	1	11	11	1	179	cards
H	H1Puget Island	-123.42710	46.19366	5	1	68	1	11	11	1	170	cards
H	H1Puget Island	-123.42710	46.19366	5	1	68	1	11	11	1	190	cards
H	H1Puget Island	-123.42710	46.19366	5	1	68	1	11	11	1	199	cards

H	H1Puget Island	-123.42710	46.19366	8	7	68	1	8		0		cards
A	A1Clatsop Spit Upper	-124.00983	46.24173	8	13	68	1	4		0		cards
A	A3Illwaco Channel	-124.03401	46.27350	8	13	68	1	6		0		cards
B	B1Ft. Stevens	-123.96482	46.21204	8	14	68	1	3		0		cards
C	C2McGowin	-123.89271	46.21321	8	14	68	1	4	1	1	330	cards
C	C2McGowin	-123.89271	46.21321	8	14	68	1	-999	1	-999	279	cards
C	C3Mouth of Skipanon	-123.92314	46.19246	8	14	68	1	3		0		cards
D	D1Taylor Sands	-123.77808	46.22935	8	15	68	1	2		0		cards
E	E1Burns Beach	-123.73014	46.21813	8	15	68	1	4	2	1	292	cards
E	E1Burns Beach	-123.73014	46.21813	8	15	68	1	4	2	1	266	cards
E	E1Burns Beach	-123.73014	46.21813	8	15	68	1	4	2	1	241	cards
E	E1Burns Beach	-123.73014	46.21813	8	15	68	1	4	3	1	292	cards
E	E2Upper Rice Is.	-123.69220	46.25096	8	15	68	1	6	3	1	266	cards
E	E2Upper Rice Is.	-123.69220	46.25096	8	15	68	1	6	3	1	292	cards
E	E2Upper Rice Is.	-123.69220	46.25096	8	15	68	1	6	4	1	187	cards
F	F6Between F-5 and F-6	-999.00000	-999.00000	8	15	68	1	2	?	1	213	cards
A	A2Sand Is.	-124.00524	46.26876	8	16	68	1	4	2	1	330	cards
B	B1Sand Is.	-123.96482	46.21204	8	16	68	1	4		0		cards
E	E1Burns Beach	-123.73014	46.21813	8	16	68	1	2	?	1	330	cards
D	D1Taylor Sands	-123.77808	46.22935	9	9	68	1	2	1	1	330	cards
D	D1Taylor Sands	-123.77808	46.22935	9	9	68	1	2	1	1	330	cards
D	D1Taylor Sands	-123.77808	46.22935	9	9	68	1	2	1	1	330	cards
D	D1Taylor Sands	-123.77808	46.22935	9	9	68	1	2	1	1	330	cards

E	E2Rice Is.	-123.69220	46.25096	9	9	68	1	2	1	2		cards
E	E2Rice Is.	-123.69220	46.25096	9	9	68	1	2	2	1		cards
G	G2Woody Island Channel	-123.53468	46.25398	4	22	68	2	4		0		cards
H	H1Lower Puget Island	-123.42710	46.19366	4	23	68	2	2		0		cards
-999	-999Puget Is. To Jim Crow Pt.	-999.00000	-999.00000	4	24	68	2	5		0		cards
H	H1Channel off H-1	-123.42710	46.19366	4	25	68	2	4	4	1	270	cards
H	H1Channel off H-1, between Bradwood and Cathlamet channel	-123.42710	46.19366	4	26	68	2	6	5	1	308	cards
G	G2Woody Island Channel	-123.53468	46.25398	4	29	68	2	5	?	1	220	cards
G	G2Woody Island Channel	-123.53468	46.25398	4	29	68	2	5	?	1	287	cards
H	H1Channel off H-1, between Bradwood and Cathlamet channel	-123.42710	46.19366	4	30	68	2	3	1	1	251	cards
H	H1Channel off H-1, between Bradwood and Cathlamet channel	-123.42710	46.19366	4	30	68	2	3	3	1	185	cards
H	H1Channel off H-1, between Bradwood and Cathlamet channel	-123.42710	46.19366	5	1	68	2	5	2	1	205	cards
H	H1Channel off H-1, between Bradwood and Cathlamet channel	-123.42710	46.19366	5	1	68	2	5	4	1	217	cards
H	H1Channel off H-1, between Bradwood and Cathlamet channel	-123.42710	46.19366	5	1	68	2	5	4	1	300	cards
H	H1Channel off H-1, between Bradwood and Cathlamet channel	-123.42710	46.19366	5	1	68	2	5	4	1	200	cards
H	H1Channel off H-1, between Bradwood and Cathlamet channel	-123.42710	46.19366	5	1	68	2	5	4	1	431	cards
H	H1Channel off H-1, between Bradwood and Cathlamet channel	-123.42710	46.19366	5	1	68	2	5	5	1	186	cards
H	H1Channel off H-1, between Bradwood and Cathlamet channel	-123.42710	46.19366	5	1	68	2	5	5	1	220	cards
H	H1Channel off H-1, between Bradwood and Cathlamet channel	-123.42710	46.19366	5	1	68	2	5	5	1	245	cards
G	G2Woody Island Channel	-123.53468	46.25398	5	2	68	2	4	1	1	330	cards
G	G2Woody Island Channel	-123.53468	46.25398	5	2	68	2	4	1	1	220	cards
G	G2Woody Island Channel	-123.53468	46.25398	5	2	68	2	4	?	1	381	cards
J	J1Ship Channel from J-1 to I-2	-123.29254	46.13970	5	2	68	2	3	1	1	189	cards

J	J1Ship Channel from J-1 to I-2	-123.29254	46.13970	5	2	68	2	3	1	1	187	cards
J	J1Ship Channel from J-1 to I-2	-123.29254	46.13970	5	2	68	2	3	1	1	170	cards
J	J1Ship Channel from J-1 to I-2	-123.29254	46.13970	5	2	68	2	3	1	1	192	cards
J	J1Ship Channel from J-1 to I-2	-123.29254	46.13970	5	2	68	2	3	1	1	199	cards
J	J1Ship Channel from J-1 to I-2	-123.29254	46.13970	5	2	68	2	3	1	1	165	cards
J	J1Ship Channel from J-1 to I-2	-123.29254	46.13970	5	2	68	2	3	1	1	192	cards
J	J1Ship Channel from J-1 to I-2	-123.29254	46.13970	5	2	68	2	3	1	1	200	cards
J	J1Ship Channel from J-1 to I-2	-123.29254	46.13970	5	2	68	2	3	1	1	355	cards
J	J1Ship Channel from J-1 to I-2	-123.29254	46.13970	5	2	68	2	3	1	1	178	cards
J	J1Ship Channel from J-1 to I-2	-123.29254	46.13970	5	2	68	2	3	2	1	190	cards
J	J1Ship Channel from J-1 to I-2	-123.29254	46.13970	5	2	68	2	3	2	1	192	cards
J	J1Ship Channel from J-1 to I-2	-123.29254	46.13970	5	2	68	2	3	2	1	220	cards
J	J1Ship Channel from J-1 to I-2	-123.29254	46.13970	5	2	68	2	3	2	1	172	cards
J	J1Ship Channel from J-1 to I-2	-123.29254	46.13970	5	2	68	2	3	2	1	150	cards
J	J1Ship Channel from J-1 to I-2	-123.29254	46.13970	5	2	68	2	3	2	1	150	cards
J	J1Ship Channel from J-1 to I-2	-123.29254	46.13970	5	2	68	2	3	2	1	170	cards
J	J1Ship Channel from J-1 to I-2	-123.29254	46.13970	5	2	68	2	3	2	1	170	cards
J	J1Ship Channel from J-1 to I-2	-123.29254	46.13970	5	2	68	2	3	3	1	145	cards
J	J1Ship Channel from J-1 to I-2	-123.29254	46.13970	5	2	68	2	3	3	1	190	cards
J	J1Ship Channel from J-1 to I-2	-123.29254	46.13970	5	2	68	2	3	3	1	173	cards
J	J1Ship Channel from J-1 to I-2	-123.29254	46.13970	5	2	68	2	3	3	1	150	cards
J	J1Ship Channel from J-1 to I-2	-123.29254	46.13970	5	2	68	2	3	3	1	186	cards
J	J1Ship Channel from J-1 to I-2	-123.29254	46.13970	5	2	68	2	3	3	1	197	cards

J	J1Ship Channel from J-1 to I-2	-123.29254	46.13970	5	2	68	2	3	3	1	178	cards
G	G2Woody Island Channel	-123.53468	46.25398	6	12	68	2	4	4	1	250	cards
G	G2Woody Island Channel	-123.53468	46.25398	6	13	68	2	6	6	1	192	cards
-999	-999Lower Columbia	-999.00000	-999.00000	7	14	68	2	3		0		cards
-999	-999Lower Columbia	-999.00000	-999.00000	7	16	68	2	6		0		cards
-999	-999Lower Columbia	-999.00000	-999.00000	7	24	68	2	3	2	1	255	cards
-999	-999Lower Columbia	-999.00000	-999.00000	7	24	68	2	3	2	1	243	cards
E	E2Rice Island	-123.69220	46.25096	8	20	68	2	4		0		cards
E	E22nd Island above Rice Is.	-123.69220	46.25096	8	20	68	2	2		0		cards
-999	-999Between Water Sample Stations 1&2	-999.00000	-999.00000	8	21	68	2	2		0		cards
C	C2Along Desdamona Sands Off Hammond	-123.89271	46.21321	8	22	68	2	1		0		cards
E	E2Rice Island	-123.69220	46.25096	8	22	68	2	3		0		cards
C	C2McGowan	-123.89271	46.21321	8	23	68	2	1		0		cards
D	D1Off Astoria btwn Tongue Pt. & Taylor Sands	-123.77808	46.22935	8	23	68	2	2	?	1	271	cards
E	E2Rice Island	-123.69220	46.25096	8	26	68	2	6		0		cards
-999	-999Buoy #43	-999.00000	-999.00000	8	27	68	2	2	2	1	268	cards
-999	-999Buoy #43	-999.00000	-999.00000	8	27	68	2	1	1	1	240	cards
C	C1Meglar	-123.89520	46.24229	8	27	68	2	-999		-999		cards
D	D1Taylor Sands	-123.77808	46.22935	8	28	68	2	7	2	1	355	cards
D	D1Taylor Sands	-123.77808	46.22935	8	28	68	2	7	5	1	254	cards
D	D1Taylor Sands	-123.77808	46.22935	8	29	68	2	8	1	1	258	cards
D	D1Taylor Sands	-123.77808	46.22935	8	29	68	2	8	4	1	279	cards
D	D1Taylor Sands	-123.77808	46.22935	8	30	68	2	1	1	3		cards

E	E2Rice Island	-123.69220	46.25096	8	30	68	2	7	2	1	248	cards
E	E2Rice Island	-123.69220	46.25096	8	30	68	2	7	3	1	245	cards
E	E2Rice Island	-123.69220	46.25096	8	30	68	2	7	3	1	248	cards
E	E2Rice Island	-123.69220	46.25096	8	30	68	2	7	3	1	253	cards
-999	-999Off Maritime Base	-999.00000	-999.00000	3	28	69	1	1		0		cards
H	H1400 yards up from Ten Is.	-123.42710	46.19366	8	5	69	1	10	2	2		cards
H	H1400 yards up from Ten Is.	-123.42710	46.19366	8	5	69	1	10	1	6		cards
A	A1Clatsop Spit	-124.00983	46.24173	8	11	69	1	3		0		cards
I	I1Puget Island	-123.38920	46.14924	8	12	69	1	8	7	1		cards
I	I1Puget Island	-123.38920	46.14924	8	12	69	1	8	3	2		cards
I	I1Puget Island	-123.38920	46.14924	8	12	69	1	8	1	4		cards
I	I1Puget Island	-123.38920	46.14924	8	14	69	1	8		0		cards
A	A1Clatsop Spit	-124.00983	46.24173	8	20	69	1	4	4	1	279	cards
A	A1Clatsop Spit	-124.00983	46.24173	8	20	69	1	4	3	1	330	cards
A	A1Clatsop Spit	-124.00983	46.24173	8	20	69	1	4	2	1	355	cards
C	C1McGowan	-123.89520	46.24229	8	20	69	1	4	4	1	292	cards
C	C1McGowan	-123.89520	46.24229	8	20	69	1	4	4	1	330	cards
C	C1McGowan	-123.89520	46.24229	8	20	69	1	4	1	1	355	cards
C	C1McGowan	-123.89520	46.24229	8	20	69	1	4	4	1	355	cards
A	A1Clatsop Spit	-124.00983	46.24173	8	21	69	1	1		0		cards
A	A2Sand Island	-124.00524	46.26876	8	21	69	1	4		0		cards
C	C1McGowan	-123.89520	46.24229	8	21	69	1	3		0		cards
A	A1Clatsop Spit	-124.00983	46.24173	8	26	69	1	1		1		cards

C	C1McGowan	-123.89520	46.24229	8	26	69	1	1		0		cards
A	A1Clatsop Spit	-124.00983	46.24173	9	5	69	1	3		0		cards
B	B1Pt. Adams	-123.96482	46.21204	9	5	69	1	1		0		cards
C	C1McGowan	-123.89520	46.24229	9	5	69	1	3	1	1	350	cards
A	A1Clatsop Spit	-124.00983	46.24173	9	12	69	1	4		0		cards
C	C1McGowan	-123.89520	46.24229	9	12	69	1	4		0		cards
A	A1Clatsop Spit	-124.00983	46.24173	9	23	69	1	2		0		cards
B	B1Pt. Adams	-123.96482	46.21204	9	23	69	1	3		0		cards
D	D1Taylor Sands	-123.77808	46.22935	10	2	69	1	4		0		cards
E	E1Between N. Channel and ship channel	-123.73014	46.21813	10	2	69	1	4		0		cards
E	E2Upper Rice Island	-123.69220	46.25096	10	2	69	1	4		0		cards
D	D1Taylor Sands	-123.77808	46.22935	10	24	69	1	3		0		cards
E	E2Rice Island	-123.69220	46.25096	10	24	69	1	3		0		cards
D	D1Taylor Sands	-123.77808	46.22935	10	31	69	1	2		0		cards
E	E1Burns Beach	-123.73014	46.21813	10	31	69	1	5		0		cards
D	D1N. Channel 2 mi. SE of Tongue Pt.	-123.77808	46.22935	2	13	69	2	2		0		cards
D	D1N. Channel 1-3 mi. above Tongue Pt.	-123.77808	46.22935	3	27	69	2	3		0		cards
D	D1Taylor Sands in the shipping channel	-123.77808	46.22935	3	27	69	2	3		0		cards
D	D1N. Channel 1-3 mi. above Tongue Pt.	-123.77808	46.22935	3	28	69	2	3		0		cards
D	D1Taylor Sands in the shipping channel	-123.77808	46.22935	3	28	69	2	3		0		cards
-999	-999Jetty #60	-999.00000	-999.00000	4	3	69	2	1		0		cards
-999	-999Light #37	-999.00000	-999.00000	4	3	69	2	1		0		cards
-999	-999Water Station 10C	-999.00000	-999.00000	4	3	69	2	1		0		cards

H	H1500 yards below Puget Island	-123.42710	46.19366	4	3	69	2	1		0		cards
I	I3Puget Island Bradwood	-123.36420	46.14923	4	3	69	2	1		0		cards
G	G2Woody Is. Channel	-123.53468	46.25398	4	4	69	2	4		0		cards
G	G1Rockland & Woody Is. Channel	-123.58041	46.25334	4	9	69	2	2		0		cards
H	H1Main channel off H-1	-123.42710	46.19366	4	9	69	2	1		0		cards
G	G2Woody Is. Channel	-123.53468	46.25398	4	10	69	2	4		0		cards
G	G2Woody Is. Channel near Miller Sands	-123.53468	46.25398	4	10	69	2	2		0		cards
D	D1N. Channel near Tongue Pt.	-123.77808	46.22935	4	14	69	2	3	2	1	330	cards
D	D1N. Channel near Tongue Pt.	-123.77808	46.22935	4	15	69	2	3		0		cards
D	D1N. Channel near Tongue Pt.	-123.77808	46.22935	4	16	69	2	3		0		cards
D	D1N. Channel near Tongue Pt.	-123.77808	46.22935	4	17	69	2	1		0		cards
D	D1N. Channel near Tongue Pt.	-123.77808	46.22935	4	18	69	2	4		0		cards
G	G2Woody Is. Channel	-123.53468	46.25398	4	23	69	2	5	2	1	317	cards
G	G2Woody Is. Channel	-123.53468	46.25398	4	24	69	2	5	2	1	261	cards
G	G2Woody Is. Channel	-123.53468	46.25398	4	24	69	2	5	3	1	297	cards
G	G2Woody Is. Channel	-123.53468	46.25398	4	24	69	2	5	1	1	381	cards
G	G2Woody Is. Channel	-123.53468	46.25398	4	25	69	2	7	6	1	317	cards
G	G2Woody Is. Channel	-123.53468	46.25398	4	25	69	2	7	1	1	381	cards
G	G2Woody Is. Channel	-123.53468	46.25398	4	25	69	2	7	4	1	431	cards
G	G2Woody Is. Channel	-123.53468	46.25398	6	11	69	2	4	1	1	164	cards
G	G2Woody Is. Channel	-123.53468	46.25398	6	11	69	2	4	2	1	198	cards
G	G2Woody Is. Channel	-123.53468	46.25398	6	12	69	2	4	4	1	159	cards
G	G2Woody Is. Channel	-123.53468	46.25398	6	12	69	2	4	3	1	169	cards

G	G2Woody Is. Channel	-123.53468	46.25398	6	12	69	2	4	4	1	184	cards
C	C1WA side below Astoria Bridge	-123.89520	46.24229	6	13	69	2	3		0		cards
D	D1Tongue Pt. By ship channel	-123.77808	46.22935	6	13	69	2	1		0		cards
C	C1WA side below Astoria Bridge	-123.89520	46.24229	6	16	69	2	3		0		cards
D	D1Tongue Pt.	-123.77808	46.22935	6	16	69	2	1		0		cards
G	G2Woody Is. Channel	-123.53468	46.25398	6	17	69	2	3		0		cards
D	D1Tongue Pt. By ship channel	-123.77808	46.22935	6	19	69	2	3		0		cards
C	C1WA side below Astoria Bridge	-123.89520	46.24229	6	20	69	2	5	1	1	187	cards
C	C1WA side below Astoria Bridge	-123.89520	46.24229	6	23	69	2	3		0		cards
G	G2Woody Is. To Jim Crow Pt. Ship channel	-123.53468	46.25398	6	24	69	2	4		0		cards
D	D1Tongue Pt./Taylor Sands ship channel	-123.77808	46.22935	6	26	69	2	4	4	1	183	cards
D	D1Tongue Pt./Taylor Sands ship channel	-123.77808	46.22935	6	26	69	2	4	3	1	194	cards
D	D1Tongue Pt./Taylor Sands ship channel	-123.77808	46.22935	6	26	69	2	4	1	1	406	cards
C	C1WA side below Astoria Bridge	-123.89520	46.24229	6	27	69	2	4		0		cards
C	C1WA side below Astoria Bridge	-123.89520	46.24229	6	30	69	2	4	3	1	212	cards
G	G2Woody Is. Channel	-123.53468	46.25398	7	2	69	2	4		0		cards
C	C1WA side below Astoria Bridge	-123.89520	46.24229	7	7	69	2	4		0		cards
G	G2Woody Is. Ship channel	-123.53468	46.25398	7	8	69	2	6		0		cards
C	C1WA side below Astoria Bridge	-123.89520	46.24229	7	10	69	2	3		0		cards
C	C1WA side below Astoria Bridge	-123.89520	46.24229	7	11	69	2	3		0		cards
D	D3Gray's Pt.	-123.76390	46.27225	7	11	69	2	3		0		cards
C	C1WA side below Astoria Bridge	-123.89520	46.24229	7	14	69	2	4		0		cards
G	G2Woody Is. Ship channel	-123.53468	46.25398	7	15	69	2	6		0		cards

C	C1WA side below Astoria Bridge	-123.89520	46.24229	7	22	69	2	2		0		cards
D	D1Tongue Pt./Taylor Sands ship channel	-123.77808	46.22935	7	22	69	2	2		0		cards
A	A4South jetty	-124.01583	46.21596	7	25	69	2	6		0		cards
A	A5North jetty	-124.09523	46.27101	7	28	69	2	6	4	1	233	cards
A	A5North jetty	-124.09523	46.27101	7	28	69	2	6	3	1	240	cards
A	A5North jetty	-124.09523	46.27101	7	28	69	2	6	3	1	265	cards
A	A5North jetty	-124.09523	46.27101	7	28	69	2	6	2	1	269	cards
A	A5North jetty	-124.09523	46.27101	7	28	69	2	6	3	1	275	cards
A	A5North jetty	-124.09523	46.27101	7	28	69	2	6	2	1	278	cards
A	A5North jetty	-124.09523	46.27101	7	28	69	2	6	3	1	280	cards
A	A5North jetty	-124.09523	46.27101	7	28	69	2	6	4	1	280	cards
A	A5North jetty	-124.09523	46.27101	7	28	69	2	6	2	1	285	cards
A	A5North jetty	-124.09523	46.27101	7	28	69	2	6	3	1	285	cards
A	A5North jetty	-124.09523	46.27101	7	28	69	2	6	4	1	285	cards
A	A5North jetty	-124.09523	46.27101	7	28	69	2	6	2	1	290	cards
A	A5North jetty	-124.09523	46.27101	7	28	69	2	6	3	1	290	cards
A	A5North jetty	-124.09523	46.27101	7	28	69	2	6	4	1	290	cards
A	A5North jetty	-124.09523	46.27101	7	28	69	2	6	4	1	300	cards
A	A5North jetty	-124.09523	46.27101	7	28	69	2	6	4	1	300	cards
A	A5North jetty	-124.09523	46.27101	7	28	69	2	6	3	1	310	cards
A	A5North jetty	-124.09523	46.27101	7	28	69	2	6	4	1	310	cards
A	A5North jetty	-124.09523	46.27101	7	28	69	2	6	2	1	320	cards
A	A5North jetty	-124.09523	46.27101	7	28	69	2	6	3	1	320	cards

A	A5North jetty	-124.09523	46.27101	7	28	69	2	6	2	1	330	cards
A	A5North jetty	-124.09523	46.27101	7	28	69	2	6	2	1	330	cards
A	A5North jetty	-124.09523	46.27101	7	28	69	2	6	2	1	480	cards
A	A5North jetty	-124.09523	46.27101	7	28	69	2	6	4	2	-999	cards
A	A5North jetty	-124.09523	46.27101	7	28	69	2	6	5	3	-999	cards
A	A4South jetty	-124.01583	46.21596	7	29	69	2	7		0		cards
-999	-999Seaside	-999.00000	-999.00000	7	30	69	2	4		0		cards
A	A4South jetty	-124.01583	46.21596	7	31	69	2	6		0		cards
A	A4South jetty	-124.01583	46.21596	8	1	69	2	6	1	1	-999	cards
A	A4South jetty	-124.01583	46.21596	8	4	69	2	5	3	1	-999	cards
A	A4South jetty	-124.01583	46.21596	8	7	69	2	5	?	1	275	cards
A	A4South jetty	-124.01583	46.21596	8	7	69	2	5	?	1	280	cards
A	A4South jetty	-124.01583	46.21596	8	11	69	2	2		0		cards
A	A1Below Lagoon	-124.00983	46.24173	5	21	70	1	4		0		cards
A	A1Downstream from lagoon	-124.00983	46.24173	5	22	70	1	4		0		cards
A	A1Downstream from lagoon	-124.00983	46.24173	5	25	70	1	1		0		cards
C	C1Magar Church	-123.89520	46.24229	5	26	70	1	2		0		cards
A	A1Below Lagoon	-124.00983	46.24173	5	28	70	1	4		0		cards
A	A1Below Lagoon	-124.00983	46.24173	6	2	70	1	5		0		cards
A	A1Below Lagoon	-124.00983	46.24173	6	3	70	1	5		0		cards
A	A1Below Lagoon	-124.00983	46.24173	6	5	70	1	6		0		cards
A	A1BELOW LAGOON	-124.00983	46.24173	6	8	70	1	-999		-999		cards
A	A1CLATSOP SPIT	-124.00983	46.24173	6	8	70	1	12		0		cards

A	A1CLATSOP SPIT	-124.00983	46.24173	6	9	70	1	11		0		cards
A	A1CLATSOP SPIT BELOW LAGOON	-124.00983	46.24173	6	10	70	1	12		0		cards
A	A1CLATSOP SPIT BELOW LAGOON	-124.00983	46.24173	6	11	70	1	12		0		cards
A	A1CLATSOP SPIT BELOW LAGOON	-124.00983	46.24173	6	12	70	1	8		0		cards
B	B1POINT ADAMS CANNERY	-123.96482	46.21204	6	15	70	1	1		0		cards
A	A1CLATSOP SPIT BELOW LAGOON	-124.00983	46.24173	6	16	70	1	10		0		cards
A	A1CLATSOP SPIT BELOW LAGOON	-124.00983	46.24173	6	17	70	1	8		0		cards
A	A1CLATSOP SPIT BELOW LAGOON	-124.00983	46.24173	6	18	70	1	7		0		cards
A	A1CLATSOP SPIT BELOW LAGOON	-124.00983	46.24173	6	19	70	1	8		0		cards
A	A1CLATSOP SPIT BELOW LAGOON	-124.00983	46.24173	6	22	70	1	5		0		cards
A	A1CLATSOP SPIT BELOW LAGOON	-124.00983	46.24173	6	23	70	1	3		0		cards
F	F3ELLIOT PNT .75 MILE ABOVE ALTOONA	-123.63791	46.26458	6	25	70	1	6	1	1	130	cards
F	F3ELLIOT PNT .75 MILE ABOVE ALTOONA	-123.63791	46.26458	6	25	70	1	6	4	1	135	cards
F	F3ELLIOT PNT .75 MILE ABOVE ALTOONA	-123.63791	46.26458	6	25	70	1	6	1	1	140	cards
F	F3ELLIOT PNT .75 MILE ABOVE ALTOONA	-123.63791	46.26458	6	25	70	1	6	1	1	140	cards
F	F3ELLIOT PNT .75 MILE ABOVE ALTOONA	-123.63791	46.26458	6	25	70	1	6	1	1	140	cards
F	F3ELLIOT PNT .75 MILE ABOVE ALTOONA	-123.63791	46.26458	6	25	70	1	6	2	1	160	cards
F	F3ELLIOT PNT	-123.63791	46.26458	6	26	70	1	4		0		cards
A	A1CLATSOP SPIT (LAGOON)	-124.00983	46.24173	6	29	70	1	7		0		cards
B	B1POINT ADAMS AND CLATSOP SPIT	-123.96482	46.21204	6	30	70	1	5		0		cards
A	A1CLATSOP SPIT (LAGOON)	-124.00983	46.24173	7	1	70	1	4		0		cards
A	A1CLATSOP SPIT (LAGOON)	-124.00983	46.24173	7	2	70	1	4		0		cards
B	B1PNT ADAMS	-123.96482	46.21204	7	2	70	1	3		0		cards

A	A1CLATSOP SPIT (LAGOON)	-124.00983	46.24173	7	6	70	1	4		0	cards
B	B1PNT ADAMS	-123.96482	46.21204	7	6	70	1	2		0	cards
A	A1CLATSOP SPIT	-124.00983	46.24173	7	7	70	1	5		0	cards
B	B1PNT ADAMS	-123.96482	46.21204	7	7	70	1	2		0	cards
B	B1LOWER COLUMBIA POINT ADAMS	-123.96482	46.21204	7	8	70	1	4		0	cards
B	B1PNT ADAMS	-123.96482	46.21204	7	9	70	1	6		0	cards
B	B1PNT ADAMS	-123.96482	46.21204	7	10	70	1	10		0	cards
A	A1CLATSOP SPIT	-124.00983	46.24173	7	13	70	1	4		0	cards
B	B1PNT ADAMS	-123.96482	46.21204	7	13	70	1	6		0	cards
B	B1PNT ADAMS	-123.96482	46.21204	7	14	70	1	10		0	cards
C	C1MCGOWAN	-123.89520	46.24229	7	15	70	1	3		0	cards
A	A1CLATSOP SPIT	-124.00983	46.24173	7	16	70	1	7		0	cards
H	H1LOWER END PUGET SOUND	-123.42710	46.19366	7	21	70	1	7		0	cards
J	J4UPPER END PUGET SOUND	-999.00000	-999.00000	7	27	70	1	7		0	cards
H	H1LOWER PUGET ISL ACROSS FROM BRADWOOD	-123.42710	46.19366	7	28	70	1	2		0	cards
I	I3PUGET ISL ACROSS FOM WEST PORT CHNL	-123.36420	46.14923	7	28	70	1	4	2	8	cards
G	G2LOWER WOODY ISL	-123.53468	46.25398	7	29	70	1	5	4	50	cards
G	G2LOWER WOODY ISL	-123.53468	46.25398	7	29	70	1	5	5	50	cards
G	G2WOODY ISL	-123.53468	46.25398	7	30	70	1	1		0	cards
A	A1CLATSOP SPIT LAGOON	-124.00983	46.24173	8	31	70	1	2		0	cards
B	B1BOAT HOUSE HAMMOND MOOR BASIN	-123.96482	46.21204	9	6	70	1	2		0	cards
D	D1E. Dr(?) Tongue POINT.	-123.77808	46.22935	3	31	71	2	1		0	cards
D	D1OFF TONGUE PNT NE	-123.77808	46.22935	3	31	71	2	1		0	cards

E	E4MARITIME BASIN	-123.73388	46.26765	3	31	71	2	3	2	1	352	cards
D	D1WEST OF TONGUE PNT COST GRD STA	-123.77808	46.22935	4	1	71	2	1		0		cards
E	E4MARITIME BASIN SO&EAST EDGE	-123.73388	46.26765	4	1	71	2	5	2	1	381	cards
E	E4MARITIME BASIN	-123.73388	46.26765	4	2	71	2	6	4	1	433	cards
E	E4MARITIME BASIN	-123.73388	46.26765	4	5	71	2	8	1	1	230	cards
E	E4MARITIME BASIN	-123.73388	46.26765	4	5	71	2	8	5	1	295	cards
E	E4MARITIME BASIN	-123.73388	46.26765	4	5	71	2	8	1	1	296	cards
E	E4MARITIME BASIN	-123.73388	46.26765	4	5	71	2	8	5	1	300	cards
E	E4MARITIME BASIN	-123.73388	46.26765	4	5	71	2	8	1	1	306	cards
E	E4MARITIME BASIN	-123.73388	46.26765	4	5	71	2	8	5	1	306	cards
E	E4MARITIME BASIN	-123.73388	46.26765	4	5	71	2	8	5	1	313	cards
E	E4MARITIME BASIN	-123.73388	46.26765	4	5	71	2	8	3	1	337	cards
E	E4MARITIME BASIN	-123.73388	46.26765	4	5	71	2	8	5	1	371	cards
E	E4MARITIME BASIN	-123.73388	46.26765	4	6	71	2	5	1	1	312	cards
E	E4MARITIME BASIN	-123.73388	46.26765	4	6	71	2	5	1	1	328	cards
E	E4MARITIME BASIN	-123.73388	46.26765	4	6	71	2	5	1	1	470	cards
E	E4MARITIME BASIN	-123.73388	46.26765	4	7	71	2	4	1	1	318	cards
E	E4MARITIME BASIN	-123.73388	46.26765	4	7	71	2	4	1	1	322	cards
E	E4MARITIME BASIN	-123.73388	46.26765	4	7	71	2	4	1	1	337	cards
E	E4MARITIME BASIN	-123.73388	46.26765	4	7	71	2	4	2	1	350	cards
C	C1PNT ELLICE	-123.89520	46.24229	4	12	71	2	1		0		cards
D	D1OFF COAST GUARD BASE AND TONGUE PNT	-123.77808	46.22935	4	13	71	2	2		0		cards
D	D1TONGUE PNT PEIR SO END	-123.77808	46.22935	4	13	71	2	1		0		cards

E	E4NE CORNER MARITIME BASIN	-123.73388	46.26765	4	13	71	2	1	1	1	319	cards
E	E4N SIDE MARITIME BASIN	-123.73388	46.26765	4	16	71	2	1	1	1	190	cards
E	E4N SIDE MARITIME BASIN	-123.73388	46.26765	4	16	71	2	1	1	1	297	cards
E	E4N SIDE MARITIME BASIN	-123.73388	46.26765	4	16	71	2	1	1	1	301	cards
E	E4N SIDE MARITIME BASIN	-123.73388	46.26765	4	16	71	2	1	1	1	343	cards
E	E4N SIDE MARITIME BASIN	-123.73388	46.26765	4	16	71	2	1	1	1	356	cards
E	E4N SIDE MARITIME BASIN	-123.73388	46.26765	4	16	71	2	1	1	1	410	cards
D	D1TONGUE PNT	-123.77808	46.22935	4	19	71	2	2	2	1	342	cards
D	D1TONGUE PNT	-123.77808	46.22935	4	19	71	2	2	2	1	343	cards
D	D1TONGUE PNT	-123.77808	46.22935	4	20	71	2	2		0		cards
D	D1SHIP CHANL SIDE TONGUE PNT	-123.77808	46.22935	4	21	71	2	4	3	1	316	cards
D	D1SHIP CHANL SIDE TONGUE PNT	-123.77808	46.22935	4	21	71	2	4	3	1	324	cards
D	D1SHIP CHANL SIDE TONGUE PNT	-123.77808	46.22935	4	21	71	2	4	1	1	339	cards
G	G2UPPER WOODY ISL CHANL	-123.53468	46.25398	4	22	71	2	4		0		cards
C	C1WASH.SIDE OF COLUMBIA ABOVE AND BELOW ASTORIA BRDG.	-123.89520	46.24229	4	26	71	2	4	4	1	253	cards
C	C1WASH.SIDE OF COLUMBIA ABOVE AND BELOW ASTORIA BRDG.	-123.89520	46.24229	4	26	71	2	4	3	1	270	cards
C	C1WASH.SIDE OF COLUMBIA ABOVE AND BELOW ASTORIA BRDG.	-123.89520	46.24229	4	26	71	2	4	1	1	313	cards
D	D3WASH. SHORE OFF GRAYS PNT	-123.76390	46.27225	4	26	71	2	1	1	1	278	cards
-999	-999INSIDE BAR MIDDLE OF RV & OF COAST GUARD STA	-999.00000	-999.00000	4	27	71	2	2		0		cards
-999	-999OFF OF MOUTH OF SKIPANON RV	-999.00000	-999.00000	4	27	71	2	1		0		cards
-999	-999WASH.SIDE TO BAR THEN BACK TO OR SIDE	-999.00000	-999.00000	4	27	71	2	2	2	1	182	cards
-999	-999WASH.SIDE TO BAR THEN BACK TO OREGON SIDE	-999.00000	-999.00000	4	27	71	2	2	2	1	225	cards
D	D1Tongue Pnt area	-123.77808	46.22935	4	29	71	2	7	7	1	186	cards

D	D1Tongue Pnt area	-123.77808	46.22935	4	29	71	2	7	3	1	292	cards
D	D1Tongue Pnt area	-123.77808	46.22935	4	29	71	2	7	3	1	302	cards
D	D1Tongue Pnt area	-123.77808	46.22935	4	29	71	2	7	4	1	324	cards
D	D1Tongue Pnt area	-123.77808	46.22935	4	29	71	2	7	3	1	331	cards
D	D1Tongue Pnt area	-123.77808	46.22935	4	29	71	2	7	7	1	348	cards
D	D1Tongue Pnt area	-123.77808	46.22935	4	29	71	2	7	6	1	364	cards
D	D1Tongue Pnt area	-123.77808	46.22935	4	29	71	2	7	6	1	372	cards
C	C1WASH SIDE WEST OF ASTRIA BRDG	-123.89520	46.24229	4	30	71	2	4	3	1	139	cards
C	C1WASH SIDE WEST OF ASTRIA BRDG	-123.89520	46.24229	4	30	71	2	4	4	1	339	cards
C	C1WASH SIDE WEST OF ASTRIA BRDG	-123.89520	46.24229	4	30	71	2	4	3	1	342	cards
G	G2WOODY ISL CHANL UPPER END	-123.53468	46.25398	5	3	71	2	4	1	1	169	cards
G	G2WOODY ISL CHANL UPPER END	-123.53468	46.25398	5	3	71	2	4	1	1	241	cards
G	G2WOODY ISL CHANL UPPER END	-123.53468	46.25398	5	3	71	2	4	1	1	340	cards
G	G2WOODY ISL CHANL UPPER END	-123.53468	46.25398	5	3	71	2	4	1	1	345	cards
G	G2UPPER WOODY ISL CHANL	-123.53468	46.25398	5	4	71	2	4	4	1	192	cards
G	G2UPPER WOODY ISL CHANL	-123.53468	46.25398	5	4	71	2	4	4	1	224	cards
G	G2UPPER WOODY ISL CHANL	-123.53468	46.25398	5	4	71	2	4	2	1	333	cards
G	G2UPPER WOODY ISL CHANL	-123.53468	46.25398	5	4	71	2	4	3	1	335	cards
G	G2UPPER WOODY ISL CHANL	-123.53468	46.25398	5	4	71	2	4	3	1	343	cards
G	G2UPPER WOODY ISL CHANL	-123.53468	46.25398	5	4	71	2	4	3	1	346	cards
G	G2UPPER WOODY ISL CHANL	-123.53468	46.25398	5	4	71	2	4	3	1	371	cards
G	G2UPPER WOODY ISL CHANL	-123.53468	46.25398	5	4	71	2	4	1	1	419	cards
-999	-999WASHINGTON	-999.00000	-999.00000	5	10	71	2	5	2	1	406	cards

C	C1ASTORIA MEGLER BRDG -AREA	-123.89520	46.24229	5	11	71	2	7	1,2,4,6	5		cards
C	C1MEGLAR	-123.89520	46.24229	5	12	71	2	5	1,2,4	1	298	cards
C	C1MEGLAR	-123.89520	46.24229	5	12	71	2	5	1,2,4	1	110	binder
C	C1MEGLAR	-123.89520	46.24229	5	12	71	2	5	1,2,4	1	110	binder
C	C1MEGLAR	-123.89520	46.24229	5	12	71	2	5	1,2,4	1	190	binder
C	C1MEGLAR	-123.89520	46.24229	5	12	71	2	5	1,2,4	1	215	binder
C	C1MEGLAR	-123.89520	46.24229	5	12	71	2	5	1,2,4	1	220	binder
C	C1MEGLAR	-123.89520	46.24229	5	12	71	2	5	1,2,4	1	235	binder
C	C1MEGLAR	-123.89520	46.24229	5	12	71	2	5	1,2,4	1	250	binder
C	C1MEGLAR	-123.89520	46.24229	5	12	71	2	5	1,2,4	1	255	binder
-999	-999BELOW ASTORIA BRDG	-999.00000	-999.00000	5	13	71	2	9	1,2,3	9	318	cards
B	B1HAMMOND	-123.96482	46.21204	5	14	71	2	7	2,3,4,5,6,7	1	230	cards
B	B1HAMMOND	-123.96482	46.21204	5	14	71	2	7	2,3,4,5,6,7	1	267	cards
B	B1HAMMOND	-123.96482	46.21204	5	14	71	2	7	2,3,4,5,6,7	1	310	cards
B	B1HAMMOND	-123.96482	46.21204	5	14	71	2	7	2,3,4,5,6,7	1	395	cards
B	B1HAMMOND	-123.96482	46.21204	5	14	71	2	7	2,3,4,5,6,7	1	180	binder
B	B1HAMMOND	-123.96482	46.21204	5	14	71	2	7	2,3,4,5,6,7	1	190	binder
B	B1HAMMOND	-123.96482	46.21204	5	14	71	2	7	2,3,4,5,6,7	1	200	binder
B	B1HAMMOND	-123.96482	46.21204	5	14	71	2	7	2,3,4,5,6,7	1	200	binder
C	C1WASH MEGLER BRDG	-123.89520	46.24229	5	25	71	2	8	1, 2, 3, 6,7, 8	1	110	binder
C	C1WASH MEGLER BRDG	-123.89520	46.24229	5	25	71	2	8		1	145	binder
C	C1WASH MEGLER BRDG	-123.89520	46.24229	5	25	71	2	8		1	155	binder
C	C1WASH MEGLER BRDG	-123.89520	46.24229	5	25	71	2	8		1	185	binder

C	C1WASH MEGLER BRDG	-123.89520	46.24229	5	25	71	2	8		1	190	binder
C	C1WASH MEGLER BRDG	-123.89520	46.24229	5	25	71	2	8		1	190	binder
C	C1WASH MEGLER BRDG	-123.89520	46.24229	5	25	71	2	8		1	195	binder
C	C1WASH MEGLER BRDG	-123.89520	46.24229	5	25	71	2	8		1	200	binder
C	C1WASH MEGLER BRDG	-123.89520	46.24229	5	25	71	2	8		1	210	binder
C	C1WASH MEGLER BRDG	-123.89520	46.24229	5	25	71	2	8		1	215	binder
C	C1WASH MEGLER BRDG	-123.89520	46.24229	5	25	71	2	8		1	235	binder
C	C1WASH MEGLER BRDG	-123.89520	46.24229	5	25	71	2	8		1	240	binder
C	C1WASH MEGLER BRDG	-123.89520	46.24229	5	25	71	2	8		1	250	binder
B	B1HAMMOND	-123.96482	46.21204	5	26	71	2	6		0		cards
B	B1HAMMOND	-123.96482	46.21204	5	27	71	2	7	1,3,4,5,6,7	1	185	binder
B	B1HAMMOND	-123.96482	46.21204	5	27	71	2	7		1	185	binder
B	B1HAMMOND	-123.96482	46.21204	5	27	71	2	7		1	190	binder
B	B1HAMMOND	-123.96482	46.21204	5	27	71	2	7		1	195	binder
B	B1HAMMOND	-123.96482	46.21204	5	27	71	2	7		1	195	binder
B	B1HAMMOND	-123.96482	46.21204	5	27	71	2	7		1	200	binder
B	B1HAMMOND	-123.96482	46.21204	5	27	71	2	7		1	205	binder
B	B1HAMMOND	-123.96482	46.21204	5	27	71	2	7		1	210	binder
B	B1HAMMOND	-123.96482	46.21204	5	27	71	2	7		1	210	binder
B	B1HAMMOND	-123.96482	46.21204	5	27	71	2	7		1	215	binder
B	B1HAMMOND	-123.96482	46.21204	5	27	71	2	7		1	215	binder
B	B1HAMMOND	-123.96482	46.21204	5	27	71	2	7		1	225	binder
B	B1HAMMOND	-123.96482	46.21204	5	27	71	2	7		1	230	binder

B	B1HAMMOND	-123.96482	46.21204	5	27	71	2	7		1	240	binder
B	B1HAMMOND	-123.96482	46.21204	5	27	71	2	7		1	250	binder
B	B1HAMMOND	-123.96482	46.21204	5	27	71	2	7		1	260	binder
B	B1HAMMOND	-123.96482	46.21204	5	27	71	2	7		1	260	binder
B	B1HAMMOND	-123.96482	46.21204	5	28	71	2	7	3,4,5,6	1	155	binder
B	B1HAMMOND	-123.96482	46.21204	5	28	71	2	7	3,4,5,6	1	170	binder
B	B1HAMMOND	-123.96482	46.21204	5	28	71	2	7	3,4,5,6	1	185	binder
B	B1HAMMOND	-123.96482	46.21204	5	28	71	2	7	3,4,5,6	1	195	binder
B	B1HAMMOND	-123.96482	46.21204	5	28	71	2	7	3,4,5,6	1	200	binder
B	B1HAMMOND	-123.96482	46.21204	5	28	71	2	7	3,4,5,6	1	200	binder
B	B1HAMMOND	-123.96482	46.21204	5	28	71	2	7	3,4,5,6	1	200	binder
B	B1HAMMOND	-123.96482	46.21204	5	28	71	2	7	3,4,5,6	1	210	binder
B	B1HAMMOND	-123.96482	46.21204	5	28	71	2	7	3,4,5,6	1	210	binder
B	B1HAMMOND	-123.96482	46.21204	5	28	71	2	7	3,4,5,6	1	215	binder
B	B1HAMMOND	-123.96482	46.21204	5	28	71	2	7	3,4,5,6	1	215	binder
B	B1HAMMOND	-123.96482	46.21204	5	28	71	2	7	3,4,5,6	1	215	binder
B	B1HAMMOND	-123.96482	46.21204	5	28	71	2	7	3,4,5,6	1	220	binder
B	B1HAMMOND	-123.96482	46.21204	5	28	71	2	7	3,4,5,6	1	220	binder
B	B1HAMMOND	-123.96482	46.21204	5	28	71	2	7	3,4,5,6	1	225	binder
B	B1HAMMOND	-123.96482	46.21204	5	28	71	2	7	3,4,5,6	1	240	binder
B	B1HAMMOND	-123.96482	46.21204	5	28	71	2	7	3,4,5,6	1	240	binder
B	B1HAMMOND	-123.96482	46.21204	5	28	71	2	7	3,4,5,6	1	250	binder
C	C1MCGOWAN BEACH	-123.89520	46.24229	6	3	71	2	7	5	1	180	binder

C	C1MCGOWAN BEACH	-123.89520	46.24229	6	3	71	2	7	5	1	255	binder
C	C1MCGOWAN BEACH	-123.89520	46.24229	6	3	71	2	7	5	1	275	binder
C	C1PNT ELLICE	-123.89520	46.24229	6	4	71	2	7	4,5,6	1	170	binder
C	C1PNT ELLICE	-123.89520	46.24229	6	4	71	2	7	4,5,6	1	175	binder
C	C1PNT ELLICE	-123.89520	46.24229	6	4	71	2	7	4,5,6	1	185	binder
C	C1PNT ELLICE	-123.89520	46.24229	6	4	71	2	7	4,5,6	1	200	binder
C	C1PNT ELLICE	-123.89520	46.24229	6	4	71	2	7	4,5,6	1	225	binder
B	B1HAMMOND	-123.96482	46.21204	6	7	71	2	7	3,4,5,7	1	165	binder
B	B1HAMMOND	-123.96482	46.21204	6	7	71	2	7	3,4,5,7	1	170	binder
B	B1HAMMOND	-123.96482	46.21204	6	7	71	2	7	3,4,5,7	1	210	binder
B	B1HAMMOND	-123.96482	46.21204	6	7	71	2	7	3,4,5,7	1	215	binder
C	C1PNT ELLICE	-123.89520	46.24229	6	8	71	2	7	1,2,4,6	1	155	binder
C	C1PNT ELLICE	-123.89520	46.24229	6	8	71	2	7	1,2,4,6	1	160	binder
C	C1PNT ELLICE	-123.89520	46.24229	6	8	71	2	7	1,2,4,6	1	160	binder
C	C1PNT ELLICE	-123.89520	46.24229	6	8	71	2	7	1,2,4,6	1	165	binder
C	C1PNT ELLICE	-123.89520	46.24229	6	8	71	2	7	1,2,4,6	1	165	binder
C	C1PNT ELLICE	-123.89520	46.24229	6	8	71	2	7	1,2,4,6	1	195	binder
C	C1PNT ELLICE	-123.89520	46.24229	6	8	71	2	7	1,2,4,6	1	205	binder
C	C1PNT ELLICE	-123.89520	46.24229	6	8	71	2	7	1,2,4,6	1	340	binder
-999	-999WASH SIDE	-999.00000	-999.00000	6	9	71	2	8	1,3,5,6,8	6		cards
-999	-999WASH SIDE	-999.00000	-999.00000	6	9	71	2	8	1	1	431	cards
C	C1MCGOWAN BEACH	-123.89520	46.24229	6	10	71	2	7	3	1	170	binder
C	C1MCGOWAN BEACH	-123.89520	46.24229	6	10	71	2	7	3	1	195	binder

C	C1MCGOWAN BEACH	-123.89520	46.24229	6	11	71	2	7	2,3,4,7	1	155	binder
C	C1MCGOWAN BEACH	-123.89520	46.24229	6	11	71	2	7	2,3,4,7	1	170	binder
C	C1MCGOWAN BEACH	-123.89520	46.24229	6	11	71	2	7	2,3,4,7	1	175	binder
C	C1MCGOWAN BEACH	-123.89520	46.24229	6	11	71	2	7	2,3,4,7	1	180	binder
C	C1MCGOWAN BEACH	-123.89520	46.24229	6	11	71	2	7	2,3,4,7	1	180	binder
C	C1MCGOWAN BEACH	-123.89520	46.24229	6	11	71	2	7	2,3,4,7	1	210	binder
C	C1MCGOWAN BEACH	-123.89520	46.24229	6	14	71	2	7	1,2,6,7	1	150	binder
C	C1MCGOWAN BEACH	-123.89520	46.24229	6	14	71	2	7	1,2,6,7	1	150	binder
C	C1MCGOWAN BEACH	-123.89520	46.24229	6	14	71	2	7	1,2,6,7	1	180	binder
C	C1MCGOWAN BEACH	-123.89520	46.24229	6	14	71	2	7	1,2,6,7	1	185	binder
C	C1MCGOWAN BEACH	-123.89520	46.24229	6	15	71	2	7	1,5	3	185	binder
C	C1MCGOWAN BEACH	-123.89520	46.24229	6	16	71	2	8	3,4,7,8	1	150	binder
C	C1MCGOWAN BEACH	-123.89520	46.24229	6	16	71	2	8	3,4,7,8	1	155	binder
C	C1MCGOWAN BEACH	-123.89520	46.24229	6	16	71	2	8	3,4,7,8	1	160	binder
C	C1MCGOWAN BEACH	-123.89520	46.24229	6	16	71	2	8	3,4,7,8	1	165	binder
C	C1MCGOWAN BEACH	-123.89520	46.24229	6	16	71	2	8	3,4,7,8	1	170	binder
C	C1MCGOWAN BEACH	-123.89520	46.24229	6	16	71	2	8	3,4,7,8	1	175	binder
C	C1MCGOWAN BEACH	-123.89520	46.24229	6	16	71	2	8	3,4,7,8	1	175	binder
C	C1MCGOWAN BEACH	-123.89520	46.24229	6	17	71	2	6	5,6	1	165	binder
C	C1MCGOWAN BEACH	-123.89520	46.24229	6	17	71	2	6	5,6	1	180	binder
C	C1MCGOWAN	-123.89520	46.24229	6	18	71	2	7	1	1		cards
A	A1Clatsop spit	-124.00983	46.24173	4	6	78	1	-999		-999		unspec
A	A2Sand Isle	-124.00524	46.26876	4	7	78	1	-999		-999		unspec

A	A1Clatsop spit	-124.00983	46.24173	4	10	78	1	7		0	cards
A	A2Sand Isle	-124.00524	46.26876	4	11	78	1	6		0	cards
A	A2Sand Isle	-124.00524	46.26876	4	14	78	1	9		0	cards
A	A1Clatsop spit	-124.00983	46.24173	4	17	78	1	9		0	cards
A	A2Sand Isle	-124.00524	46.26876	4	18	78	1	-999		-999	unspec
A	A1Clatsop spit	-124.00983	46.24173	4	19	78	1	-999		-999	unspec
A	A2Sand Isle	-124.00524	46.26876	4	25	78	1	8		0	cards
A	A1Clatsop spit	-124.00983	46.24173	4	27	78	1	9		0	cards
A	A2Sand Isle	-124.00524	46.26876	5	2	78	1	9		0	cards
A	A1Clatsop spit	-124.00983	46.24173	5	4	78	1	9	7	1	unspec
A	A1Clatsop spit	-124.00983	46.24173	5	4	78	1	9	6	2	unspec
A	A1Clatsop spit	-124.00983	46.24173	5	9	78	1	9		0	cards
A	A2Sand Isle	-124.00524	46.26876	5	11	78	1	9		0	cards
A	A1Clatsop spit	-124.00983	46.24173	5	18	78	1	7	1	1	unspec
A	A1Clatsop spit	-124.00983	46.24173	5	18	78	1	7	2	2	unspec
A	A1Clatsop spit	-124.00983	46.24173	5	18	78	1	7	4	3	unspec
A	A1Clatsop spit	-124.00983	46.24173	5	24	78	1	9	6	2	unspec
A	A2Sand Isle	-124.00524	46.26876	5	24	78	1	-999		-999	unspec
A	A2Sand Isle	-124.00524	46.26876	5	30	78	1	9		0	cards
A	A1Clatsop spit	-124.00983	46.24173	6	6	78	1	9		0	cards
A	A2Sand Isle	-124.00524	46.26876	6	9	78	1	9		0	cards
A	A1Clatsop spit	-124.00983	46.24173	6	13	78	1	9		0	cards
A	A2Sand Isle	-124.00524	46.26876	6	15	78	1	9	3	2	unspec

A	A2Sand Isle	-124.00524	46.26876	6	27	78	1	9		0	cards
A	A1Clatsop spit	-124.00983	46.24173	6	29	78	1	9		0	cards
A	A2Sand Isle	-124.00524	46.26876	7	10	78	1	-999		-999	unspec
A	A1Clatsop spit	-124.00983	46.24173	7	13	78	1	9		0	cards
A	A2Sand Isle	-124.00524	46.26876	7	19	78	1	-999		-999	unspec
A	A1Clatsop spit	-124.00983	46.24173	7	31	78	1	-999		-999	unspec
A	A1Clatsop spit	-124.00983	46.24173	9	6	78	1	7		0	cards
C	C1Astoria Meglar Bridge	-123.89520	46.24229	4	4	78	2	-999		-999	unspec
C	C1Astoria Meglar Bridge	-123.89520	46.24229	4	20	78	2	6		0	cards
C	C1Astoria Meglar Bridge	-123.89520	46.24229	4	21	78	2	5		0	cards
C	C1Astoria Meglar Bridge	-123.89520	46.24229	4	24	78	2	4		0	cards
C	C1Astoria Bridge	-123.89520	46.24229	4	26	78	2	4		0	cards
C	C1Astoria Bridge	-123.89520	46.24229	4	28	78	2	6	4	1	unspec
C	C1Astoria Bridge	-123.89520	46.24229	5	1	78	2	6	1	1	unspec
C	C1Astoria Bridge	-123.89520	46.24229	5	3	78	2	5	1	1	unspec
C	C1Astoria Bridge	-123.89520	46.24229	5	5	78	2	4		0	cards
C	C1Astoria Bridge	-123.89520	46.24229	5	8	78	2	4		0	cards
C	C1Astoria Bridge	-123.89520	46.24229	5	10	78	2	4		0	cards
C	C1Astoria Bridge	-123.89520	46.24229	5	12	78	2	5		0	cards
C	C1Astoria Bridge	-123.89520	46.24229	5	15	78	2	2		0	cards
C	C1Astoria Bridge	-123.89520	46.24229	5	16	78	2	5		0	cards
C	C1Astoria Bridge	-123.89520	46.24229	5	17	78	2	5	2	1	unspec
C	C1Astoria Bridge	-123.89520	46.24229	5	17	78	2	5	1	3	unspec

C	C1Astoria Bridge	-123.89520	46.24229	5	19	78	2	5	1	1		unspec
C	C1Astoria Bridge	-123.89520	46.24229	5	19	78	2	5	2	1		unspec
C	C1Astoria Bridge	-123.89520	46.24229	5	22	78	2	3	3	2		unspec
C	C1Astoria Bridge	-123.89520	46.24229	5	22	78	2	3	2	3		unspec
C	C1Astoria Bridge	-123.89520	46.24229	5	23	78	2	4	4	2		unspec
C	C1Astoria Bridge	-123.89520	46.24229	5	23	78	2	4	3	3		unspec
C	C1Astoria Bridge	-123.89520	46.24229	5	23	78	2	4	2	4		unspec
C	C1Astoria Bridge	-123.89520	46.24229	5	25	78	2	4		0		cards
C	C1Astoria Bridge	-123.89520	46.24229	5	26	78	2	4		0		cards
C	C1Astoria Meglar Bridge	-123.89520	46.24229	6	1	78	2	4	1	2		unspec
C	C1Astoria Meglar Bridge	-123.89520	46.24229	6	2	78	2	4	1	1		unspec
C	C1Astoria Meglar Bridge	-123.89520	46.24229	6	2	78	2	4	3	1		unspec
C	C1Astoria Bridge	-123.89520	46.24229	6	5	78	2	4	1	1		unspec
C	C1Astoria Bridge	-123.89520	46.24229	6	5	78	2	4	2	2		unspec
C	C1Astoria Bridge	-123.89520	46.24229	6	7	78	2	4	2	1		unspec
C	C1Astoria Bridge	-123.89520	46.24229	6	8	78	2	3		0		cards
C	C1Astoria Bridge	-123.89520	46.24229	6	12	78	2	5	2	1	345	cards
C	C1Astoria Bridge	-123.89520	46.24229	6	14	78	2	5	5	1	190	cards
C	C1Astoria Bridge	-123.89520	46.24229	6	16	78	2	5	4	2		unspec
C	C1Astoria Bridge	-123.89520	46.24229	6	17	78	2	5	5	1		unspec
C	C1Astoria Bridge	-123.89520	46.24229	6	17	78	2	5	4	2		unspec
C	C1Astoria Bridge	-123.89520	46.24229	6	21	78	2	5		0		cards
C	C1Astoria Bridge	-123.89520	46.24229	6	22	78	2	5		0		cards

C	C1Astoria Bridge	-123.89520	46.24229	6	24	78	2	5		0		cards
C	C1Astoria Bridge	-123.89520	46.24229	6	27	78	2	5		0		cards
C	C1Astoria Bridge	-123.89520	46.24229	6	30	78	2	3		0		cards
C	C1Astoria Bridge	-123.89520	46.24229	7	3	78	2	1		0		cards
C	C1Astoria Bridge	-123.89520	46.24229	7	5	78	2	5		0		cards
C	C1Astoria Bridge	-123.89520	46.24229	7	7	78	2	3		0		cards
C	C1Astoria Bridge	-123.89520	46.24229	7	21	78	2	5		0		cards
C	C1Astoria Bridge	-123.89520	46.24229	7	24	78	2	5		0		cards
C	C1Astoria Bridge	-123.89520	46.24229	7	26	78	2	5		0		cards
F	F4Pillar Rock & Vicinity	-123.61083	46.25219	7	28	78	2	3		0		cards
C	C1Astoria Bridge	-123.89520	46.24229	8	1	78	2	5	2	1		unspec
C	C1Astoria Bridge	-123.89520	46.24229	8	1	78	2	5	3	2		unspec
C	C1Astoria Bridge	-123.89520	46.24229	8	1	78	2	5	1	6		unspec
C	C1Astoria Bridge	-123.89520	46.24229	8	7	78	2	5	3	1	280	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	7	78	2	5	3	1	300	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	7	78	2	5	4	1	305	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	7	78	2	5	5	1	310	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	7	78	2	5	4	1	330	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	23	78	2	3		0		cards
C	C1Astoria Bridge	-123.89520	46.24229	8	31	78	2	5	2	1	255	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	31	78	2	5	2	1	300	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	31	78	2	5	1	1	330	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	31	78	2	5	1	1	335	cards

C	C1Astoria Bridge	-123.89520	46.24229	9	7	78	2	6	1	1	295	cards
C	C1Astoria Bridge	-123.89520	46.24229	9	7	78	2	6	2	1	300	cards
C	C1Astoria Bridge	-123.89520	46.24229	9	7	78	2	6	3	1	300	cards
C	C1Astoria Bridge	-123.89520	46.24229	9	7	78	2	6	1	1	310	cards
C	C1Astoria Bridge	-123.89520	46.24229	9	7	78	2	6	3	1	310	cards
C	C1Astoria Bridge	-123.89520	46.24229	9	7	78	2	6	2	1	320	cards
C	C1Astoria Bridge	-123.89520	46.24229	9	7	78	2	6	2	1	325	cards
C	C1Astoria Bridge	-123.89520	46.24229	9	7	78	2	6	4	1	360	cards
C	C4Youngs Bay N entrance	-123.86854	46.18872	9	8	78	2	3		0		cards
C	C1Astoria Bridge	-123.89520	46.24229	9	11	78	2	-999		-999		unspec
C	C1Astoria Bridge	-123.89520	46.24229	9	15	78	2	4		0		cards
C	C1Astoria Bridge	-123.89520	46.24229	9	20	78	2	-999		-999		unspec
C	C1Astoria Bridge	-123.89520	46.24229	9	29	78	2	4		0		cards
C	C1Astoria Bridge	-123.89520	46.24229	10	2	78	2	-999		-999		unspec
C	C1Astoria Bridge	-123.89520	46.24229	10	18	78	2	-999		-999		unspec
C	C3Tansy Pt.	-123.92314	46.19246	5	30	79	2	1		0		cards
C	C4Young's Bay	-123.86854	46.18872	5	30	79	2	5		0		cards
C	C3Tansy Pt.	-123.92314	46.19246	5	31	79	2	1		0		cards
C	C1Bridge Purse	-123.89520	46.24229	6	4	79	2	4		0		cards
C	C1Bridge Purse	-123.89520	46.24229	6	7	79	2	3	2	1	365	cards
C	C1Bridge Purse	-123.89520	46.24229	6	11	79	2	3	1	1	-999	cards
C	C1Bridge Purse	-123.89520	46.24229	6	11	79	2	3	3	1	-999	cards
C	C1Bridge Purse	-123.89520	46.24229	6	14	79	2	3		0		cards

C	C1Bridge Purse	-123.89520	46.24229	6	15	79	2	3		0		cards
C	C1Bridge Purse	-123.89520	46.24229	6	18	79	2	3		0		cards
C	C1Bridge Purse	-123.89520	46.24229	6	22	79	2	3	3	1	420	cards
C	C1Bridge Purse	-123.89520	46.24229	6	25	79	2	4		0		cards
C	C1Astoria Bridge	-123.89520	46.24229	7	2	79	2	4		0		cards
C	C1Astoria Bridge	-123.89520	46.24229	7	4	79	2	4		0		cards
C	C1Astoria Bridge	-123.89520	46.24229	7	11	79	2	4	4	2	375	cards
C	C1Astoria Bridge	-123.89520	46.24229	7	13	79	2	4	2	1	290	cards
C	C1Astoria Bridge	-123.89520	46.24229	7	13	79	2	4	4	1	350	cards
C	C1Astoria Bridge	-123.89520	46.24229	7	13	79	2	4	1	3	280	cards
C	C1Astoria Bridge	-123.89520	46.24229	7	17	79	2	4	2	2	-999	cards
C	C1Astoria Bridge	-123.89520	46.24229	7	17	79	2	4	3	3	-999	cards
C	C1Astoria Bridge	-123.89520	46.24229	7	17	79	2	4	4	7	-999	cards
C	C1Astoria Bridge	-123.89520	46.24229	7	18	79	2	3	3	3	-999	cards
C	C1Astoria Bridge	-123.89520	46.24229	7	18	79	2	3	2	4	-999	cards
C	C1Astoria Bridge	-123.89520	46.24229	7	19	79	2	4	2	1	-999	cards
C	C1Astoria Bridge	-123.89520	46.24229	7	19	79	2	4	3	1	-999	cards
C	C1Astoria Bridge	-123.89520	46.24229	7	19	79	2	4	1	2	-999	cards
C	C1Astoria Bridge	-123.89520	46.24229	7	19	79	2	4	4	2	-999	cards
C	C1Astoria Bridge	-123.89520	46.24229	7	20	79	2	4	4	1	-999	cards
C	C1Astoria Bridge	-123.89520	46.24229	7	20	79	2	4	3	4	-999	cards
C	C1Astoria Bridge	-123.89520	46.24229	7	20	79	2	4	2	7	-999	cards
C	C1Astoria Bridge	-123.89520	46.24229	7	20	79	2	4	1	24	-999	cards

C	C1Astoria Bridge	-123.89520	46.24229	7	31	79	2	4	4	11	340	cards
C	C1Astoria Bridge	-123.89520	46.24229	7	31	79	2	4	3	13	320	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	3	79	2	4		0		cards
D	D1Tongue Pt.	-123.77808	46.22935	8	6	79	2	3		0		cards
C	C1Astoria Bridge	-123.89520	46.24229	8	7	79	2	4	3	6	-999	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	7	79	2	4	4	6	-999	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	7	79	2	4	2	9	435	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	8	79	2	4	2	1	255	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	8	79	2	4	1	1	270	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	8	79	2	4	1	1	270	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	8	79	2	4	2	1	280	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	8	79	2	4	3	1	285	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	8	79	2	4	2	1	295	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	8	79	2	4	2	1	305	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	8	79	2	4	2	1	305	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	8	79	2	4	2	1	310	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	8	79	2	4	3	1	310	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	8	79	2	4	2	1	315	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	8	79	2	4	4	1	360	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	8	79	2	4	2	1	390	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	8	79	2	4	2	1	405	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	13	79	2	4		0		cards
C	C1Astoria Bridge	-123.89520	46.24229	8	14	79	2	2		0		cards

C	C1Bridge Purse	-123.89520	46.24229	8	20	79	2	5	2	1	270	cards
C	C1Bridge Purse	-123.89520	46.24229	8	20	79	2	5	2	1	305	cards
C	C1Bridge Purse	-123.89520	46.24229	8	20	79	2	5	1	1	275	cards
C	C1Bridge Purse	-123.89520	46.24229	8	20	79	2	5	1	1	285	cards
C	C1Bridge Purse	-123.89520	46.24229	8	20	79	2	5	1	1	295	cards
C	C1Bridge Purse	-123.89520	46.24229	8	20	79	2	5	1	1	300	cards
C	C1Bridge Purse	-123.89520	46.24229	8	20	79	2	5	1	1	305	cards
C	C1Bridge Purse	-123.89520	46.24229	8	20	79	2	5	1	1	315	cards
C	C1Bridge Purse	-123.89520	46.24229	8	20	79	2	5	1	1	355	cards
C	C1Bridge Purse	-123.89520	46.24229	8	20	79	2	5	1	1	360	cards
D	D1Tongue Pt.	-123.77808	46.22935	8	22	79	2	4	1	1	-999	cards
D	D1Tongue Pt.	-123.77808	46.22935	8	22	79	2	4	3	4	-999	cards
D	D1Tongue Pt.	-123.77808	46.22935	8	22	79	2	4	4	4		cards
D	D1Tongue Pt.	-123.77808	46.22935	8	22	79	2	4	2	6	-999	cards
C	C1Bridge Purse	-123.89520	46.24229	8	24	79	2	-999	?	1	260	cards
C	C1Bridge Purse	-123.89520	46.24229	8	24	79	2	-999	?	1	270	cards
C	C1Bridge Purse	-123.89520	46.24229	8	24	79	2	-999	?	1	295	cards
C	C1Bridge Purse	-123.89520	46.24229	8	24	79	2	-999	?	1	295	cards
C	C1Bridge Purse	-123.89520	46.24229	8	24	79	2	-999	?	1	310	cards
C	C1Bridge Purse	-123.89520	46.24229	8	24	79	2	-999	?	1	315	cards
C	C1Bridge Purse	-123.89520	46.24229	8	24	79	2	-999	?	1	325	cards
C	C1Bridge Purse	-123.89520	46.24229	8	24	79	2	-999	?	1	330	cards
C	C1Bridge Purse	-123.89520	46.24229	8	24	79	2	-999	?	1	345	cards

C	C1Bridge Purse	-123.89520	46.24229	8	24	79	2	-999	?	1	345	cards
C	C1Bridge Purse	-123.89520	46.24229	8	24	79	2	-999	?	1	355	cards
C	C1Bridge Purse	-123.89520	46.24229	8	24	79	2	-999	?	1	360	cards
C	C1Bridge Purse	-123.89520	46.24229	8	24	79	2	-999	?	1	375	cards
C	C1Bridge Purse	-123.89520	46.24229	8	24	79	2	-999	?	1	380	cards
C	C1Bridge Purse	-123.89520	46.24229	8	24	79	2	-999	?	1	390	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	27	79	2	4	4	1	275	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	27	79	2	4	3	1	285	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	27	79	2	4	4	1	285	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	27	79	2	4	4	1	290	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	27	79	2	4	3	1	300	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	27	79	2	4	3	1	300	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	27	79	2	4	4	1	305	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	27	79	2	4	3	1	310	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	27	79	2	4	3	1	310	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	27	79	2	4	4	1	310	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	27	79	2	4	4	1	315	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	27	79	2	4	3	1	335	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	27	79	2	4	4	1	335	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	27	79	2	4	3	1	340	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	27	79	2	4	4	1	345	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	27	79	2	4	4	1	350	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	27	79	2	4	4	1	360	cards

C	C1Astoria Bridge	-123.89520	46.24229	8	27	79	2	4	4	1	360	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	27	79	2	4	3	1	370	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	27	79	2	4	4	1	370	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	27	79	2	4	4	1	375	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	27	79	2	4	3	1	380	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	27	79	2	4	3	1	385	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	27	79	2	4	3	1	395	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	27	79	2	4	4	1	395	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	29	79	2	4	2	1	335	cards
C	C1Astoria Bridge	-123.89520	46.24229	8	31	79	2	5	4	1	375	cards
C	C1Astoria Bridge	-123.89520	46.24229	9	5	79	2	4	2	1	300	cards
C	C1Astoria Bridge	-123.89520	46.24229	9	5	79	2	4	1	1	305	cards
C	C1Astoria Bridge	-123.89520	46.24229	9	5	79	2	4	2	1	315	cards
C	C1Astoria Bridge	-123.89520	46.24229	9	5	79	2	4	2	1	330	cards
C	C1Astoria Bridge	-123.89520	46.24229	9	5	79	2	4	2	1	335	cards
C	C1Astoria Bridge	-123.89520	46.24229	9	5	79	2	4	2	1	340	cards
C	C1Astoria Bridge	-123.89520	46.24229	9	5	79	2	4	3	1	-999	cards
C	C1Astoria Bridge	-123.89520	46.24229	9	5	79	2	4	3	1	-999	cards
C	C1Astoria Bridge	-123.89520	46.24229	9	5	79	2	4	3	1	-999	cards
C	C1Astoria Bridge	-123.89520	46.24229	9	6	79	2	6	1	1	275	cards
C	C1Astoria Bridge	-123.89520	46.24229	9	6	79	2	6	1	1	285	cards
C	C1Astoria Bridge	-123.89520	46.24229	9	6	79	2	6	1	1	290	cards
C	C1Astoria Bridge	-123.89520	46.24229	9	6	79	2	6	1	1	300	cards

C	C1Astoria Bridge	-123.89520	46.24229	9	6	79	2	6	3	6	-999	cards
C	C1Astoria Bridge	-123.89520	46.24229	9	6	79	2	6	2	7	-999	cards
C	C1Astoria Bridge	-123.89520	46.24229	9	6	79	2	6	4	7	-999	cards
-999	-999Upriver	-999.00000	-999.00000	9	10	79	2	4		0		cards
C	C1Astoria Bridge	-123.89520	46.24229	9	11	79	2	5	5	1	275	cards
C	C1Astoria Bridge	-123.89520	46.24229	9	11	79	2	5	4	1	340	cards
C	C1Astoria Bridge	-123.89520	46.24229	9	13	79	2	5		0		cards
C	C1Astoria Bridge	-123.89520	46.24229	9	14	79	2	6		0		cards
C	C1Astoria Bridge	-123.89520	46.24229	9	17	79	2	5		0		cards
C	C1Astoria Bridge	-123.89520	46.24229	9	19	79	2	6		0		cards
C	C1Astoria Bridge	-123.89520	46.24229	7	2	80	2	2	2	1	365	cards
C	C1Astoria Bridge	-123.89520	46.24229	7	6	80	2	2	2	1	280	cards
C	C1Astoria Bridge	-123.89520	46.24229	7	9	80	2	5		0		cards
C	C1Astoria Bridge	-123.89520	46.24229	7	10	80	2	4		0		cards
C	C1Astoria Bridge	-123.89520	46.24229	7	11	80	2	5	2	1	-999	cards
C	C1Astoria Bridge	-123.89520	46.24229	7	14	80	2	4	1	1	365	cards
C	C1Astoria Bridge	-123.89520	46.24229	7	15	80	2	4	1	1	420	cards
C	C1Astoria Bridge	-123.89520	46.24229	7	15	80	2	4	2	1	380	cards
C	C1Astoria Bridge	-123.89520	46.24229	7	15	80	2	4	2	1	235	cards
C	C1Astoria Bridge	-123.89520	46.24229	7	15	80	2	4	3	1	400	cards
C	C1Astoria Bridge	-123.89520	46.24229	7	16	80	2	4	2	1	410	cards
C	C1Astoria Bridge	-123.89520	46.24229	7	16	80	2	4	4	2	-999	cards
C	C1Astoria Bridge	-123.89520	46.24229	7	17	80	2	5	2	1	350	cards

C	C1Astoria Bridge	-123.89520	46.24229	7	17	80	2	5	2	1	385	cards
C	C1Astoria Bridge	-123.89520	46.24229	7	17	80	2	5	2	1	370	cards
C	C1Astoria Bridge	-123.89520	46.24229	7	17	80	2	5	5	1	276	cards
C	C1Astoria Bridge	-123.89520	46.24229	7	18	80	2	4	1	1	259	cards
C	C1Astoria Bridge	-123.89520	46.24229	7	18	80	2	4	2	1	435	cards

D-4 ECOLOGY AND BEHAVIOR OF COLUMBIA RIVER SALMONIDS

4.1 Salmonids In Highly Modified River

The lower Columbia River and its estuary are part of a highly modified river system. The modifications have resulted in a number of the salmon stocks being officially listed as threatened or endangered under the Endangered Species Act (ESA). Modifications began during the 1860s and 1870s when commercial fishing became sufficiently intense to essentially eliminate some stocks of salmon (Gilbert and Evermann, 1894). Subsequent modifications to the physical and biological characteristics of the river basin have resulted in the official listing of 14 evolutionarily significant units (ESUs) and distinct population segments (DPSs), or species for the Columbia River. These alterations and their potential impacts were identified in R. M. Thom's white paper (2001) on a conceptual model for the Columbia River Navigation Channel Improvements Project (the Project).

Thom's white paper identifies 14 species of concern and presents information describing their basic habitat needs during the periods they occupy the lower Columbia River in the area potentially affected by the channel deepening project. A brief description of the species (ESUs and DPSs) is followed by a summary of information describing the habitat characteristics identified in the existing literature as important to the life stages of ESUs and DPSs as they move through the lower Columbia River and similar areas of the Pacific Northwest.

Nearly all the information available to describe the biological processes related to listed species in the Columbia River was obtained after the river system's biological and physical characteristics had been highly modified. Thus, our understanding of how the system functions is derived from this modified system. We have only inferential logic and sketchy information to describe how the river system most likely functioned naturally before it was modified.

In the following discussion, the term "salmon" refers to various life stages of the chinook, chum sockeye, and steelhead ESUs and DPSs. The term "salmonid" refers to each of these salmon ESUs as well as the anadromous forms of the cutthroat trout and bull trout DPSs.

4.1.1 Objective

The purpose of this document is to describe the known biological characteristics of the listed species pertinent to the action area and the proposed Project.

The discussion in this paper is restricted to information describing biological processes only in the project area, other than a brief description of each ESUs spawning and rearing areas, and how they influence timing and habitat use within the project area. The information provided has been developed both from the lower Columbia River and from other Pacific Northwest estuarine areas that support the fish species listed in the project area. The assembled information is appropriate for interpretation of potential impacts of the proposed navigation channel deepening project on listed species. This purpose of this information is twofold: (1) to help avoid impacts to habitat supporting listed species, and (2) to potentially identify how the project can support recovery of the species.

4.1.2 Habitat Conditions In Project Area

The Project encompasses an area that essentially all juvenile salmon and returning adults use as a migratory corridor. Their use of habitat within the action area varies with life stage and species, primarily related to size of the fish when they migrate through the action area.

Juvenile rearing and migrations

Young salmon are likely present in at least small numbers through out the year; however, substantial numbers of juveniles first appear in the project area in middle to late March. These young chinook and chum are fish produced in the lower river area, including tributaries within the Bonneville Dam area and possibly within the Willamette River basin. Commonly these very young chinook and chum are the smallest migrants passing through the project area. Other subyearling chinook migrating later in the year from upstream locations tend to be somewhat larger, with the largest subyearlings reaching the lower river from the upstream reaches in the autumn. Consequently, several different size groups of sub-yearling salmon that account for some juveniles in the lower Columbia River appear in substantial numbers from March through about October.

Smaller juvenile salmon tend to rear and move relatively slowly through the lower river, primarily in shallow water habitat. Older subyearlings and smolts tend to move faster through the lower river, with less dependence on shallow water habitat; they also tend to be surface-oriented.

Juvenile cutthroat and bull trout are present within the Columbia River estuary during the spring and early summer at the same time as the young salmon. However, the young trout tend to be the size of salmon smolts and larger. These fish are relatively rare in fish collections; therefore information on their habitat requirements in the lower Columbia River is limited.

Adult migrations

Adult salmon return through the lower Columbia River from early spring through early autumn. Spring chinook begin entering the lower river in March or April, with the majority moving through the area in middle to late April or early May. They are sequentially followed by summer chinook and fall chinook, with chum, steelhead, and cutthroat and bull trout moving upstream during the same general period. During their upstream migrations through estuaries and lower rivers, the adult salmon are not oriented to any specific habitats. They generally tend to remain relatively close to the surface but also use greater depths at times. The National Marine Fisheries Service (NMFS) has designated two basic reproductive ecotypes of steelhead, depending on the time they migrate upstream—ocean-type (winter run) and stream-type (summer run). Stream-maturing steelhead enter the lower river in a sexually immature condition, requiring several months of residence within the river prior to spawning.

4.2 ESUs and DPSs

The listed species (ESUs and DPSs) shown in Table D4-1 pass through the lower Columbia River both as juvenile downstream migrants and as sub-adults or adults on return migrations. Some individuals of the steelhead, cutthroat, and bull trout species may pass through the lower Columbia River more than once because they survive to spawn more than one time.

Table D4-1: Listed ESUs and DPSs for the Columbia River System

SPECIES (Evolutionarily Significant Unit)	STATUS	JUVENILE LIFE STATE IN PROJECT AREA	DATE LISTED
CHINOOK			
Snake River spring/summer	Threatened	Yearling	April 22, 1992
Snake River fall	Threatened	Subyearling	April 22, 1992
Lower Columbia River	Threatened	Subyearling	March 24, 1999
Upper Columbia River spring	Endangered	Yearling	March 24, 1999
Upper Willamette River	Threatened	Yearling	March 24, 1999
SOCKEYE			
Snake River	Endangered	Smolt	November 20, 1991
STEELHEAD			
Snake River	Threatened	Smolt	August 18. 1997
Lower Columbia River.	Threatened	Smolt	March 19, 1998
Middle Columbia River	Threatened	Smolt	March 25, 1999
Upper Columbia River	Endangered	Smolt	August 18, 1997
Upper Willamette River	Threatened	Smolt	March 25, 1999
CHUM			
Columbia River	Threatened	Subyearling	March 25, 1999
BULL TROUT			
Columbia River	Threatened	Smolt or larger	June 10, 1998
CUTTHROAT TROUT			
Southwestern Washington/Columbia River	Threatened	Smolt or larger	October 25, 1999

4.3 Three Guilds of Columbia River ESUs

Each of the Columbia River ESUs and DPSs has some unique life history characteristics that help to separate it from adjacent populations of the same species. However, for consideration of the Project, these ESUs and DPSs can be aggregated into several general life history types. The salmon tend to follow one of two life history types—ocean type and stream type—that provide different size fish with substantially different habitat requirements. A portion of the cutthroat and bull trout populations are anadromous and follow a third life history form, as do some wild steelhead. Characteristics of each of the life history types are listed below.

Ocean type

- Rear only weeks to months in fresh water
- Are small (30 to 80 centimeters [cm])
- Use shallow water/shoreline habitat (0.1 to 2 meters deep, current less than 0.3 meters per second)
- Prolonged rearing in lower river (weeks to months)
- Include fall chinook, chum, and pink (few listed)

Stream type

- Rear more than 1 year in fresh water prior to downstream migration
- Are large (10 to 30 cm or larger)
- Generally move in open water
- Move relatively quickly through lower river (days to weeks)
- Include spring chinook, coho, sockeye, steelhead, bull trout, and cutthroat trout

Trout

- Rear 2 to 3 years in fresh water streams
- Migrate as very large juveniles (14 to 30 cm) or as adults
- Rear throughout the late spring and summer in estuarine or ocean areas
- Are scarce in scientific collections, which implies they are not commonly found in shallow water habitats or are adept at escaping sampling gear

A question raised during this process was whether or not the 14 ESUs and DPSs can be grouped into guilds or if they require individual species analyses. The first step in answering this question is to identify a common definition of a guild. The guild concept was defined by Root (1967):

> "A guild is defined as a group of species that exploit the same class of environmental resources in a similar way."

According to Jaksi (1981), the term guild should be reserved for co-occurring, interacting species in a particular habitat. The salmonid ESUs and DPSs in the Columbia River fit this requirement for at least a portion of their life cycles.

In the lower Columbia River and its estuary, several general classes of environmental resources are exploited or used by salmon, including:

- Shallow water (less than 6 feet deep) beaches and tideflats composed of fine-grained sediment, and having low current velocities (less than 0.3 foot per second)
- Near surface (within 20 feet of surface) water column areas not associated with specific substrate types or specific current velocities
- The entire water column

Because various members of the ocean-type and stream-type groups tend to use the lower river's environmental resources in a similar way, they tend to fit the definition of a guild.

Ocean-type salmon fry migrate through the lower estuary slowly, remaining in shallow water most of the time. These small fish undergo a rearing migration that provides substantial growth prior to their entry into ocean conditions. In the lower river, ocean-type chinook are present as several different size groups ranging from small fry [~35 millimeters (mm)] to much larger late summer migrants (~80 to 100 mm).

Stream-type salmon migrate relatively rapidly through the lower river and estuary in a directed migration that takes only days to weeks. During this migration, they remain surface oriented but occupy a greater depth range and areas of higher current velocity than do the smaller ocean-type fish. These larger juveniles tend to be water-column-oriented rather than substrate-oriented like the smaller ocean-type juveniles. Because of their larger size, the stream-type juveniles are generally ready to meet ocean conditions by the time they enter the project area.

Adult and sub-adult salmon form a separate guild. Adult fish, which include the chinook, steelhead, and sockeye ESUs and DPSs enter the project area on their upstream migration as sexually maturing fish nearly ready to spawn. These fish generally have ceased feeding by the time they enter estuarine areas. The adults actively swim within the water column, occupying a wide range of depths but commonly within about 50 feet of the surface. At times the adult salmon are found near the bottom, but do not appear to use the substrate in any specific manner. Adults appear to be consistently milling or actively migrating.

Anadromous trout juveniles and adults may rear within the estuary; however, little factual information is available to document this occurrence. Apparently their numbers are sufficiently small and their capacity to avoid sampling gear is sufficiently great that little information data has been generated regarding the characteristics of the estuarine habitat they use. Brown (1992), Kraemer (1994), and Smith and Slaney (1980) provide what information is known about the anadromous form of bull trout. Most juveniles migrate at 2 to 3 years of age. Surviving anadromous adults also migrate back to saline conditions following spawning to undergo additional rearing in the saline environment. Downstream migration occurs during the spring, with rearing in either the estuary or the ocean during the summer, and return migration in the autumn. Some adults return upstream as early as April in some streams, migrating much as adult salmon with little or no feeding. Cutthroat trout appear to have similar life-history characteristics. Sumner (1962), Lowry (1965), Giger (1972), and Johnson (1981) provide information on the life history characteristics of the anadromous form of coastal cutthroat trout. Most migrate to the estuary or ocean during the spring for several months of rearing, returning to their natal streams as sub-adults or adults. These trout may migrate to high salinity areas and return to spawn several times.

4.4 Salmonid Habitat Requirements

Habitat supporting a species or a life stage of a species generally makes up only part of an ecosystem. This discussion focuses on defining those aspects of the lower Columbia River and estuary portion of the ecosystem that provide habitat for the listed fish species.

The quality or suitability of habitat meeting the needs of an organism of concern is determined by a variety of factors. These include the physical characteristics of the environment that are important to the organism, biological production yielding food sources for the organism, and populations of other organisms that are either competitors or predators

Water depth, water velocity, and substrate type are basic physical characteristics determining the suitability of the habitat for young and adult salmon. Water temperature, salinity and turbidity are secondary physical factors that influence the suitability of the habitat. Salmon appear to find relatively wide ranges acceptable for these secondary factors.

4.4.1 Physical Habitat Characteristics of Lower Columbia River Guilds

Each of the three guilds or groups of salmon moving through the lower Columbia River project area has substantially different habitat requirements. Ocean-type juveniles appear to have the most restrictive requirements for physical habitat characteristics. Stream-type juvenile salmon have somewhat less rigid habitat preferences. Adult salmon appear to be relatively none specific in the physical characteristics they are willing to accept. The following information on the habitat characteristics important to young salmon is derived primarily from Weitkamp (2001a) except where otherwise noted.

Ocean-Type Juvenile Salmon

Ocean-type subyearlings require specific physical characteristics in the habitat they commonly use. Apparently, because of their small size, they are unable or unwilling to use much of the habitat that larger juveniles find suitable.

Water Depth: These small fish are generally found within 1 meter of the water surface. Because they are shoreline oriented, this commonly means they occupy shallow water habitat with depths of 0.3 to 2 meters (1 to 7 feet).

Water Currents: The small ocean-type juveniles are not capable of dealing with substantial current velocities; consequently, they tend to occupy areas with current velocities of 9 centimeters per second (0.3 foot per second) or less.

Substrate Type: Subyearling salmon actually are found associated with a wide range of substrate types throughout their range, extending from mud flats to rock cliffs. However, because they are both strongly shoreline oriented and require weak current speeds to remain within the habitat, they are most frequently found in areas with fine grain substrates of silt and sand.

Salinity: Ocean-type juveniles occupy a substantial range of salinities. Although they all begin their rearing migration in freshwater, they appear to have the capacity to readily enter moderate to high salinity conditions within hours to a day. Wagner et al. (1969) found that all fall chinook alevins tested were able to tolerate 15 to 20 parts per thousand (ppt) salinity immediately following hatching. Ellis (1957) found ocean-type fall chinook fry (3 grams) adapted rapidly to high salinity, with high survival to adult returns after only 5 days of incremental adaptation to saltwater with 25 to 75 percent salinity (~ 9 to 25 ppt). Tiffan, et al. (2000) determined that once active migrant fall chinook passed McNary Dam, 470 kilometers upstream from the Columbia River's mouth, 90 percent of the subyearlings were able to survive challenge tests in 30 ppt seawater at 18.3°C. Clark and Shelbourn (1985) determined that very small chinook fry of 1.5 grams and larger could survive and grow in seawater.

Water Temperature: Subyearling salmon commonly experience a wide range of temperatures during their rearing migration through the lower Columbia and other rivers. Because these fish remain in shallow water and migrate in the spring through early summer, they are exposed to water with temperatures raised to near the upper end of their range. Tidal fluctuations cause water to flow over flats heated by the sun resulting in temperatures that frequently reach 15 to 20° C for brief periods, only to be replaced within hours by much cooler river or estuarine water. The lethal temperature for young salmon is about 22° C for fish acclimated to cold water (Brett, 1956; Lee and Rinne, 1980). These studies have shown that young salmon can survive substantially higher temperatures when acclimated to moderate temperatures (10 to 15°C), and can tolerate higher temperatures for brief periods of time (hours) (Brett, 1956; Elliott, 1981).

Sublethal effects can occur at temperatures well below lethal limits. Exposure to high but sublethal temperatures for prolonged periods can have a broad range of effects on various fish functions . Brett (1971) identified 25 physiological responses in sockeye. Two general response patterns have been identified. The response (e.g., standard metabolic rate, active heart rate, gastric evacuation) can either increase continuously with increased temperature, or the response (e.g., growth rate, swimming speed, feeding rate) can increase with temperature to maximum values at optimum temperatures and then decrease as temperature continues to increase (Brett, 1971; Elliott, 1981). At or near 22°C salmonids tend to cease feeding. Growth rates tend to be highest for salmonids between 10 and 18°C when adequate food rations are available. At lower food availability growth decreases at higher temperatures (Brett et al., 1969). At low food rations growth is very low or ceases at temperatures above about 15°C.

Turbidity: Turbidity and suspended sediment are a natural part of the habitat occupied by young and adult salmon. Although they these two parameters are often used interchangeably, they refer to different properties. Turbidity refers to light attenuation by materials in the water, while suspended sediment refers to the amount of mineral particles suspended in the water column.

Turbidity at moderate levels of about 25 to 110 nephelometric turbidity units (NTUs) is common in rivers with migrating salmon. Turbidity can decrease predation on young salmonids. Gregory and Levings (1998) found that young salmon are less likely to be eaten by piscivorus fish at higher turbidities. Turbidity can also reduce the feeding efficiency of young salmonids. Gregory (1988) reported the reaction distance of young chinook to benthic prey decreased greatly between 0 and about 50 NTUs. However, from 50 to 250 NTUs there was little change in reaction distance, in part because the fish were only reacting to prey within about 8 cm at 50 NTUs. Berg and Northcote (1985) demonstrated a similar decrease in the reaction distance of juvenile coho to pelagic prey at turbidities of 30 and 60 NTUs as compared to zero NTU. Growth of young steelhead and coho was reduced by chronic turbidity in the range of 20 to 50 NTUs in freshwater rearing (Sigler et al., 1984). However, turbidity in the range of 30 to 60 NTUs is common in natural rivers such as the Columbia.

Direct survival of young salmonids is can be affected at high suspended sediment loads. Noggle (1978) defined the lethal concentration 50 (LC_{50}) for turbidity (the amount expected to cause death in 50 percent of the exposed population) under summer conditions (the most sensitive) as near 1.2 grams per liter (g/L) for young coho. Smith (1978) determined the LC50 for chum to be greater than 2.5 g/L.

In the lower Columbia River turbidity is important in relation to the zone of the turbidity maximum. Relatively high turbidity is a characteristic of the intermixing of fresh and saltwater where high biological productivity occurs. However, Jones et al. (1990) concluded that, in the lower Columbia River, the standing stocks of benthic infauna were highest in the protected tidal flat habitats, while those of epibenthic and zooplanktonic organisms were concentrated within the estuary mixing zone.

Stream-Type Juvenile Salmon

Because of their relatively large size and rapid migration, stream-type juveniles have somewhat different habitat requirements in the lower Columbia River and its estuary than the subyearlings. These relatively large smolts have the physical capacity to deal with a much larger range of conditions than the subyearlings.

Water Depth: These larger juveniles have been found over a substantial range of water depths although they appear to have some propensity to remain near the water surface. Because they are not shoreline-oriented, they are found throughout a substantial portion of the near-surface water column at depths of 0.3 to 10 meters.

Water Currents: The larger stream-type juveniles are capable of resisting substantially greater current velocities than subyearlings. They are found throughout a wide range of current speeds as they move downstream, generally avoiding low velocity areas except during brief periods when they tend to hold position against tidal or river currents.

Substrate Type: Salmon smolts generally are not associated with river or estuarine substrate types. Because they tend to be more water column oriented than the subyearlings, the smolts are found in areas having a wide range of substrate types.

Salinity: Stream-type juveniles commonly begin the process of smoltification prior to initiating their downstream migration. Salinity challenge tests have routinely shown they are capable of residing in moderate to high salinities long before they reach the saline water of the estuary. Sims (1970) reported that young chinook in the Columbia River that were marked one day in a fresh water area were found the next day in a high salinity area 43 kilometers downstream. Even subyearling salmon migrating from upstream areas are generally able to tolerate immediate exposure to the high salinity conditions of sea-water challenge tests by the time they reach McNary Dam, far upstream from the estuary (Tiffan, et al., 2000).

Movement from fresh water to saline water apparently does not place high metabolic demands on young salmon. Bullivant (1961) found young chinook had no significant difference in oxygen consumption rates when in fresh water, dilute sea water, or sea water (35.4 ppt). He interpreted this lack of difference in oxygen consumption as an indication that the energy expended on osmoregulation was a small portion of the total energy consumption.

Water Temperature: These habitat characteristics are the same for the stream-type guild as for the ocean-type guild.

Turbidity: These habitat characteristics are the same for the stream-type guild as for the ocean-type guild.

Adult Salmonids

Adult salmon have much less restrictive habitat requirements as they migrate through estuarine and lower river areas as compared to juveniles.

High concentrations of suspended sediment can influence the homing of adult salmon. Whitman, et al. (1982) found adult chinook tended to avoid Mount St. Helens ash at about 650 milligrams per liter (mg/L), but ash at average concentrations of 3.4 g/L in the Toutle River did not appear to influence homing performance.

Generally adult salmon are not exposed to temperatures in a lethal range because of their capacity to avoid high temperatures together with their propensity to remain in relatively open water until they reach spawning areas. However, high temperatures can delay their migrations. In 1941, extremely high water temperatures (22 to 24° C) apparently resulted in chinook, sockeye and steelhead adults congregating in small cold streams near the Bonneville and Rock Island Dams (Fish and Hanavan, 1948). At the Okanogan River Major and Mighell (1967) observed that temperatures greater than 21°C blocked sockeye migrations, while stable or even rising temperatures below 21°C did not block migration.

Trout

Considerable information regarding trout habitat was previously presented to the Sustainable Ecosystems Institute (SEI) Science Panel by Doug Young (USFWS) during the initial workshop held in March 2001. Published and other information on cutthroat trout was recently assembled by Trotter (1989) and again for Appendix D-2 of this document. Previously Sumner (1962), Lowry (1965), and Giger (1972) have provided information on anadromous forms of cutthroat trout in Oregon coastal streams, although not the Columbia River. Likewise, available information on anadromous forms of bull trout comes primarily from areas other than the Columbia River. As stated above, the characteristics of habitat used by cutthroat trout and bull trout in estuarine areas are not well defined, but can be inferred from the available information.

Most likely the trout move relatively rapidly through the lower Columbia River to the estuary or ocean. Cutthroat trout generally make up a small portion of the salmonid collections that have been obtained in the lower river, while char (bull trout/Dolly Varden) have been absent. Substantial numbers of adult cutthroat trout have been taken at times in relatively shallow water along shallow bars by sport fishers. Cutthroat have also been collected in the lower Columbia River at a number of estuarine locations (Loch, 1982) and just upstream from the estuary at Jones Beach (Dawley, 1985). Downstream migration of juvenile and adult cutthroat appears to occur in April and May, peaking in early May (Dawley, et al., 1979 and 1980). Johansen and Sims (1973) captured cutthroat in small numbers in purse seines in the channels of the lower river and estuary. Most of the trout were yearling fish collected in April to June.

In other areas, anadromous bull trout appear to move quickly through the lower river and estuarine areas during both smolt out migrations and adult spawning migrations based on their complete absence in most scientific collections. No information is available indicating holding, feeding, or other extended use of the lower Columbia River by either juvenile or returning adult bull trout. Anadromous bull trout most likely feed where forage fish are present, but not near the bottom in subtidal areas or near the shorelines, which do not provide habitat for forage fish. Anadromous bull trout have been found in Puget Sound in areas where Pacific herring, surf smelt, and Pacific sand lance spawn occur (Kraemer, 1994) apparently following concentrations of prey species.

Because bull trout are a relatively long-lived iteroparous species (spawn multiple times), the potential exists for the anadromous forms to make several outmigration and spawning runs through the lower Columbia River. Upstream migrations of bull trout spawners typically occur in early summer (late June and July) when water temperatures are relatively cool (Rieman and McIntyre, 1993), most likely in moderate to low velocity areas. Bull trout are not known to use shoreline habitat in the lower Columbia River.

4.4.2 Juvenile Salmonid Prey Resources

No information is available on prey resources historically used by young salmon before the substantial modification of the lower river and its estuary. Studies of the prey consumed by young salmon began long after the river system had become highly modified, providing information about how the system currently supports their survival, but not necessarily how it naturally supported their survival prior to modification.

Prey consumed by young salmon in the lower Columbia River with modified conditions and in other estuarine areas includes a variety of organisms (Table D4-2). As stated in Higgs, et al. (1995, p. 262), "…all Pacific salmon species are opportunistic in their food habits. Frequently, their daily diet consists of many food items. Moreover, prey selection is directed generally at the most commonly encountered species (available and abundant) that are organoleptically acceptable based on previous experience, visible, unable to escape readily, and of appropriate actual or perceived size relative to the size of the fish (Hyatt, 1979)."

In an early study of juvenile salmon food habits in the lower Columbia River, Craddock, et al. (1976) found they consume primarily insects in the spring and fall, while Daphnia is the major prey—selected more than other planktonic organisms—from July to October. Dawley et al. (1986) found that young salmon in the lower Columbia River consume diptera, hymenoptera, coleoptera, tricoptera, and ephemeroptera in the upstream portion of the area. Downstream their diet changes to diptera, cladocerans, and amphipods (*Corophium salmonis*, *Corophium spinicorne*, *Eogammarus confervicolus*). Many yearlings passing through the lower river were found by Dawley, et al. (1986) to have empty or less than full stomachs. Considerable overlap occurred in the diets of the salmon species, with dipterans being most important for coho. More recently, Bottom and Jones (1990) reported young chinook ate primarily *Corophium*, *Daphnia*, and insects, with *Corophium* being the dominant prey species in winter and spring, and *Daphnia* the dominant prey species in summer.

Corophium is commonly discussed as a primary prey item of juvenile salmon in the lower Columbia River. *Corophium salmonis* is a euryhaline species tolerating salinities in the range of 0-20 ppt (Holton and Higley, 1984). As shown by the above investigations, it is one of several major prey species consumed by juvenile chinook under existing conditions. Data from other estuaries indicates *Corophium* can be a substantial portion of the dietary intake for young salmon, but it is not included in most estuarine habitats. Data are not available that indicate its historic role in the diet of Columbia River salmon prior to substantial modification of the river system. *Corophium* may not be a highly desirable food source for young salmon. According to Higgs, et al. (1995), gammarid amphipods are high in chitin and ash and low in available protein and energy relative to daphnids and chironomid larvae. This may be in part why daphnids and chironomid larvae are commonly a major portion of the prey consumed by juvenile salmonids in the upper portions of estuaries where these organisms are generally available.

Table D3-2: Prey Consumed by Young Chinook in Estuarine Habitats (Weitkamp, 2001)

PREY CONSUMED	LOCATION	REFERENCE
Neomysis, Corophium, and insects	Sacramento-San Joaquin, CA	Sasaki, 1966
Primarily copepods, amphipods, and fish larvae within the inland delta.	Sacramento-San Joaquin, CA	Kjelson, et al., 1982
Insects in spring and fall. Daphnia is major prey, selected more than other planktonic organisms, from July to October.	Columbia R. OR-WA	Craddock, et al., 1976
Subyearlings at Jones Beach (RKm 75) were in a feeding transition zone from insects (diptera, hymenoptera, coleoptera, tricoptera, ephemeroptera) upstream to diptera, cladocerans, and some amphipods (*Corophium salmonis, C. spinicorne, Eogammarus confervicolus*) downstream. Many yearlings passing through the estuary had empty or less than full stomachs. Considerable overlap of the salmon species occurred, with dipterans most important for coho.	Columbia R. OR-WA	Dawley, et al., 1986
Chinook ate *Daphnia, Corophium* and insects, with major prey being *Corophium* in winter and spring and *Daphnia* in summer.	Columbia R. OR-WA	Bottom and Jones, 1990
Corophium, gammarids, mysids, cumacea, crangonids, and crab predominant prey.	Chehalis R. WA	Herrmann, 1970
Insects, gammarids, and mysids consumed in constructed and natural sloughs (also coho). Lower stomach content fullness in constructed sloughs.	Chehalis R. WA	Miller and Simenstad, 1997
Fry fed almost exclusively on chironomid larvae in Capitol Lake until August, when they began to feed on *Daphnia* and *Epischura.*	Deschutes R. WA	Engstrom-Heg, 1968
Dipterans, gammarids, decapod larvae, calanoids, euphausids, mysids, and fish.	Nisqually R. WA	Fresh, et al., 1978
Diptera, mysids and gammarids.	Nisqually R. WA	Pearce, et al., 1982
Copepods and harpacticoids in general area. Primarily crab larvae and gammarids in Hylebos waterway.	Commencement Bay, WA	Meyer, et al., 1981
Observed feeding under piers. Appeared to acquire less food than natural shorelines.	Commencement Bay, WA	Simenstad, et al., 1985
Ate crab larvae, and drift insects; ate chum and consumed harpacticoids in highly modified shorelines with little eelgrass or macrophytes.	Commencement Bay, WA	Simenstad, Cordell, et al., 1985
Tended to select chironomid larvae (epibenthic) in March-May in constructed wetlands, but ate few harpacticoids and nematodes although these were dominant in wetlands. In river fed on adults (neuston) as well as plecoptera, dipterans, *Daphnia, Corophium, Eogammarus*, and cyclopoids.	Puyallup R.WA	Shreffler, et al., 1992a

Gammarids, chironomids, and calanoids. Ate more marine prey at downstream locations. Near shorelines ate epibenthic. In deeper water ate pelagic prey.	Duwamish R. WA	Meyer, et al., 1980
Consumed insects, gammarid amphipods, cumacea, *Corophium*, and mysids (in order of numerical abundance); gammarids (28 percent), insects (27 percent), and fish (19 percent) were the most important by weight.	Snohomish R. WA	Conley, 1977
Chinook consumed fish larvae and gammarids along beaches, with some insects and cumacea. In deeper water they ate fish larvae, barnacle larvae, crab larvae, insects, and gammarids.	Snohomish R. WA	Parametrix, Inc., 1985
Fry consumed *Corophium*, harpacticoids, and insect larvae in marsh area.	Skagit R. WA	Congleton and Smith, 1976
Fed on copepods (50 percent) and chironomids (26 percent) eaten by fry (40-95 mm) in high saline waters.	San Juan Is. WA	Annan, 1958
Juvenile chinook and chum were found to prey on larval and juvenile baitfish.	Birch Bay Marina north Puget Sound WA	Cardwell, et al., 1980
Crab larvae, herring, sand lance larvae, and polychaetes eaten by smolts (118 mm) near shore. Offshore ate herring, euphausids, gammarids, and mysids.	Puget Sound,	Fresh, et al., 1981
Chinook preferred euphausids along with fish in spring, and crab larvae and fish during the summer. During fall they ate a variety of euphausids, amphipods, crab larvae, and fish. Offshore, chinook, chum, and coho juveniles preyed on the same food sources with different preferences.	Puget Sound	Beamish, et al., 1998
Ate pelagic prey, insects, calanoids, juvenile fish, and polychaetes in August.	San Juan beaches, WA	Simenstad, et al., 1977
Ate primarily adult insects, cumacea, and *Neomysis*. Dominant organisms varied with time of day on Fraser R. tide flat.	Fraser R. BC	Levings, 1982
Ate chironomids, cladocera, *Anisogammarus, Corophium, Neomysis*, and insects.	Fraser R. BC	Dunford, 1975
Ate harpacticoids, chironomids, adult insects, and amphipods. Diets varied considerably over time, location/habitats within, & different among years, indicating opportunistic feeders.	Fraser R. BC	Healey, 1980b
At Nanaimo, fed mainly on decapod larvae, mysids, and adult insects in the inner estuary, and larval herring in the outer estuary (1978, 1979). In 1972 their diet included more amphipods and harpacticoids. At Nitinat, fed primarily on adult insects, gammarids, and crab larvae, and occasionally on cladocera; showed seasonal shift in prey items with cladocera and fish larvae becoming important later in migration period.	Fraser R. BC Nanaimo R. BC Nitinat R. BC	Healey, 1982b
Large fry (57 to 69 mm) fed on epibenthic prey at low rates in high turbidity (370 to 810 NTU) and clear water, and at highest rates in intermediate turbidity (18 to150 NTU) present in tidal channels). Small fry (49 to 50 mm) fed at highest rates in low turbidity; planktonic prey consumed at highest rates in low turbidity for both sizes.	Fraser R. BC laboratory	Gregory, 1994
Harpacticoids important prey in March-early April, decapod larvae and amphipods in April-May, and mysids and insects in May-July. Ate fish as they moved offshore. Diets varied considerably over time, location/habitats within, & different among years, indicating opportunistic feeders.	Nanaimo R. Vancouver Is, BC	Healey, 1980b
Fed on *Anisogammarus* found in periphyton on logs and near bank substrates in Inlet having steep intertidal. Also fed on chironomids when nearshore, but fish larvae, euphausids, decapod larvae, copepods, cladocerans, chaetognaths, barnacle	Somas R., Alberni Inlet, Vancouver Is. BC	Kask and Parker, 1972

larvae, polychaete larvae, and cephalopods when in open water.		
Fed on zooplankton, not harpacticoids. Diets varied considerably over time, location/habitats within, & different among years, indicating opportunistic feeders .	Nitinat R. BC	Healey, 1980b
Ate benthic estuarine organisms along with fish in estuary in March-May, and primarily juvenile herring during July-September, along with decapod larvae.	Cowichan R. BC	Argue, et al., 1985
Ate *Anisogammarus* and *Neomysis ragii*, plus benthic invertebrates (chum and coho ate same).	Squamish R, BC	Goodman and Vroom, 1972
Neomysis and insects (June-July).	Squamish R, BC	Levy and Levings, 1978
Wild chinook consumed *Bosmina* and insects, shifted to *Neocalanus* & *Cumella* at outer estuary locations (chum same).	Campbell R. BC	MacDonald, et al., 1986

Adult salmon have generally ceased feeding by the time they enter estuarine areas. Chinook, sockeye, and steelhead have acquired food reserves in the ocean environment that sustain them through their migration according to Burgner (1991). "Salmon usually cease feeding before entering their natal streams and depend on their energy reserves for migration, maturation of gonads, spawning, and redd (nest) defense until death."

Only one investigation of the estuarine prey eaten by bull trout was identified. Narver and Dahlberg (1965) found that juvenile bull trout ate predominantly on Pacific sand lance, caplin, greenling, sculpin, and juvenile sockeye, together with Gammarus and eupahusids. Feeding by cutthroat trout and bull trout during their upstream migration through the lower river has not been defined. It is likely these fish continue to feed to some degree as they commonly retain a functional digestive system and return to saltwater following spawning.

4.4.3 Time Present in Project Area

Subyearlings

Chinook and chum fry from the lower Columbia spawning areas appear in the project area by late March. Most likely chum and the early chinook rear in the project area through late April or early June, based on the residence time of these fry in other Pacific Northwest estuaries (Weitkamp, 2001).

Yearling Smolts

Chinook, sockeye, and steelhead smolts (second to third year of life) migrate through the project area primarily from April through August.

Adults

Adult salmonids are present in the project area throughout much of the year. Generally upstream migration begins with spring chinook migrating to upstream portions of the watershed in March or April. These early chinook are followed by summer and fall run chinook that form a nearly continuous run of upstream migrants through September.

Trout

Downstream migration of juvenile and adult cutthroat appears to occur in April and May, peaking in early May (Dawley et al., 1979 and 1980). Johansen and Sims (1973) captured cutthroat in small numbers in purse seines in the channels of the lower Columbia River and estuary. Most of the trout were yearling fish collected in April to June.

Upstream migrations of bull trout spawners typically occur in early summer (late June and July) when water temperatures are relatively cool (Rieman and McIntyre, 1993), most likely in moderate to low velocity areas.

4.5 References

Berg, L., and T.G. Northcote. 1985. Changes in Territorial, Gill-Flaring, and Feeding Behavior in Juvenile Coho Salmon (*Oncorhynchus kisutch*) Following Short-Term Pulses of Suspended Sediment. *Canadian Journal of Fisheries and Aquatic Sciences* 42:1410-1417.

Bottom, D.L., and K.K. Jones. 1990. Species Composition, Distribution, and Invertebrate Prey of Fish Assemblages in the Columbia River Estuary. *Progress in Oceanography* 25:243-270.

Brett, J.R. 1995. Energetics. In: Physiological Ecology of Pacific Salmon. C. Groot, L. Margolis, and W.C. Clarke, editors. University of British Columbia Press, Vancouver, British Columbia.

Brett, J.R. 1971. Energetic Responses of Salmon to Temperature: A Study of Some Thermal Relations in the Physiology and Freshwater Ecology of Sockeye Salmon (*Oncorhynchus nerka*). *American Zoology* 11(1):99-113.

Brett, J.R. 1958. Implications and Assessments of Environmental Stress. In: The Investigation of Fish-Power Problems. P.A. Larkin, editor. H.R. MacMillan Lectures in Fisheries, University of British Columbia, Vancouver, British Columbia.

Brett, J.R. 1956. Some Principles in the Thermal Requirements of Fishes. *The Quarterly Review of Biology* 31(2):75-87.

Brett, J.R. 1952. Temperature Tolerance in Young Pacific Salmon, Genus *Oncorhynchus. Journal of the Fisheries Research* 9(6):265-323.

Brett, R.J., W.C. Clarke, and J.E. Shelbourn. 1982. Experiments on Thermal Requirements for Growth and Food Conversion Efficiency of Juvenile Chinook Salmon *Oncorhynchus tshawytscha*. Canadian Technical Report: Fisheries and Aquatic Sciences No. 1127.

Brett, R.J., J.E. Shelbourn, and C.T. Shoop. 1969. Growth Rate and Body Composition of Fingerling Sockeye Salmon, *Oncorhynchus nerka,* in Relation to Temperature and Ration Size. *Journal of the Fisheries Research Board of Canada* 26:2363-2394.

Brown, L.G. 1992. On the Zoogeography and Life History of Washington's Native Char: Dolly Varden *Salvelinus malma* (Walbaum) and Bull Trout *Salvelinus confluentus* (Suckley).

Bullivant, J.S. 1961. The Influence of Salinity on the Rate of Oxygen Consumption of Young Quinnat Salmon (*Oncorhynchus tschawytscha*). *New Zealand Journal of Science* 4:381-391.

Burgner, R.L. 1991. Life History of Sockeye Salmon (*Oncorhynchus nerka*). In: Pacific Salmon Life Histories. C. Groot, and R. Margolis, editors. University of British Columbia Press, Vancouver, British Columbia.

Calkins, R.D., W.F. Durand, and W.H. Rich. 1939. Report of the Board of Consultants on the Fish Problems of the Upper Columbia River. Stanford University, California. Section I, 20 pp. Section II, 127 p.

Clark, C., and J.E. Shelbourn. 1985. Growth and Development of Seawater Adaptability by Juvenile Fall Chinook Salmon (*Oncorhynchus tshawytscha*) in Relation to Temperature. *Aquaculture* 45:21-31.

Craig, J.A., and R.L. Hacker. 1940. The History and Development of the Fisheries of the Columbia River. *Bulletin of the Bureau of Fisheries,* No. 32.

Dawley, E.M., R.D. Ledgerwood, T.H. Blahm, C.W. Sims, J.T. Durkin, R.A. Kirn, A.E. Rankin, G.E. Monan, and F.J. Ossiander. 1986. Migrational Characteristics, Biological Observations, and Relative Survival of Juvenile Salmonids Entering the Columbia River Estuary, 1966-1983. Unpublished report by National Marine Fisheries Service, Seattle, Washington. 256 pp.

Dawley, E.M., C.W. Sims, R.D. Ledgerwood, D.R. Miller, and F.P. Thrower. 1980. A Study to Define the Migrational Characteristics of Chinook and Coho Salmon and Steelhead Trout in the Columbia River Estuary. Annual Report, National Marine Fisheries Service, Seattle, Washington. 53 pp.

Dawley, E.M., C.W. Sims, R.D. Ledgerwood, D.R. Miller, and F.P. Thrower. 1979. A Study to Define the Migrational Characteristics of Chinook and Coho Salmon and Steelhead Trout in the Columbia River Estuary. 1979 Annual Report to the Pacific Northwest Regional Commission. 90 pp.

Dawley, E.M., C.W. Sims, and R.D. Ledgerwood. 1978. A Study to Define the Migrational Characteristics of Chinook and Coho Salmon and Steelhead Trout in the Columbia River Estuary. Annual Report, National Marine Fisheries Service, Seattle, Washington. 36 pp.

Elliott, J.M. 1981. Some Aspects of Thermal Stress on Freshwater Teleosts. In: Stress and Fish. A.D. Pickering, editor. Academic Press: London.

Ellis, C.H. 1957. Effect of Salt Water Rearing on Survival of Fall Chinook Salmon. Unpublished Report by Washington State Department of Fisheries (now Department of Fish and Wildlife), Olympia, Washington. 12 pp.

Fish, F.F., and M.G. Hanavan. 1948. A Report Upon the Grand Coulee Fish-Maintenance Project 1939-1947. U.S. Fish and Wildlife Service, Special Scientific Report No. 55.

Fox, D.S., S. Bell, W. Nehlsen, and J. Damron. 1984. The Columbia River Estuary Atlas of Physical and Biological Characteristics. Columbia River Estuary Data Development Program, Portland, Oregon.

Giger, R.D. 1972. Ecology and Management of Coastal Cutthroat Trout in Oregon. Fishery Research Report Number 6. Oregon State Game Commission, Corvallis, Oregon. 61 pp.

Gilbert, C.H., and B.W. Evermann. 1894. A Report Upon Investigations in the Columbia River Basin, with Descriptions of Four New Species of Fishes. Bulletin of the United State Fish Commission, Vol. XIV for 1894. Pp. 169-209.

Gregory, R.S., and C.D. Levings. 1998. Turbidity Reduces Predation on Migrating Juvenile Pacific Salmon. *Transactions of the American Fisheries Society* 127:275-285.

Gregory, R.S. 1988. Effects of Turbidity on Benthic Foraging and Predation Risk in Juvenile Chinook Salmon. In: Effects of Dredging on Anadromous Pacific Coast Fishes. C.A. Simenstad, editor. Workshop Proceedings, University of Washington, Seattle, Washington. Pp. 64-73.

Hess, S.S. 1982. Cutthroat Trout in Lower Columbia River Tributaries of Oregon. Unpublished Report, Project Number F-99-R-6. Oregon Department of Fish and Wildlife. 12 pp.

Higgs, D.A., J.S. Macdonald, C.D. Levings, and B.S. Dosanjh. 1995. Nutrition and Feeding Habits in Relation to Life History Stage. In: Physiological Ecology of Pacific Salmon. C.L. Groot, Margolis, and W.C. Clarke, editors. University of British Columbia Press, Vancouver, British Columbia. Pp. 154-315.

Holton, R.L., and D.L. Higley. 1984. Salinity-Temperature Relations of the Amphipod *Corophium salmonis* in the Columbia River Estuary. Unpublished Report by Oregon State University to U.S. Army Corps of Engineers, Portland, Oregon. 36 pp.

Hyatt, K.D. 1979. Feeding Strategy. In: I. Volume 8: Bioenergetics and Growth. W.S. Hoar, D.J. Randall, and J.R. Brett, editors. Academic Press, New York, New York. Pp. 71-119.

Jaksi, F.M. 1981. Abuse and Misuse of the Term “Guild” in Ecological Studies. *Oikos* 37:397-400.

Johnsen, R.C., and C.W. Sims. 1973. Purse Seining for Juvenile Salmon and Trout in the Columbia River Estuary. *Transactions of the American Fisheries Society* 102:341-345.

Johnston, J.M. 1981. Life Histories of Anadromous Cutthroat with Emphasis on Migratory Behavior. In: Proceedings of the Salmon and Trout Migratory Behavior Symposium. E.L. Brannon, and E.O. Salo, editors. University of Washington, Seattle, Washington. Pp. 123-127.

Jones, K.K., C.A. Simenstad, D.L. Higley, and D.L. Bottom. 1990. Community Structure, Distribution, and Standing Stock of Benthos, Epibenthos, and Plankton in the Columbia River Estuary. *Progress in Oceanography* 25:211-241.

Kraemer, C. 1994. Some Observations on the Life History and Behavior of the Native Char, Dolly Varden (*Salvelinus malma*) and Bull Trout (*Salvelinus confluentus*) of the North Puget Sound. Unpublished draft report, Washington Department of Wildlife. 35 pp.

Ledgerwood, R.D., F.P. Thrower, and E.M. Dawley. 1991. Diel Sampling of Migratory Juvenile Salmonids in the Columbia River Estuary. *Fishery Bulletin* 89:69-78.

Lee, R.M., and J.N. Rinne. 1980. Critical Thermal Maxima of Five Trout Species in the Southwestern United States. *Transactions of the American Fisheries Society* 109:632-635.

Loch, J.J., and D.R. Miller. 1988. Distribution and Diet of Sea-Run Cutthroat Trout Captured in and Adjacent to the Columbia River Plume, May-June 1980. *Northwest Science* 62:41-48.

Loch, J.J. 1982. Juvenile and Adult Steelhead and Sea-Run Cutthroat Trout within the Columbia River Estuary, 1980. Washington Department of Game, Fish Management Division Report 82-2.

Lowry, G.R. 1965. Movement of Cutthroat Trout, *Salmo clarki clarki* (Richardson) in Three Oregon Coastal Streams. *Transactions of the American Fisheries Society* 96:334-338.

Major, R.L., and J.L. Mighell. 1967. Influence of Rocky Reach Dam and the Temperature of the Okanogan River on the Upstream Migration of Sockeye Salmon. *Fishery Bulletin* 66:131-147.

Michael, J.H., Jr. 1989. Life History of Anadromous Coastal Cutthroat Trout in Snow and Salmon Creeks, Jefferson County, Washington, with Implications for Management. *California Fish and Game* 75:188-203.

Narver, D.W., and M.L. Dahlberg. 1965. Estuarine Food of Dolly Varden at Chignik, Alaska. *Transactions of the American Fisheries Society* 94:405-408.

Noggle, C.C. 1978. Behavioral, Physiological and Lethal Effects of Suspended Sediment on Juvenile Salmonids. Thesis, University of Washington, Seattle, Washington. 87 pp.

Reiman, B.E., and J.D. McIntyre. 1993. Demographic and Habitat Requirements for Conservation of Bull Trout. U.S. Forest Service Intermountain Research Station General Technical Report INT-302.

Root, R.B. 1967. The Niche Exploitation Pattern of the Blue-Gray Gnatcatcher. *Ecological Monographs* 37:317-350.

Sigler, J.W., T.C. Bjornn, and F.H. Everest. Effects of Chronic Turbidity on Density and Growth of Steelheads and Coho Salmon. *Transactions of the American Fisheries Society* 113:142-150.

Sims, C.W. 1970. Juvenile Salmon and Steelhead in the Columbia River Estuary. Proceedings of Northwest Estuarine and Coastal Zone Symposium. Portland, Oregon. Pp. 80-86.

Smith, D.W. 1978. Tolerance of Juvenile Chum Salmon (*Oncorhynchus keta*) to Suspended Sediments. Thesis, University of Washington, Seattle, Washington. 86 pp.

Smith, H.A., and P.A. Slaney. 1980. Age, Growth, Survival and Habitat of Anadromous Dolly Varden (*Salvelinus malma*) in the Keogh River, British Columbia. British Columbia Ministry of Environment, Fisheries Management Report No. 76. 50 pp.

Stables, B. 2001. Use and Importance of the Columbia River Tidewater, Estuary, and Ocean Plume to Coastal Cutthroat Trout. Working Draft, Port of Portland, Portland, Oregon. 18 pp.

Sumner, F.H. 1962. Migration and Growth of the Coastal Cutthroat Trout in Tillamook County, Oregon. *Transactions of the American Fisheries Society* 91:77-83.

Thom, R.M. 2001. Development of a Conceptual Model for the Columbia River Navigation Channel Improvements Project Reconsultation Process. Unpublished Report, Battelle Marine Science Laboratory, Sequim, Washington. 16 pp.

Tiffan, K.F., D.W. Rondorf, and P.G. Wagner. 2000. Physiological Development and Migratory Behavior of Subyearling Fall Chinook Salmon in the Columbia River. *North American Journal of Fisheries Management* 20:28-40.

Tipping, J.W. 1981. Cowlitz Sea-Run Cutthroat Study. Report 81-12. Washington State Department of Game, Olympia, Washington.

Trotter, P.C. 1989. Coastal Cutthroat Trout: A Life History Compendium. *Transactions of the American Fisheries Society* 114:463-473.

Van Hyning, J. 1973. Factors Affecting the Abundance of Fall Chinook Salmon in the Columbia River. Research Report, Fish Commission of Oregon, 4(1):1-87.

Van Hyning, J. 1968. Factors Affecting the Abundance of Fall Chinook Salmon in the Columbia River. Dissertation, Oregon State University, Corvallis, Oregon. 424 pp.

Wagner, H.H., F.P. Conte, and J.L. Fessler. 1969. Development of Osmotic and Ionic Regulation in Two Races of Chinook Salmon *Oncorhynchus tshawytscha*. *Comparative Biochemistry and Physiology* 29:325-341.

Weitkamp, D.E. 2001. Young Salmon in Estuarine Habitats. Unpublished Report, Review Draft. Parametrix, Inc., Kirkland, Washington. 106 pp.

Whitman, R.P., T.P. Quinn, and E.L. Brannon. 1982. Influence of Suspended Volcanic Ash on Homing Behavior of Adult Chinook Salmon. *Transactions of the American Fisheries Society* 111:63-69.