FINAL

King County Marine Habitat Report
Prepared in support of the Wastewater Treatment Division Habitat Conservation Plan and The Brightwater Marine Outfall Siting Study

January 2001

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1.0 INTRODUCTION

The shores surrounding King County have a rich variety of habitats containing a great abundance and diversity of seashore life. The seashore habitats in this largely urbanized county include rocky shores with reefs, tide pools and boulders; sandy beaches exposed to light to moderately heavy surf; and quiet bays with substrate ranging from clean sand to black mud. In this setting, King County is in the planning stages of selecting a location for the construction of a new wastewater treatment facility, called Brightwater Treatment Facility, and a new marine outfall in northern King County or southern Snohomish County.

Prior to constructing the Brightwater Treatment Facility (herein referred to as Brightwater), conveyance system, and outfall, the County is preparing a Habitat Conservation Plan (HCP) under Section 10(a)(1)(B) of the Endangered Species Act. The HCP will be submitted to the National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS) as part of an application for an incidental take permit. The proposed permit would authorize impacts that may occur to species addressed in the HCP as a result of construction and operation of the north treatment facilities, thereby ensuring the project's compliance with the ESA. With the listing of chinook salmon and bull trout and the potential listing of other marine fish (e.g., certain rockfish species) and marine mammals in the Puget Sound region by the National Marine Fisheries Service (NMFS), it became apparent that a report documenting the state of marine habitats in King County was needed to assist in selection of a site for the marine outfall and preparation of the HCP.

This report is a result of a collaborative effort by the staff of Striplin Environmental Associates in Seattle, WA, Battelle Marine Sciences in Sequim, WA and King County Water and Land Division, Department of Natural Resources in Seattle, WA.

1.1 Purpose and Objectives

The primary purpose of the Marine Habitat Report (MHR) is to support the King County Wastewater Treatment Division (WTD) in preparation of its HCP by supplying information to the HCP Team on the species and types of marine habitats in the King County and southern Snohomish County region. The four objectives of the MHR are:

- Present brief life history information for the marine species proposed for coverage under the HCP (this includes species listed as threatened or endangered under the ESA and species that may be listed within the proposed 40-year HCP permit period);

- Document the marine habitats in King County and Southern Snohomish County that may be utilized by marine species proposed for coverage under the HCP;
- Document the distribution of marine species proposed for coverage in the HCP that inhabit King County and Southern Snohomish County; and
- Identify major data gaps in the distribution of species proposed for coverage in the HCP.

1.2 Description of the Study Area

The geographic area to be covered in the MHR extends from Mukilteo to the north to mid Vashon Island to the south. The east-west boundary extends from the supralittoral zone[1] on the eastern side of central Puget Sound to the King County line running through the middle of the central basin. The southern portion of the study area includes both the east and west shores of Vashon Island. The entire study area including the locations of wastewater treatment plant, combined sewer overflow (CSO) treatment plant, and CSO outfalls is presented in Figure 1-1. The study area has been further divided into three sub-areas based on north-south geography and the presence of wastewater discharges:

- Area 1. Brightwater Outfall Siting Area -- Extends from Mukilteo to Golden Gardens Park
- Area 2. WTD Existing Discharge Area -- Extends from the King County boundary to the northern tip of Vashon Island, and includes Elliot Bay
- Area 3. Vashon Island Area -- Extends from the northern tip of Vashon Island to roughly half way down the length of the island and includes both the eastern and western shores of the island.

These sub-areas are also shown in Figure 1-1.

1.3 Report Organization

The remaining sections of this report provide brief life history descriptions of the proposed covered species, describe the habitats and species distributions, and identify major data gaps. Specifically, Section 2 reviews the primary list of species and presents brief life history information, ecological role and environmental requirements for each, as well as describes the habitat types presented in the report. Sections 3, 4, and 5 discuss habitats, species distributions, and data gaps in the Brightwater Siting Area, the WTD Existing Discharge Area, and the Vashon Island Area, respectively. The report concludes in Section 6 with a synthesis and summary of all data collected for the report and

[1] The supralittoral zone is the area immediately above the intertidal zone and is often referred to as the "marine riparian" zone (see Section 2.7.1).

a discussion of major data gaps. All figures and tables presented in this report are found at the end of each section. Additional information on species diet and figures and tables on species distributions can be found in the report appendices.

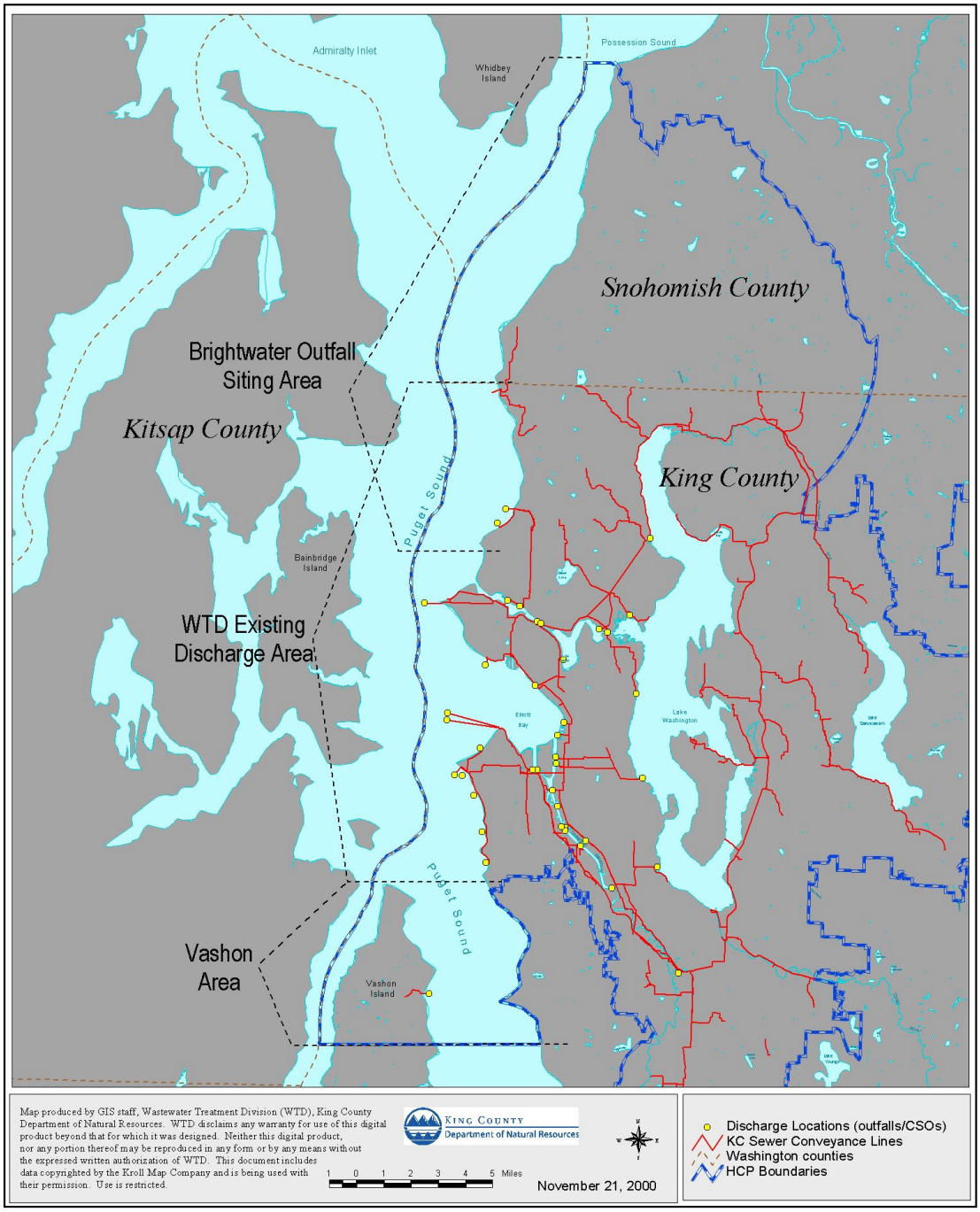

Figure 1-1. Habitat Conservation Plan Marine Study Area and three sub-areas discussed in the Marine Habitat Report.

2.0 SPECIES AND HABITAT COVERAGE

Jones and Stokes (1999) documented a number of criteria for selecting the species and habitats that are proposed for inclusion in King County's Wastewater Treatment Division's HCP. A total of 127 species are under consideration for inclusion in the HCP, and the subset of 41 species that inhabit the marine areas of the HCP Study Area are discussed in this report. The 41 marine species discussed in this report can be broken down into seven groups. These include:

- Marine Mammals and Birds 6 species
- Salmonids 7 species
- Lampreys 2 species
- Marine Invertebrates 2 species
- Ground Fish 6 species
- Forage Fish 4 species
- Rockfish 14 species

The species covered in this report are listed on the following page. Species which are currently listed under the U.S. Endangered Species Act (ESA) as threatened include the Steller sea lion, marbled murrelet, chum salmon (Hood Canal summer and Lower Columbia stocks), sockeye salmon (Lake Ozette stock), chinook salmon (Puget Sound, Snake River [spring, summer, fall], and Lower Columbia stocks), steelhead (Snake River, Middle and Lower Columbia stocks), and bull trout. Species that are currently listed as endangered under the ESA include sockeye salmon (Snake River stock), chinook salmon (Upper Columbia spring stock), and steelhead (Upper Columbia stock). Species that have been listed as a species of concern under the ESA include the harlequin duck, Pacific lamprey, and river lamprey. All remaining species have been included in this document as they are listed as a species of concern (candidate species status) by the Washington State Department of Fish and Wildlife (WDFW) and may receive federal status as a species of concern in the future.

As most of the species covered in the report are highly mobile and may migrate between Washington and British Columbia waters, the status of these species in British Columbia is provided. In 1999, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) listed the southern resident killer whale population as threatened.

Common Name	Scientific Name
Marine Mammals and Birds	
Killer Whale	*Orcinus orca*
Harbor Porpoise	*Phocoena phocoena*.
Steller (Northern) Sea Lion	*Eumetopias jubatus*
Common Murre	*Uria aalge*.
Marbled Murrelet	*Brachyramphus marmoratus*.
Harlequin Duck	*Histrionicus histrionicus*
Salmonids	
Bull Trout	*Salvelinus confluentus*.
Chinook Salmon	*Oncorhynchus tshawytscha*
Chum Salmon	*Oncorhynchus keta*
Coho Salmon	*Oncorhynchus kisutch*
Cutthroat trout	*Oncorhynchus clarki*
Sockeye salmon	*Oncorhynchus nerka*
Steelhead	*Oncorhynchus mykiss*
Lampreys	
Pacific Lamprey	*Entosphenus tridentatus*
River Lamprey	*Lampetra ayresi*
Marine Invertebrates	
Northern Abalone	*Haliotis kamtschatkana*
Olympia Oyster	*Ostrea conchaphila (*Formerly *O. lurida)*
Ground Fish	
Green Sturgeon	*Acipenser medirostris*
White Sturgeon	*Acipenser transmontanus*
Pacific Cod	*Gadus macrocephalus*
Walleye Pollock	*Theragra chalcogramma*
Pacific Hake	*Merluccius productus*
Lingcod	*Ophiodon elongates*
Forage Fish	
Pacific Herring	*Clupea harengus pallasi*
Sand Lance	*Ammodytes hexapterus*
Surf Smelt	*Hypomesus pretiosus*
Eulachon	*Thaleichthys pacificus*
Rockfish	
Brown Rockfish	*Sebastes auriculatus*
Copper Rockfish	*Sebastes caurinus*
Greenstriped Rockfish	*Sebastes elongates*
Widow Rockfish	*Sebastes entomelus*
Yellowtail Rockfish	*Sebastes flavidus*
Quillback Rockfish	*Sebastes maliger*
Black Rockfish	*Sebastes melanops*
Blue Rockfish	*Sebastes mystinus*
China Rockfish	*Sebastes nebulosus*
Tiger Rockfish	*Sebastes nigrocinctus*
Bocaccio Rockfish	*Sebastes paucispinus*
Canary Rockfish	*Sebastes pinniger*
Redstripe Rockfish	*Sebastes proriger*
Yelloweye Rockfish	*Sebastes ruberrimus*

Species also listed as threatened in British Columbia by the COSEWIC include the marbled murrelet and northern abalone. There are no HCP species that may occur in the study area listed as endangered by the COSEWIC.

A brief description of each species' life history, ecological role and environmental requirements is provided in Sections 2.1 through 2.5. These descriptions are general and are not meant to be detailed as more specific information can be found in other reference sources. The topics discussed are outlined below.

Life History	Ecological Role	Environmental Requirements
Spawning/Reproduction	Prey	Water depth
Larval Stages	Predators	Habitat
Juvenile Stages		Migration/Movement
Adult Stages		
Age at Maturity		
Gender Dimorphology		
Size		
Lifespan		

In some cases, information on these topics was not available. Finally, a general discussion of the marine habitats to be evaluated is presented in Section 2.6. The marine habitats discussed are located in the Central Puget Sound Basin, are utilized by the covered species, and extend from the deep subtidal (aphotic) zone to the supralittoral zone. Specific discussions of habitat characteristics in each of the three sub-areas are contained in Sections 3 through 5.

2.1 Marine Mammals and Birds

Three species of marine mammals and three species of marine birds are proposed for coverage in the HCP. The marine mammals include one member each of the dolphin family, the porpoise family, and the sea lion family. The marine birds include two members of the Alcid family and one member of the Anatid (waterfowl) family. Each of these is discussed below.

2.1.1 Dolphins – Family Delphinidae

There are over 30 species of dolphins worldwide, with most living in the oceans of the world. This family includes Orcas (killer whales), bottlenose dolphins, pilot whales, and Pacific white-sided dolphins. Delphinids have conical shaped teeth and a prominent dorsal fin, with the exception of one genus that has no dorsal fin. Members of this family also have either a prominent beak (bottlenose dolphins) or a short beak and a distinctly bulging forehead (Orcas). They

generally do not make prolonged deep dives and tend to frequent shallow waters and stay near the surface. They are considered fast agile swimmers and use echolocation to actively pursue fishes and squids. They may stun their prey with high-intensity sound (Yates 1998; Ridgway and Harrison 1998).

Orca -- *Orcinus orca*

Life History. Orcas (killer whales) are widely distributed in the oceans of the world, although they prefer the colder waters of both hemispheres. Orcas have strong social bonds and travel together in stable groups, called pods, of up to 50 whales. In British Columbia and Washington State, pods have been identified as either 'transient', 'resident', or ‘offshore’ based on ecology, genetics, and behavior (Ford et al. 1994).

Male Orcas can reach a length of 9.5 meters (m) and can weigh in excess of 7,300 kilograms (kg) while females rarely exceed 7 m and 3,630 kg (Ridgway 1972; Leatherwood and Reeves 1983; Yates 1998). Females become sexually mature at about 10 years of age but do not typically calve until early teens and males reach sexually maturity at 12-14 years. Females may give birth as frequently as every three years, but typically calve every 8-10 years and stop calving around the age of 40 years. Gestation is thought to be between 16 and 17 months and calves are approximately 2.5 m in length and weigh 200 kg at birth (Ford et al. 1994). The calves nurse for a minimum of 1 year and may remain within their birth pod for their entire life. Orcas are known to live over 35 years, with maximum estimates of 60 years for males and 80 to 90 years for females. However, a typical life span is around 30 years for males and 50 years for females (Ford et al. 1994).

Ecological Role. Orcas are top predators with pronounced diet differences between Puget Sound resident and transient whales. Resident whales feed primarily on fish (salmon, lingcod, halibut, flatfish, greenling) and squid, with few observations of attacks on seals and porpoises. During spring through fall, the predominant prey item is salmon, with chinook being the most preferred (Ford et al. 1994; Everitt et al. 1980). Transient whales prey mostly on other marine mammals, including harbor seals, sea lions, and porpoises, but also prey on birds and fish (Ford et al. 1994; Dahlheim et al. 2000). They have no predators other than humans.

Environmental Requirements. In the Pacific Northwest, there are resident pods of whales that consist of extended families. The southern resident whale community consisting of three separate pods (designated J, K, and L) occasionally enter central Puget Sound, particularly the J pod. The J pod currently contains 19 whales; the K pod 17 whales, and the largest, L pod, contains 47 whales (A. Traxler, Whale Museum, pers. comm.). The distribution and movements of Orcas in central Puget Sound is directly related to prey abundance and/or the search for prey (Balcomb and Goebal 1976). If there is sufficient water for locomotion, there is no area in marine waters where the

whales will not enter in search of prey (Balcomb 1982). Transient whales are not known to enter inland Puget Sound waters.

Resident whales spend the majority of time (>70%) in the upper 20 m of the water column where salmon are concentrated. However, they occasionally dive to 100 m or more (a dive of 201 m has been recorded) when they are suspected to be feeding on bottom and mid-water fish (Baird et al. 1998).

2.1.2 Porpoises – Family Phocoenidae

There are six species of Phocoenids found in the coastal waters of all oceans and seas; two species are found in Puget Sound. Porpoises are small, with robust bodies that are generally less than 2.5 m in length (Leatherwood and Reeves 1983). Unlike dolphins, porpoises have spade shaped teeth rather than conical teeth and have a poorly defined beak, if one at all. Porpoises inhabit a variety of habitats including bays, estuaries, nearshore areas, and the open sea. Although large aggregations have been reported, porpoises tend to travel in small groups averaging less than twenty individuals (Leatherwood and Reeves 1983).

Harbor Porpoise -- *Phocoena phocoena*

Life History. The harbor porpoise occurs in cold temperate and subarctic waters of the northern hemisphere and is the smallest porpoise found in the Pacific Northwest. Harbor porpoises were common throughout Puget Sound until their decline in the 1940's and now sightings south of the San Juan Islands and Strait of San Juan de Fuca are rare (B. Hanson, NMML, pers. comm.). The maximum length and weight is about 2 m and 90 kg and the average length is 1.5-1.6 m with a weight between 45-65 kg (Leatherwood and Reeves 1983). There is no size difference between males and females. Age at sexual maturity is estimated at 3-4 years and the principal mating season occurs between July and August (Ellis 1982; Palka et al. 1996). The gestation period is approximately 11 months with calves born every 1-2 years in late spring and early summer (Osborne et al. 1988). Calves are between 70-90 centimeters and nurse for approximately 8 months (Everitt et al. 1980). The harbor porpoise is one of the shortest-lived cetaceans, with a maximum lifespan of 17 years but with few animals living to 10 years (Read and Hohn 1995). The harbor porpoise avoids vessel traffic and does not ride bow waves, unlike some other porpoises and dolphins. These porpoises have a high metabolic rate that requires them to consume at least 10 % of their body weight daily, which creates a high oxygen demand (Read and Gaskin 1985). Consequently, harbor porpoises must surface frequently to breath and may surface as often as 8 times per minute which limits their dives to fewer than 4 minutes (Harrison 1974). As a result, these porpoises are not deep divers and their high-energy demands restrict lengthy migrations and movements.

Ecological Role. Harbor porpoises feed on fish, squid, and shrimp but prefer schooling fishes, such as Pacific herring, smelt, walleye pollock, and Pacific whiting (Osmek et al. 1997; Leatherwood and Reeves 1983). Kelp or seaweed,

sometimes with herring eggs attached, has also been found in their stomachs (Ridgway 1972). Killer whales and sharks are known predators of the harbor porpoise (Leatherwood and Reeves 1983).

Environmental Requirements. There are two recognized harbor porpoise stocks: the Oregon/Washington Coast stock and the inland Washington stock. The inland Washington harbor porpoise stock occurs in British Columbia and Washington State waters but sightings are rare south of the San Juan Islands and the Strait of San Juan de Fuca (Calambokidis et al. 1992; B. Hanson, NMML, pers. comm.). This is primarily a coastal species and is frequently found in bays, estuaries, tidal channels, and nearshore areas (Forney et al. 1999; Leatherwood and Reeves 1983). They prefer water temperatures from 5 to 16°C (Ellis 1982). Seasonal movements follow prey availability and tend to be inshore to offshore, rather than north to south (Osborne et al. 1988). Harbor porpoises usually travel singly or in small groups of 2-6 individuals but occasionally large aggregations will be seen where prey is abundant and during the mating season (Osborne et al. 1988). Although harbor porpoises may be seen year round throughout their range, the largest concentrations are found in summer and early fall in the northern San Juan Islands (Osborne et al. 1988). Harbor porpoises are usually found in waters less than 200 m deep in the eastern North Pacific (Osmek et al. 1997).

2.1.3 Eared Seals – Family Otariidae

This family contains 14 species worldwide, two of which are found in Puget Sound. Otariids have small external ears and can use their rotating hind flippers to move quickly on land, which distinguishes them from the true seals. In the water, they use their long fore flippers to move themselves through the water while they steer with their hind flippers. Otariids range from 150 kg to 1,100 kg in size, with females much smaller than males. The size difference between males and females is common for pinnipeds that have polygynous breeding habits. Otariids form large congregations during the breeding season with males maintaining harems and vigorously defending their territories. Upon arrival at the breeding grounds and before mating, females give birth to young from the previous year's breeding season.

Steller (Northern) Sea Lion -- *Eumetopias jubatus*

Life History. The Steller sea lion is found throughout the north Pacific rim and in the eastern Pacific ranges from Alaska to central California. This sea lion is the largest of the eared seals. Males may attain a maximum length of 3.3 m and weight of 1,120 kg but averages about 2.8 m and 566 kg. Females are much smaller with a maximum length and weight of 2.9 m and 350 kg, respectively, but average approximately 2.3 m and 263 kg (Reeves et al. 1992). Males reach sexual maturity at approximately 3-7 years of age but do not typically breed before they are 10 years old, as they cannot successfully defend a territory until this time. Dominant males will fast from 1-2 months while maintaining a

territory at a rookery (breeding and pupping area). Most females attain sexual maturity between 4 to 5 years of age (Reeves et al. 1992). Gestation is about 12 months (including a 3 month delayed implantation stage) and females give birth to a single pup annually (Burns et al. 1985). Pups are born between mid-May to mid-July and weigh between 16 and 23 kg (Reeves et al. 1992). Pups will nurse for approximately 9 days and then the mother will go to sea to feed and alternate nursing with 1-3 day feeding trips. Pups usually nurse for up to 1 year but may nurse for 2 years (Reeves et al. 1992). Males are not known to live longer than 18 years and information regarding lifespan of females was not readily available (Reeves et al. 1992).

Within Puget Sound, Steller sea lions are seen in small groups but at their haulout sites in northern Puget Sound and the outer Washington coast, they may occur in large aggregations of 100 or more individuals (Jeffries et al. 2000). They are often seen at haulout sites with California sea lions.

Ecological Role. Most of the diet information for Steller sea lions is for the Alaskan population and little is known about food habits and diet for this species in Washington State. One of the few studies conducted in Washington waters found the dominant prey item to be Pacific whiting. Other prey items included Pacific herring, spiny dogfish, skates, and smelt. This study also determined that although salmonids were preyed upon, they did not make up a significant portion of the diet (Gearin et al. 1999). Males have been known to occasionally prey on other pinnipeds, particularly northern fur seal pups (Osborne et al. 1988). Prey for Steller sea lions in British Columbia and Alaskan waters includes various flatfish, Pacific whiting, walleye pollock, rockfish, Pacific herring, salmon, squid, and octopus (Everitt et al 1980). Predators include sharks and killer whales (Mate and Gentry 1979).

Environmental Requirements. Although single animals can occasionally be seen in inland Puget Sound at any time, they are seen most often from early fall to early spring and seldom during the summer months (Jeffries et al. 2000; Everitt et al. 1980). The migration and abundance of Steller sea lions on the northern Washington coast appears to be strongly correlated with the availability of Pacific whiting (Gearin et al. 1999). Haulout sites are found on jetties, offshore rocks, coastal islands, and navigational buoys. In inland Puget Sound, Steller sea lions (1 to 2 individuals) can typically be seen on navigational buoys and a few individuals can also be found interspersed with California sea lions in the Everett Harbor area (M. Lance, WDFW, pers. comm.). The closest congregations (> 10 individuals) to Puget Sound are found at Tatoosh Island on the outer coast, Sombria Point and Race Rocks in the Strait of Juan de Fuca, and Sucia Island in the San Juan Islands. None of these areas are breeding rookeries (Osborne et al. 1988).

Steller sea lions forage mostly in nearshore areas and over the continental shelf at relatively shallow depths in the water column. However, they are capable of diving to deeper depths and a dive of close to 300 m has been recorded (Reeves et al. 1992).

2.1.4 Alcids – Family Alcidae

The family Alcidae has 23 species and includes auks, puffins, guillemots, murres, and murrelets. Alcids are diving seabirds that come ashore only to breed. They are found in northern oceans and breed as far south as Baja California. The sexes are similar and adults fly and walk poorly. In the water they use their feet for surface movement and their wings to swim underwater. They are migratory and gather in large colonies to breed. Alcids are pelagic but stay close to shore and catch their prey underwater. They lay their eggs on rocky ledges with little or no nesting material. Both parents care for the eggs and young birds (Parker 1982; Yates 1998).

Common Murre -- *Uria aalge*

Life History. The common murre is a true seabird found in the northern hemisphere and is a permanent resident of the Washington coast. This species spends most of the year on open waters and only comes to shore to nest in breeding colonies during the months of June and July (Angell and Balcomb 1982). These birds reach a length of 41 cm, have short wings (approximately 20 cm) and tail feathers, and have their feet positioned close to the tail (Freethy 1987). As a consequence, they are poor fliers but excellent swimmers. They breed in large colonies on rocky cliffs on the Washington coast where each pair lays a single egg on bare rock. The egg incubation time ranges from 28-39 days during which time the male and female take turns brooding the egg constantly (Freethy 1987). The juveniles jump from the cliffs into the sea to join their parents approximately 3-3.5 weeks after hatching but are not able to fly until 50-70 days after hatching (Freethy 1987; Baron and Acorn 1997). During this time the chicks are susceptible to storms and predation (Alcorn 1978; McConnaughey and McConnaughey 1985). Most common murres do not breed until they are 5 years old and the lifespan has been estimated to be at least 25 years (Freethy 1987).

Ecological Role. The diet of the common murre includes small fish, worms, and other marine invertebrates such as crustaceans and molluscs (Ehrlich et al. 1988; Jewett et al. 1953; Terres 1987). Fishes are the dominant prey items, consisting primarily of sand lance, smelt, and capelin, with sand lance the preferred prey (Angell and Balcomb 1982). Information on murre predators was limited; however, predators include gulls (both on eggs and young) at the breeding colony and at sea before the chicks fledge. Although not direct predation, eggs of common murres are often dislodged from rocky ledges when panicked adults fly off the nest (Gaston and Jones 1998). Predators of colonial seabirds in general include avian predators such as bald eagles, peregrine falcons, gulls and land predators such as mustelids, mice, and foxes (Gaston and Jones 1998).

Environmental Requirements. Although a resident of Washington's coast, these birds do not breed in Puget Sound and appear in the Sound in late summer and fall as the coastal colonies disperse (Angell and Balcomb 1982). This cross migration of Puget Sound occurs with the coastal breeding in summer months.

Common murres feed by diving under the water to catch their prey. Common murres will typically dive to a depth of 20-30 m to feed upon small schooling fish and have been recorded to a maximum dive depth of approximately 167 m (Ehrlich et al. 1988; Yates 1998). The common murre spends most of its time in open water and comes to shore only to breed. Their nesting habitat can be found along rocky cliffs. They migrate, in some cases hundreds of miles, to over-wintering areas, including Puget Sound, after the young fledge and leave the breeding colonies (Baron and Acorn 1997).

Marbled Murrelet -- *Brachyramphus marmoratus*

Life History. The marbled murrelet is a small seabird that occurs in the Pacific from Alaska to southern California (Nelson 1997). This species spends most of its life on the ocean and nearshore marine waters but moves inland to nest in trees in older, coastal forests. In Puget Sound, marbled murrelets nest inland, often in large conifers that are most often associated with old growth forests (Angell and Balcomb 1982). At higher elevations they may also use ground burrows for nesting. Marbled murrelets do not reach sexual maturity until their second year and there is no difference in size between the sexes. They nest inland from mid April to late September and lay one egg. The incubation time is approximately 30 days, with about 28 days to fledge. After nesting season their plumage changes from brown to black and white. Adults are 24-25 cm in length with a wing length of 12-15 cm (Nelson 1997). They are most readily seen flying at dawn and dusk (Jewett et al. 1953; Alcorn 1978; WDFW 1993a; Baron and Acorn 1997).

Ecological Role. Marbled murrelets are considered opportunistic feeders and dive for small schooling fishes in clear open waters. During the breeding season, they feed primarily on fish such as sand lance, Pacific herring, surf smelt, and sea perch with sand lance being the dominant prey item (Angell and Balcomb 1982; Nelson 1997). During the winter and spring murrelets feed primarily on small crustaceans (euphausiids and amphipods), surf smelt and Pacific herring. They are also known to prey on walleye pollock, rockfish, cod, squid, and shrimp (Nelson 1997). Predators on eggs include ravens, Steller's jays, mice and squirrels. Chick predators include ravens, Steller's jays, and sharp-shinned hawks (Nelson 1997; Masselink 1999; Marzluff et al. 1999). Known predators of nesting adults include great horned owls, peregrine falcons, Cooper's hawks, and sharp-shinned hawks. Predators on adults while at sea include peregrine falcons, bald eagles, western gulls, and northern fur seals (Nelson 1997).

Environmental Requirements. The marbled murrelet is a year-round visitor to the Puget Sound region, although its numbers are typically greater in fall and winter as many are winter residents only (Angell and Balcomb 1982). Seasonal movements consist primarily of movements from outer coastal areas to protected waters (i.e., into Puget Sound) and from inland waters to breeding areas (Nelson 1997). They have been recorded in some inland stands during all months of the year. They are most often associated with the nearshore marine environment,

primarily within 5 km of shore and in waters less than 60 m deep (Nelson 1997; Terres 1987). It has been noted that they avoid kelp beds (Jewett 1953).

Marbled murrelets may obtain prey throughout the water column, including the bottom, and most likely forage in waters less than 50 m deep (Nelson 1997). Generally, open waters of entrance channels off rocky shores or over reefs are important feeding locations (Angell and Balcomb 1982).

2.1.5 Waterfowl – Family Anatidae

The Anatid family includes swans, geese, and ducks. Male and female swans and geese are similar in appearance while male ducks are colorful and females are brown. All waterfowl have webbed feet, narrow pointed wings, and most have long necks. Most have long flat bills with serrated edges to filter small plants and animals from the water. Most are gregarious, monogamous, and migratory. The harlequin duck belongs to the sea duck Tribe *Mergini* (Parker 1982; Yates 1998).

Harlequin Duck -- *Histrionicus histrionicus*

Life History. On the west coast, harlequin ducks are distributed from Alaska to northern California and are residents in Puget Sound. Harlequin ducks use fast-flowing rivers and streams for breeding (and occasionally estuarine areas), and then migrate to coastlines where they occupy shallow intertidal zones (Robertson and Goudie 1999). They are diving ducks and will flip over cobbles and rocks in search of prey, but will also dabble at the surface in search of insects (Robertson and Goudie 1999). Harlequins are typically 33-46 cm in length with a wingspread of 66 cm and the males are slightly larger than females (Angell and Balcomb 1982; Robertson and Goudie 1999). Males have very distinctive breeding plumage. The females lay their eggs (5-10) in riparian zones of upland streams. The incubation time is approximately 30 days, with about 40-60 days to fledge (Ehrlich et al. 1988; Terres 1987). The females travel downstream with the juveniles to join the males in the Sound for the winter; typically October to May (Angell and Balcomb 1982; Alcorn 1978; Baron and Acorn 1997). The life span is not known but one banded harlequin duck was estimated to be a minimum of 10 years old (Robertson and Goudie 1999).

Ecological Role. While on breeding grounds, harlequin ducks feed on aquatic insects and fish eggs. On wintering grounds in marine waters, they feed on intertidal and subtidal marine invertebrates, particularly crabs, amphipods, barnacles and snails, at depths between 10-20 m. Other prey items include chitons, echinoderms, limpets, and mussels. They occasionally feed on small fish (sculpins and gunnels) and fish eggs (herring, salmonids, and suckers) on wintering grounds (Robertson and Goudie 1999). Juveniles feed on same prey items as adults but will also feed on some algae and seeds (Robertson and Goudie 1999).

Predators include bald eagles and mustelids (mink and river otters), which have been known to prey on ducklings and nesting females. Ducklings and nesting

females are also vulnerable to predation by hawks and great horned owls. Egg predators include ravens, mink, and possibly squirrels (Robertson and Goudie 1999).

Environmental Requirements. Harlequin ducks require the freshwater of rivers and streams for breeding and rearing of juveniles in early spring (Jewett et al. 1953; Yates 1998). After breeding, the males and nonbreeding females gather in small groups on rocky Puget Sound shores through the summer. In winter, they gather in small groups in the nearshore environment and in Washington, are often found in less than 1.5 m of water over eelgrass and kelp communities (Robertson and Goudie 1999). They are also associated with cobble and rocky nearshore areas as they have the ability to dive and turn over rocks in search of invertebrate prey. They dive most frequently in shallow waters but are good swimmers and may dive to at least 20 m. These birds roost on open water farther from shore at night (Robertson and Goudie 1999).

2.2 Salmonids

Seven species of salmonids will be included in the HCP. These include chinook, chum, coho, and sockeye salmon, bull and cutthroat trout, and steelhead.

Members of the family Salmonidae are medium to large fish and are powerful swimmers. They have a small dorsal adipose fin that distinguishes this family from all other fish except smelts. Most salmon and trout in the Pacific Northwest are anadromous (live most of their life in salt water but return to freshwater to spawn). There are some salmonid species and runs that are not anadromous and spend their entire life in freshwater; e.g., Kokanee and cutthroat trout. Sexual dimorphism is pronounced at spawning time with changes in color and with males developing large canine teeth, a hooked jaw, and a “razor back.” Spawning adult females dig shallow depressions in the gravel beds of streams and lay small round eggs for males to fertilize. Pacific salmon die soon after spawning but some sea run trout, steelhead and bull trout can return for multiple yearly spawning. After 2-5 months the eggs hatch from the gravel. Pink and chum salmon migrate downstream immediately after hatching; chinook, coho, and steelhead remain in the stream for 6 months to two years; and sockeye move to lakes for their first 1 to 2 years. Juvenile members of the family Salmonidae use estuaries to transition into saltwater and to feed and grow (Yates 1998). Salmonids are highly migratory and most feed in the ocean for several months to several years before returning to their native rivers to spawn (Pearcy 1992).

In general, the marine phase of salmonid life history is not as well understood as the freshwater phase. Only recently have ocean environmental conditions been considered an important factor to be considered in the management of salmon resources (Bisbal and McConnaha 1999). Historically, the ocean was assumed to be an unlimited resource for salmon production, but this assumption is now being widely questioned. The suggestion that the first few months of marine rearing

can be a critical period of mortality is not new (Healey 1980). Information on marine rearing by juvenile salmon is sparse and derived primarily from purse seine, trawl, and beach seine sampling. The period of residence within "inside waters" (e.g., Puget Sound or Strait of Georgia) is variable among the different anadromous salmonids and even within a species. For example, ocean-type chinook tend to spend more time rearing in inside waters compared to larger stream-type chinook. Some coho and chinook individuals that locate sufficient food sources remain within inside waters for their entire marine rearing phase or have limited migrations (Sandercock 1991). Healey (1980) also suggested there is a tendency towards resource partitioning based upon fish size and preferred forage type. Salmon that enter marine waters as fry (pink, chum, ocean-type chinook) or that prefer smaller foods (sockeye) tend to stay in shallow estuarine and nearshore waters and feed on copepods, amphipods, and invertebrate eggs. In contrast, coho and stream-type chinook that enter marine waters as larger fish prey upon larger invertebrates and other fish (Healey 1980).

Migration patterns are one of the better-understood aspects of the marine life history phase. Most Pacific salmon stocks have a tendency to migrate in a northerly direction after entering the ocean. Chinook and coho salmon usually remain within the confines of the continental shelf. In contrast, pink, chum, steelhead, and sockeye salmon may migrate long distances to feed in pelagic regions of the North Pacific Gyre off the coast of Alaska. During the spring and summer of their last year in marine waters, maturing adults navigate towards their natal rivers for spawning. A number of mechanisms have been proposed that allow salmon to find their home stream including both celestial and magnetic orientation (Quinn and Dittman 1990). As fish approach their streams, olfaction begins to take over, and they ultimately find their natal streams following odors imprinted during their early life history (Quinn and Dittman 1990).

Pacific salmon primarily use surface waters during their marine phase—usually depths less than 50 m (CATAG 1999; Burgner 1980; Ichihara and Nakamura 1982; Healey 1980). Ultrasonic tracking of fish has revealed detailed data on their homing, migration, and rearing in the open ocean. In the open ocean, sockeye, pink, coho, chum, and steelhead swim at the shallowest depths, usually less than 10 ms, while chinook swim somewhat deeper, between 20 and 40 m (CATAG 1999). However, brief dives may occur to 150-200 m in depth (CATAG 1999). Depths used by returning sockeye and steelhead within inside waters are also shallow and appear to be related to the depth of the thermocline/halocline (Quinn et al. 1989; Ruggerone et al. 1990).

Bull Trout – *Salvelinus confluentus*

Life History. The bull trout is a char native to the Pacific Northwest and western Canada. The taxonomic distinction between bull trout and Dolly Varden (the other native char in the Pacific Northwest) has been debated although the two chars are genetically distinct and are currently considered two separate species (King County 2000a). Bull trout exhibit four distinct life history patterns: stream-resident, fluvial, adfluvial, and anadromous (McPhail and Baxter 1996).

Stream-resident, fluvial, and adfluvial forms complete their entire life cycle in freshwater while anadromous forms spend a portion of time in saltwater. There are several drainages in Puget Sound where anadromous bull trout are known/thought to occur, including Hood Canal, Skykomish River, Skagit River, Green River, and Cedar River watersheds (WDFW 1998). The Skagit River supports the largest natural population of anadromous bull trout/Dolly Varden in Puget Sound (WDFW 1998).

Bull trout mature at five to seven years of age with spawning in Puget Sound streams and rivers peaking in September and October. Fry emerge from the streambed in late winter to early spring and juveniles grow in the stream for two to three years, but this time may be shorter dependent upon life history strategy (King County 2000a). All bull trout forms may spawn repeatedly and can live as long as 12 years (Rieman and McIntyre 1993). The anadromous form is the least studied of all the bull trout forms and information regarding time spent in the marine environment is lacking.

Ecological Role. Adult bull trout are opportunistic feeders with food habits reflecting their life history strategy. Freshwater forms feed on salmon, trout, sculpins, kokanee, and steelhead fry (Rieman and McIntyre 1993). Anadromous forms feed primarily on fish such as salmon, trout, whitefish, yellow perch, and sculpins (63 FR 31693). Observations of adult char (both bull trout and Dolly Varden) in northern Puget Sound marine waters indicate feeding on bait fish (smelt, Pacific herring, Pacific sand lance) and pink salmon smolts (Kraemer 1994). Juveniles of all forms feed on terrestrial and aquatic insects, zooplankton, amphipods, mysids, and crayfish (Rieman and McIntyre 1993). Once juveniles reach a length of approximately 110 mm, they feed on small fish such as sculpins, whitefish, and trout fry (McPhail and Baxter 1996). Information on bull trout predators was scarce but may include warm-water species such as bass, centrarchids (sunfish), and perch (WDFW 1998).

Environmental Requirements. Water temperature is thought to be the most important habitat feature limiting the distribution and abundance of this species. Bull trout are uncommon in freshwater environments where water temperatures exceed 15 ^{o}C for more than a few days per year (King County 2000a). Both juvenile and adult bull trout have been found to be associated with coarse substrates such as gravel, cobble, and boulders. Larger fish tend to congregate in deeper pools, particularly those containing large woody debris or undercut banks (King County 2000a).

Anadromous adults begin downriver migration after spawning from late fall to early winter and enter estuarine waters in the spring. They remain in estuarine waters until early to mid-summer then move upriver (WDFW 1998). Anadromous smolts migrate in the spring (April to June) to river mouths and nearshore estuarine areas then return to the lower river areas in the fall, where they overwinter in the lower river (Kraemer 1994). The smolts then move into estuarine waters in late winter and early spring and will remain in these waters until starting their spawning migration in late May to July (Kraemer 1994,

WDFW 1998). Information regarding water depth and nearshore usage for both juveniles and adults in estuarine waters is lacking.

Chinook Salmon -- *Oncorhynchus tshawytscha* --- juveniles

Life History. Although life history strategies for chinook salmon are complex and diverse, there are two main life-history types: stream-type and ocean-type. The stream-type remains in freshwater for a year or more before migrating to ocean waters and the ocean-type migrates to ocean waters within one year (Myers et al. 1998). Most chinook in coastal areas, including Puget Sound, are the ocean-type, which reside in estuarine waters longer than the stream-type. Juveniles may reside up to 189 days in estuarine waters although data for residence times in nearshore areas are lacking (Wallace and Collins 1997).

Ecological role. There are two broad categories of juvenile chinook feeding. The first category is nearshore feeding fish that consume mainly gammarid amphipods, other epibenthic crustaceans, and terrestrial (neustonic) insects. The second category is pelagic feeding fish that feed as small juveniles on planktonic crustaceans (primarily euphausiids, as well as shrimp and crab larvae, planktonic amphipods, and copepods) and as larger juveniles on herring and other fish (Simenstad and Cordell 2000; Myers et al. 1998; see Appendix A).

Predators on juvenile chinook salmon include other salmonids, sculpins, and a variety of birds (Emmett et al. 1991).

Environmental Requirements. Important habitat for chinook salmon in Puget Sound includes intertidal and shallow subtidal areas that contain high abundances of prey items used by chinook juveniles, including harpacticoid copepods and gammarid amphipods (Simenstad and Cordell 2000). Important habitats probably include intertidal mud flats as well as areas of high detritus buildup. Based on beach seine catches, it is believed that juvenile chinook are oriented to shallow water depths located close to shore. The actual depth distribution has not been studied. Juvenile chinook are found in greatest numbers in channels and shallow waters near estuarine and tidal marshes, eelgrass meadows, and over tideflats, but are also known to occur near kelp forests and seaweed beds (C. Simenstad, Univ. of Wash., pers. comm.). Although not well studied, it is believed that the juveniles generally are found in areas with low tidal surge and wave energy (Simenstad and Cordell 2000).

Juveniles migrate along the shorelines of estuaries and the nearshore zone, where they are known to feed and rear young. Estuarine residence times vary with geographic distribution and can range from 1 to 60 days (Shreffler et al. 1990) but may be up to 189 days (Wallace and Collins 1997). During estuarine residence, the fish can move both downstream and upstream, perhaps driven by tidal dynamics in the system.

Chinook Salmon -- *Oncorhynchus tshawytscha* --- adult

Life History. Chinook salmon can be found from southern California to the Bering Sea. They mature in three to six years and return to spawn in larger Puget Sound streams in spring and fall. In Puget Sound, the spring-run chinook typically return to freshwater in April and May and spawn from August to September. Summer-run chinook return to freshwater from June to July and spawn in September. The fall-run chinook begin to return to freshwater in August and spawn between late September to January (Myers et al. 1998). Most adult chinook weigh less than 23 kg but individuals weighing 57 kg have been recorded (Emmett et al. 1991).

Ecological Role. Adult chinook are carnivorous opportunistic feeders. They feed primarily on fishes, including northern anchovy, scorpaenids, Pacific herring, Pacific sand lance, and euphasiids, decapod larvae, squid, and other invertebrates. Chinook salmon may directly compete with coho salmon for prey. Adults do not feed after entering freshwater. Adult chinook salmon are prey for marine mammals (e.g., sea lions, and Orcas). Upon entering freshwater chinook fall prey to eagles, bears, and other mammals (Hart 1980; Emmett et al. 1991; Kruckeburg 1995).

Environmental Requirements. Eggs and alevins require spawning gravel or cobble; freshwater juveniles are found over all substrates; saltwater juveniles in estuaries are found over mud, sand, gravel, and eelgrass; and marine adults do not show a preference for any substrate type. Adults inhabit the nearshore and estuaries. Chinook adults spawn in deeper water (generally main river channels) than other salmon and require larger gravel.

Chum Salmon -- *Oncorhynchus keta* --- juveniles

Life History. Chum fry enter the estuary immediately after emerging from the redd, and reach the estuary at a relatively small size (30-55 mm). The migration period in Washington estuaries is between January and July, with a peak from March to May (Emmett et al. 1991). Chum migration slows once the fish are in the estuary where they may remain for up to several months. When they reach a fork length of about 80-100 mm, chum salmon move offshore to feed on zooplankton.

Ecological role. Similar to chinook, chum salmon depend on two major habitats for feeding. In the spring when they are small, they feed primarily on the epibenthic harpacticoid copepods *Harpacticus* spp. and *Tisbe* spp. (Cordell 2000, Appendix A). Food web linkages at this stage have been presumed to be detritus based, but may also include some epibenthic primary production organisms (e.g., diatoms). At this time, they also feed on epibenthic aquatic insect larvae such as chironomids. In late spring to early summer, chum salmon switch to feeding on planktonic primary consumers such as larvaceans and copepods. In the summer, they feed on larger zooplankton such as euphausiids, hyperiid amphipods, and fish larvae (Johnson et al. 1997; Cordell 2000, Appendix A).

Predators on chum salmon include other salmonid species, particularly coho and cutthroat trout, sculpins, and Pacific cod, and a variety of marine birds (Johnson et al. 1997).

Environmental Requirements. Like chinook, juvenile chum are oriented to shallow water depths located close to shore. Although the depth distribution has not been studied, juvenile chum are found in greatest numbers in channels and shallow waters near estuarine and tidal marshes, eelgrass meadows, and over tideflats, but are also known to occur near kelp forests and seaweed beds (Johnson et al. 1997). Juvenile chum prefer exposed cobble and gravel beaches in nearshore areas, particularly in embayments. They school in shallow habitats during the day but disperse into smaller groups at night (Johnson et al. 1997). Estuarine residence times vary but have been documented to range from 1 to 14 days (Shreffler et al. 1990) and 4 to 32 days (Johnson et al. 1997). During estuarine residence, the fish can move both downstream and upstream, perhaps driven by tidal dynamics in the system. During their first year at sea, juveniles tend to group together and remain relatively close to shore—generally within 36 km (Johnson et al. 1997).

Chum Salmon -- *Oncorhynchus keta* --- adults

Life History. Chum salmon are found from Northern California to the Bering Sea and are the second most abundant and the most widely distributed salmonid in the north Pacific region. Chum salmon are anadromous and spawn in Puget Sound rivers in late fall. They are sexually dimorphic when they reach maturity between two and seven years of age. Adult chum salmon average four kg in weight (Hart 1980; Emmett et al. 1991).

Ecological role. Adult chum salmon are opportunistic carnivores and feed upon euphasiids, squids, pteropods, and fishes (Emmett et al. 1991). Orcas, harbor seals, and other mammals eat adult chum salmon. Spawning adults are eaten by large birds, including eagles and osprey, and bears. Pink salmon and chum salmon may directly compete for prey resources (Hart 1980; Emmett et al. 1991; Kruckeberg 1995).

Environmental Requirements. Chum salmon are generally highly migratory. Although most chum salmon move offshore in spring and early summer and head north to the Gulf of Alaska and other waters, some chum appear not to migrate and remain in Puget Sound. Adult chum salmon are epipelagic and prefer the bottom when in rivers and streams. Adults occur over a variety of substrates (Hart 1980; Emmett et al. 1991; Pearcy 1992).

Coho Salmon -- *Oncorhynchus kisutch* --- juveniles

Life History. Coho migrate as smolts from freshwater through the estuarine waters to ocean waters. By the time they reach the estuary, they are usually large enough that they are no longer dependent on benthic prey resources. The peak outmigration for juveniles, regardless of area, usually occurs in May (Weitkamp et al. 1995).

Ecological role. There is limited diet data for juvenile coho salmon. It appears that food web linkages for Puget Sound coho salmon are similar to those for chinook, with larger fish feeding on herring and other "baitfish" and smaller fish feeding on planktonic crustaceans. Coho differ from chinook in being less dependent on benthic/epibenthic habitats, as evidenced by fewer cases of diet dominated by taxa such as gammarid amphipods (Cordell 2000, Appendix A). When amphipods occurred as important prey for coho, they were often pelagic types, such as the gammarid *Cyphocaris challengeri* and the hyperiid *Parathemisto pacifica* (Cordell 2000, Appendix A).

Predators on juvenile coho salmon in estuaries include other salmonid species, sculpins, and a variety of marine birds.

Environmental Requirements. Smolts are often caught in intertidal and pelagic habitats in estuaries; however, the actual depth distribution has not been studied. Coho smolts are often found in beach seine catches collected over shallow habitats such as eelgrass meadows and tideflats. Being much larger than chinook and chum juveniles, it is assumed that they migrate through the estuary and nearshore zone rather rapidly.

Coho Salmon -- *Oncorhynchus kisutch* --- adults

Life History. Coho salmon are found from northern California to the Bering Sea. Coho salmon are anadromous and die after spawning. Coho salmon spawn in Puget Sound in winter. Most coho mature between 2 and 5 years (with an average of 3 years) and range from 41 to 100 cm in length (Emmett et al. 1991). Up to 5% of the native coho of Puget Sound may reach maturity within the Strait of Juan de Fuca (Hart 1980; Emmett et al. 1991; Pearcy 1992).

Ecological role. Coho eat fishes, including northern anchovy, Pacific herring, Pacific sardine, scorpaenids, and capelin. Coho are eaten by marine mammals, including harbor seals, Steller and California sea lions, and Orcas. Mammals including bears and large birds such as osprey and eagles prey upon spawning coho.

Environmental Requirements. Adult coho are primarily epipelagic, staying near the ocean surface, usually within the top 10 m (Emmett et al. 1991). They are found in ocean waters ranging from 4 to 15°C (Emmett et al. 1991). Coho are bottom oriented when in rivers and streams and can be found over a wide variety of substrates ranging from mud flats to rocks.

Cutthroat trout -- *Oncorhynchus clarki*

Life History. Cutthroat trout are found from northern California to southeast Alaska and are found in most of the major rivers emptying into Puget Sound as well as the Lake Washington system (Johnson et al. 1999). The cutthroat trout has an anadromous form (referred to as coastal cutthroat) that returns to the ocean after spawning or over-wintering in freshwater. Native adults mature from 2 to 10 years of age and can reach 46 cm in length (Emmett et al. 1991). One-year-

old hatchery fish can return to freshwater to spawn. In Puget Sound, coastal cutthroat trout rarely extend further inland than 160 km and are usually found less than 100 km inland (Johnson et al. 1999).

Ecological role. Juvenile and adult cutthroat feed on northern anchovy, kelp greenling, scorpaenids, salmonids, euphausiids, mysids, and crab megalopae (Emmett et al. 1991). There is limited information about predation on cutthroat, but sculpins, salmonids, and piscivorous birds likely feed on juveniles and marine mammals prey on this species in marine waters.

Environmental Requirements. Cutthroat trout migration is not well understood, with some fish remaining close to where they entered saltwater and others documented as far as 20 miles offshore (Hart 1980; Emmett et al. 1991; Pearcy 1992). Juveniles and adults typically migrate through estuaries, although some are known to remain in the estuary. Adult cutthroat trout can be found in tidal freshwater areas of estuaries as they await favorable conditions to go upstream. Juveniles and adults can be found over a variety of substrates.

Sockeye salmon -- *Oncorhynchus nerka*

Life History. Sockeye salmon are found from southern Oregon to the Bering Sea. Most spawn in streams near lakes or in lakes themselves where juveniles rear for one to three years before migrating to the ocean. In Washington waters, the lake/stream residence time is normally one to two years (Gustafson et al. 1997). River-type sockeye use lakes for rearing, migrate to ocean waters, and return to their natal lake system after spending one to four years in the ocean. Sea-type sockeye, which spawn in rivers, use lower, slow-velocity sections in rivers as juvenile rearing habitat for one to two years or migrate to the ocean after spending only a few months in freshwater (Gustafson et al. 1997). Sea-type sockeye also return to natal spawning habitat after spending one to four years in the ocean. Sockeye have a non-anadromous form (called kokanee), which reside in lakes and spawn in freshwater stream. The river and sea-type sockeye make extensive migrations, with juveniles from Washington waters initially migrating to the Gulf of Alaska staying relatively close to shore before moving to offshore waters (Gustafson et al. 1997). Adult sockeye average 64 cm in length and weigh three to four kg (Emmett et al. 1991). In the Puget Sound area, sockeye smolts outmigrate in spring to early summer with a shorter residence time in estuaries than other salmonids (Hart 1980; Emmett et al. 1991; Kruckeberg 1995).

Ecological role. In estuaries juvenile sockeye feed on fish larvae, juvenile shrimp, copepods, insects, amphipods, mysids, and euphausiids (Emmett et al. 1991; Gustafson et al. 1997). In marine waters juvenile sockeye feed near the surface, generally at dusk or at night. Ocean predators include spiny dogfish, salmon shark, salmonids, harbors seals, Orcas, Dall's porpoise, and predatory birds.

Environmental Requirements. Juvenile and adult sockeye are pelagic, but in freshwater adults are found near the bottom of streams and rivers. Sockeye

salmon are known to move near the surface at night and return to deeper waters during the day. Young sockeye use nearshore areas during northward migrations and migrate in groups (Gustafson et al. 1997). In marine waters, sockeye are found to a depth of 60 m (Emmett et al. 1991).

Steelhead Trout -- *Oncorhynchus mykiss*

Life History. Steelhead are anadromous rainbow trout and are found from central California to the Bering Sea with most streams in the Puget Sound region containing steelhead populations (Pauley et al. 1986). There are two runs of steelhead trout: winter-run and summer-run. Winter-run steelhead migrate to native streams and rivers in late fall and early winter and spawn within a few months of entering freshwater, usually between late March and early May (Pauley et al. 1986). Winter-run steelhead are found in most major Puget Sound rivers. Summer-run steelhead migrate to native streams and rivers during spring and summer but do not mature and spawn until the following spring. Summer-run steelhead are found in four major rivers on the eastern side of Puget Sound: Skagit, Stillaguamish, Skykomish, and Green Rivers (Pauley et al. 1986). Juvenile steelhead spend from one to four years (usually two to three) in freshwater, then spend two to three years, occasionally four, in the ocean before returning to freshwater to spawn. Some steelhead may not die after spawning and may spawn in as many as five successive years. Adult steelhead usually weigh from two to five kg, but can weigh up to 19.5 kg (Pauley et al. 1986; Emmett et al. 1991; Kruckeberg 1995). The maximum lifespan is estimated at eight to nine years (Pauley et al. 1986).

Ecological role. In rivers and streams, juvenile steelhead feed on gammarid amphipods, small crustaceans, insects, aquatic worms, fish eggs, and small fishes (Cordell 2000). In marine waters, juvenile and adult sockeye eat fish, crustaceans, amphipods, squid, and herring (Emmett et al. 1991, Pauley et al. 1986). Predators include marine mammals, such as seals, sea lions, and Orcas and other fish (Pauley et al. 1986).

Environmental Requirements. Juveniles and adults are found in fresh and marine waters. Juveniles and adults migrate through estuaries but with a short residence time. Steelhead can tolerate a wide range of salinities and although they can live in waters from -18 to 27°C, they will move to deeper, cooler waters if local water temperatures rise. Juveniles usually move to sea from April through June (Wydoski and Whitney 1979, Emmett et al. 1991). Adult steelhead do not form schools and are found in marine waters usually in the upper 12.5 m of the water column, however, ocean distribution is not well known (Pauley et al. 1986). Washington steelhead stocks spend at least part of their ocean residency in the Alaskan gyre (Pauley et al. 1986).

2.3 Lampreys – Family Petromyzontidae

Two species of lampreys are proposed for inclusion in the HCP. These are the Pacific lamprey and the river lamprey.

Pacific Lamprey -- Entosphenus tridentatus

Life History. The Pacific lamprey is an anadromous nongame fish. The Pacific lamprey can reach a length of 76 cm and spends from two to three years in the ocean before returning to spawn (Moyle 1976, Wydoski and Whitney 1979). Returning adults enter freshwater in late spring where they do not feed and die shortly after spawning. The young larval fish, called an ammocoete, of the Pacific lamprey may live in freshwater for up to six years before metamorphosing to the parasitic adult form and migrating to the ocean (Boschung et al. 1998). The juveniles remain in the river system from three to six years where they are filter feeders eating microscopic plants and some animals (Wydoski and Whitney 1979). Migrating juveniles are approximately 11 cm in length and enter the ocean during high water periods of late winter and early spring (Wydoski and Whitney 1979; Hart 1980)

Ecological Role. Adult lampreys are parasitic on fish, including salmon, while in the ocean (Wydoski and Whitney 1979; Hart 1980). The extent of damage to salmon stocks is uncertain, but as much as 20 percent of young salmon sampled have shown scars from lamprey parasitism (Wydoski and Whitney 1979). As well as being parasitic, lampreys are also scavengers and predators and have been known to prey on marine mammals (Wydoski and Whitney 1979; Hart 1980). Lampreys can be prey for game fishes during spawning migrations. Other predators include sperm whales, seals, crayfish, and birds (Scott and Crossman 1973; Hart 1980).

Environmental Requirements. Lampreys require low gradient sections in streams with gravel and sandy bottoms for spawning. During the juvenile stage, lampreys depend on muddy bottoms, backwater areas, and also low gradient areas (Hart 1980). As adults they migrate to the ocean. Information regarding environmental requirements for the adult life stage in marine waters was not readily available.

River Lamprey -- *Lampetra ayresi*

Life History. River lampreys are distributed primarily from California to Alaska, though adult forms roam widely through the North Pacific Ocean (Wydoski and Whitney 1979; Hart 1980). River lampreys are anadromous. The biology of the river lamprey is not well understood and is assumed to be similar to the Pacific lamprey. Adult river lampreys can reach 30 cm in length and are parasitic on ocean fish and marine mammals (Wydoski and Whitney 1979). They enter freshwater streams in late spring and spawn in June and July in shallow redds excavated in fine stream gravels. The adults die after spawning. After about two months, the young hatch and drift downstream to burrow in low-energy, fine-

grained sediment deposits (e.g., backwaters) where they feed on protozoa and invertebrates (Wydoski and Whitney 1979; Hart 1980). River lamprey juveniles and smaller adults are difficult to distinguish from the Pacific lamprey. There is some evidence that they can spend all of their lives in freshwater systems that have been dammed (elib.cs.berkeley.edu).

Ecological Role. In the marine environment adults are primarily parasitic, feeding on larger fish and some marine mammals. Known predators of lampreys include fish, whales, and seals (Wydoski and Whitney 1979; Eschmeyer et al. 1983).

Environmental Requirements. River lampreys require low gradient sections in streams with gravel and sandy bottoms for spawning. During the juvenile stage, lampreys depend on muddy bottoms, backwater areas, and also low gradient areas (Hart 1980). As adults they migrate to the ocean. Information regarding environmental requirements for the adult life stage in marine waters was not readily available.

2.4 Marine Invertebrates

Two species of invertebrates are proposed for inclusion in the HCP. These species are the northern abalone and the Olympia oyster.

2.4.1 Abalones – Family Haliotidae

Abalones are large marine molluscs with a thick commercially valuable shell and edible flesh. The shell has been known to reach over 20 cm in diameter, but is more commonly around 12 cm, and has prominent holes used for water exchange (Kozloff 1983). Abalones are cosmopolitan and live from the intertidal zone to 50 m depths but are most common at deeper depths (Grzimek 1970). They use their powerful foot to hold fast to solid substrates and have a radula to scrape off algae for food.

Northern Abalone -- *Haliotis kamtschatkana*

Life History. The northern abalone is found along the Pacific coast from Baja California to as far north as Sitka, Alaska (McConnaughey and McConnaughey 1985). Although commercially valuable, the shell of the northern abalone is thin compared to other abalone species. Mature northern abalones are broadcast spawners and males and females synchronize the release of gametes in the water column between April and June (Sloan and Breen 1988). After fertilization there is a brief pelagic free-swimming larval stage that lasts for approximately two to seven days, then the larvae settle to the bottom. It is thought that larval dispersal is limited to a geographic area less than 100 m (Sloan and Breen 1988). An average adult is approximately 10-13 cm in length and can live to 50 years of age (Sloan and Breen 1988).

Ecological role. Northern abalones are herbivores and typically graze at night (Kozloff, 1983; Yates 1998). Juveniles have small, weak mouthparts and are unable to exploit food sources other than coralline algae, diatoms, and bacterial films (Fallu 1991). As the juveniles develop, their predominant feeding habits shift to grazing on mostly brown algae. Predation varies throughout the life of the abalone. Species such as crab, fish (including rockfish), octopus, sea stars, and snails will prey on egg and larval stages (Sloan and Breen 1988). Developing and adult abalones can be dislodged by cabezon and swallowed whole, however, the most effective known predator, other than man, is the sea otter.

Environmental Requirements. The northern abalone is usually found on firm substrates, generally rocks, in areas of moderate water exchange, such as exposed outer coasts (Sloan and Breen 1988). They can occur from the lower intertidal zone down to a subtidal depth of over 100 m, but in Puget Sound they are found almost exclusively in subtidal areas at water depths between 10 to 15 m (Kozloff 1983; Yates 1998; McConnaughey and McConnaughey 1985). Generally, northern abalones do not occur in estuaries and in Puget Sound inland waters; they have not been observed south of the Keystone ferry dock on central Whidbey Island (R. Anderson, Seattle Aquarium, pers. comm.).

2.4.2 Oysters - Family Ostreidae

Oysters are common bivalves with eight North American species and two species in the Pacific Northwest. Adult oysters can reverse sexes and can produce up to 500,000 larvae per year (Conte et al. 1994). The eggs of oysters are fertilized and develop within the mantle cavity. Once they are released into the water column, the larvae attach to hard substrates, including oyster shells, and develop into mature oysters. Oysters are filter feeders and generally live submerged in salt waters that are relatively free of turbidity (Parker 1982; Yates 1998).

Olympia Oyster -- *Ostrea conchaphila* (Formerly *O. lurida*)

Life History. The Olympia oyster is a small native oyster rarely exceeding 5 cm in length and is found along the northern Pacific coastline from Baja, California to southern Alaska, although not in abundance (Kozloff 1983). In Washington State, Olympia oysters grow slowly and reach their maximum lengths in approximately three years, but their maximum lifespan has not been determined (Couch and Hassler 1989). The Olympia oyster initially spawns as a male then alternates its functional gender between each spawning cycle. Spawning occurs at water temperatures between 13 to 16°C (Couch and Hassler 1989). Fertilized eggs are brooded in the mantle cavity for 10-14 days and then are released as larvae (Haderlie and Abbott 1980). The larvae swim for 30-40 days, develop an eyespot and a foot for crawling onto hard substrates, and then metamorphose into spat. For settling surfaces, the spat have a preference for the underside of rocks and old oyster shells (Conte et al. 1994; McConnaughey and McConnaughey 1985).

Ecological role. Similar to other bivalves, the Olympia oyster is a filter feeder with planktonic algae as its principal staple throughout all life stages; however, some nutrients can be derived from detritus, micronutrients in solution, and other materials (Conte et. al. 1994). The known natural predators of the Olympia oyster are sea stars and diving ducks (such as scaups and scoters), although predation from introduced Japanese oyster drills, *Ocenebra japonica*, the flatworm *Pseudostylochus ostreaophagus*, and the copepod *Mytilicola orientalis* has also impacted Olympia oysters (Cook et al. 1998). The red rock crab, *Cancer productus*, is an important predator throughout much of the Olympia oyster's range and is a common crab in Puget Sound (Couch and Hassler 1989). Other factors that affect Olympia oyster populations are competition for space by the Pacific oyster (*Crassostrea gigas*) and substrate disruption caused by burrowing ghost and mud shrimp and smothering by slipper shells (Cook et al. 1998).

Environmental Requirements. The Olympia oyster resides in intertidal and subtidal marine habitats including the underside of rocks, mud flats, bays, gravel bars, and on pilings (Kozloff 1983; McConnaughey and McConnaughey 1985). They occur in tidal channels, bays, and in estuaries (Couch and Hassler 1989). These oysters are sensitive to extreme high and low temperatures but can tolerate salinity fluctuations (Couch and Hassler 1989). Olympia oysters occur in inland Puget Sound waters but are abundant only in Case Inlet and southern Puget Sound (Cook et al. 1998).

2.5 Marine Fish

Twenty-four species of marine fish are proposed for inclusion in the HCP. The covered species include six species of ground fish, four species of forage fish, and 14 species of rockfish.

2.5.1 Ground Fish

Six species of ground fish will be included in the HCP. These include two sturgeon, three true cod, and lingcod.

Family Acipenseridae

There are approximately 25 species of sturgeons, but only two species occur in the Pacific Northwest (green and white sturgeons) (Delacy and Borton 1972). Acipenseridae are characterized by elongate and fusiform body shapes with 5 rows of bony plates on the back, middle of each side, and each side of the belly. The bony plates of juveniles are sharp but become smooth as the fish age to the point of disappearing in very old individuals. The head is bony, and the snout is long with four barbels in front of the mouth. There are no teeth in adults. The caudal fin is forked; only one dorsal fin is present.

In the Pacific Ocean, sturgeons are found off eastern Asia (Japan, Korea, and Russia) and from northern Baja, Mexico to the Gulf of Alaska (Hart 1980). All

sturgeons spawn in freshwater, but some species are anadromous. In marine waters, sturgeons are found in bays and estuaries at the mouths of large coastal rivers. Sturgeons feed primarily on bottom organisms, including worms, molluscs, crustaceans, and small fish (Eschmeyer et al. 1983). Sturgeons are fished recreationally and commercially in Washington coastal rivers and estuaries (Columbia River, Willapa Bay, Skagit River, and Grays Harbor). The white sturgeon is considered more valuable than the green sturgeon for the quality of its meat. Roe is also collected. Sturgeons are often incidentally caught in gill nets during the salmonid fishing season. An average of 4.7 and 15.9 tons of green and white sturgeon, respectively, are landed each year in Grays Harbor and Willapa Bay (Emmett et al. 1991).

Green Sturgeon -- Acipenser medirostris

Life History. Spawning generally occurs in spring and early summer for green sturgeons occurring in California and Oregon (Emmett et al. 1991). Gravid females have been caught in the Columbia River in the fall, but no life history data exist for sturgeon present in Puget Sound. Individual females probably do not spawn each year. Green sturgeons broadcast spawn on substrate ranging from sand to bedrock in areas where freshwater is flowing relatively fast. Spawning most likely occurs in water depths greater than 3 m (Emmett et al. 1991). Eggs adhere to the substrate after fertilization. Little data are available for the larval and juvenile stages of green sturgeons. From data collected on white sturgeons, green sturgeon larvae may be 8-19 mm in length when hatched. It is presumed that juveniles range from 2 cm to 1.5 m in length (Emmett et al. 1991). Juveniles are also benthic feeders, but large juveniles may feed on epibenthic invertebrates and small fish. Sturgeons mature late in life. Among white sturgeons, maturity ranges from 11 to 34 years of age. The maximum lifespan of green sturgeon is unknown. A green sturgeon caught in Klamath River was estimated to be 60 years old. Adults can attain lengths over 2 m and weights of 136 kg or more (Emmett et al. 1991).

Ecological Role. Sturgeons largely prey on benthic invertebrates; however, large juveniles and adults will also feed on epibenthic invertebrates and small fish (Emmett et al. 1991). A wide range of fish species likely preys upon sturgeon eggs, larvae, and juveniles. Large adults have few predators other than humans and large marine mammals (Emmett et al. 1991).

Environmental Requirements. Green sturgeons must exist in areas where freshwater rivers, having relatively rapid flow rates, open into estuaries and embayments. Juvenile sturgeon stay in the lower, freshwater areas of large coastal rivers (i.e., San Joaquin River, Klamath River) and then migrate to estuaries before they are two years old (Emmett et al. 1991). Migration typically occurs during the summer and fall months. As they grow, juveniles will migrate from freshwater deltas and estuaries into nearshore subtidal waters where they will reside as adults. Adult green sturgeons spend limited time in freshwater and reside in subtidal marine waters. In Oregon and Washington, green sturgeons rarely move far up rivers or estuaries. Spawning generally occurs in spring and

early summer (Emmett et al. 1991). However, green sturgeons have been shown to travel great distances. Fish tagged in the Sacramento-San Joaquin estuary have been caught in the Columbia River and in Grays Harbor one to three years later. Occurrences of green sturgeons in the Strait of Juan de Fuca have been reported for adults only, and the occurrences are rare.

White Sturgeon -- Acipenser transmontanus

Life History. The white sturgeon is anadromous but is capable of completing its life cycle in freshwater (i.e., fish landlocked by dams) (Emmett et al. 1991). Like the green sturgeon, the white sturgeon spawns in large, freshwater rivers but, unlike the green sturgeon, adults can spend a great deal of time in both marine and freshwater. Females do not spawn annually, but probably every 3 to 5 years (Emmett et al. 1991). Spawning occurs during the spring in rivers with relatively high flow rates. White sturgeons are highly fecund broadcast spawners and spawn in areas with large cobble and boulder substrate. Eggs adhere to the substrate after fertilization. Larvae range in length from 8 to 19 mm and begin active feeding approximately 12 days after hatching. Young juveniles may be 20 mm in length and grow to 1.2 m or longer before maturing (Emmett et al. 1991). Growth and maturity tend to vary among west coast estuaries, but all sturgeons are slow growing and mature late in life. In Oregon, the females mature at approximately 15 years of age (1.7 m in length), while the males mature earlier and are shorter (Emmett et al. 1991). The maximum age of the white sturgeon is not known but may exceed 100 years. Some adults exceed weights of 800 kg and can reach lengths of 6 m (Emmett et al. 1991).

Ecological Role. Juveniles and adults are benthic carnivores. Juveniles prey on benthic and epibenthic invertebrates, including amphipods, shrimp, bivalves, and insect larvae (Emmett et al. 1991). Large juveniles and adults will feed on amphipods, clams, *Crangon* shrimp, ghost shrimp, mud shrimp and other benthic invertebrates (Emmett et al. 1991). They will also feed on fish, including eulachon and northern anchovy. A wide range of fish species likely preys upon sturgeon eggs, larvae, and juveniles. Humans catch large adults, while some may be eaten by large marine mammals (Emmett et al. 1991).

Environmental Requirements. Larvae and young juveniles are riverine, while older juveniles and adults are riverine, estuarine, and marine. River flow is important for the effective movement of juveniles downstream. The older life stages are largely spent in riverine and estuarine habitat, generally in subtidal areas. However, the white sturgeon has been observed feeding in intertidal areas at high tide (Emmett et al. 1991). Small juveniles have been observed in shallow freshwater locations of the San Joaquin Delta and deep-water channels of the Columbia River. White sturgeons occur on a variety of sediment types, ranging from sandy silt and clay to coarse sand and gravel. General movement patterns exist among juvenile and adult white sturgeons but no migration has been noted (Emmett et al. 1991). Large adults move upstream to spawn in late winter and spring and downstream in fall and winter. Some white sturgeons have been tracked between California and Washington, but most white sturgeons do not

move these great distances (Emmett et al. 1991). Occurrences of white sturgeons in Puget Sound are rare, however, they have been observed in the Strait of Juan de Fuca, Port Orchard, the Seattle area, and southern Puget Sound (Delacy and Borton 1972).

Family Gadidae

Gadidae, generally termed codfishes, includes true cods, hake, pollock, and haddock. There are about 75 species, but only four species occur in the Pacific Northwest. Of these, three species are proposed for inclusion in the HCP: Pacific hake, walleye pollock, and Pacific cod.[2] They are moderate in size, elongate, and have small cycloid scales. In the Northwest, codfishes have well-formed, square caudal fins, two or three dorsal fins, and one or two anal fins. The pacific cod have chin barbels. Codfishes generally live on or near the bottom feeding on prey such as crabs, molluscs, and fish.

Pacific Cod -- Gadus macrocephalus

Life History. Pacific cod form large spawning aggregates in shallow waters during the late winter. Pacific cod are broadcast spawners, and large females can produce millions of eggs. Eggs of the Pacific cod sink to the sea floor where they adhere to fine-grained sediments and particulates. In Puget Sound, cod spawn in shallow water embayments, such as Port Townsend Bay and Agate Passage (Wilson et al. 1994, West 1997). Depending on temperature, eggs develop into larvae in 8-21 days. Cod larvae are 3-4 mm in length and occur both near the bottom and in the water column, rising to water depths of 15-30 m (West 1997). It takes several months for larvae to achieve the juvenile form. By late summer, juveniles settle in a relatively shallow, demersal habitat, typically in eelgrass beds. Pacific cod reach maturity at 2 to 3 years of age, ranging from 40 to 70 cm in length and 1-4.5 kg in weight (Hart 1980). Large females may reach a length of 100 cm. Due to natural predation and other factors, Pacific cod seldom live beyond age six.

Ecological Role. Juvenile cod are bottom feeders, preying on crabs, shrimp, snails and fish (flatfish, zoarcids, stichaeids, cottids, pricklebacks, eelpouts, and walleye pollock) (Wilson et al. 1994). Adult Pacific cod feed on euphausiids, shrimp, and both benthic and pelagic fishes, including sand lance, herring, and other species (Lamb and Edgell 1986; West 1997).

Environmental Requirements. Pacific cod are found in a variety of habitats generally in water depths of 50-200 m (Wilson et al. 1994). Juveniles tend to inhabit areas of eelgrass with a sandy substrate. Adults are demersal, and can be found over fine to coarse-grained substrate. After spawning, adult cod disperse to deeper waters where they feed during the remainder of the year. The distribution of this species depends on water temperature and the availability of prey. In Puget Sound, abundances decline from north sound to south sound. Three spawning populations exist in Puget Sound. One stock is located in the

[2] Hart (1980) places Pacific Hake in the family Gadidae. Others put this species in the family Merlucciidae, based on certain internal features.

Gulf of Georgia, the second occurs in the Straits of Juan de Fuca (Port Angeles, Green Point, Hein Banks) and Port Townsend Bay, and the third stock occurs south of Admiralty Inlet. Other important spawning, feeding, and nursery areas in Puget Sound are Orcas Island, Kilisut Harbor, Port Gamble, Agate Pass, Dyes Inlet, Quartermaster Harbor, Point Defiance, Point Fosdick, and Fox Island (Wilson et al. 1994). Pacific cod have been observed in Seattle and the Duwamish River (Stober and Pierson 1984).

In the 1980s, abundances of Pacific cod declined severely in Puget Sound due to a period of warm water temperatures, over fishing, and mammal predation (Wilson et al. 1994). The recreational fishery in Agate Passage and a commercial set net fishery in Port Townsend Harbor have been closed for several years. Populations in southern Puget Sound have been described as “near extinct” (Palsson et al. 1997).

Walleye Pollock -- Theragra chalcogramma

Life History. Spawning aggregations of walleye pollock form from February to April in deep water. Spawning locations have been identified in Halibut Bank, Active Pass and Point Roberts, and Port Townsend Bay (Wilson et al. 1994). Eggs and larvae are pelagic and have been found at water depths between 100 and 300 m (Wilson et al. 1994). Female fecundity varies with size of the female. Females 40 cm in length may produce 200,000 eggs, while females 75 cm in length may produce 1.4 million eggs. Adult pollock range from 28 to 65 cm in length, and are thought to live to age 17 (Wilson et al. 1994). Recent data suggest that pollock may live longer than 17 years.

Ecological Role. Juvenile pollock feed primarily on crustaceans. As walleye pollock mature, they feed on small fishes, including other pollock, sand lance, and herring (Wilson et al. 1994). They themselves may be preyed upon by large mammals and historically were part of a recreational fishery.

Environmental Requirements. Juveniles become semi-demersal, moving to inshore, shallow habitats in their first year of life. They settle in areas with eelgrass, and gravel and cobble substrate. In their second year of life, juvenile pollock move back to deeper waters, occupying mid-water and near-bottom habitat near sandy or muddy substrates (West 1997, Wilson et al. 1994). In general, the species prefers cold, northern waters and is found throughout Puget Sound. Currently, there are at least two stocks of pollock in Puget Sound: one in the Strait of Georgia (Point Roberts), which has been exploited commercially from time to time, and the second in northern Puget Sound (Port Townsend, Marrowstone Island, Indian Island) (Wilson et al. 1994). Walleye pollock were once the most common species caught recreationally in Puget Sound. In the 1980's, like the Pacific cod, numbers of walleye pollock declined sharply due largely to natural mortalities and fishing pressures (West 1997).

Pacific Hake -- Merluccius productus

Life History. Spawning aggregations of Pacific hake form from January through March at mid-water depths. In Puget Sound, Port Susan appears to be the primary spawning ground (Wilson et al. 1994). Eggs and larvae are pelagic. In the Strait of Georgia, the eggs occur at depths of 170 to 220 m, and eggs hatch within five days (Wilson et al. 1994). Larvae move to shallow, inshore waters where considerable growth occurs during the summer months. Fish mature and spawn at age four and may reach a maximum age of 20 years (Wilson et al. 1994). In general, commercially caught hake range from 4 to 11 years in age and from 40 to 50 cm in length.

Ecological Role. Hake larvae feed upon copepods and their eggs during the spring and early summer months. Adult Pacific hake primarily feed upon euphausiids and sand lance, and to a lesser extent herring, smelt, anchovy, and shrimp (Wilson et al. 1994). Dogfish and large mammals (sea lions, harbor seals, cetaceans) prey upon hake (Wilson et al. 1994, Hart 1980, Eschmeyer et al. 1983). Historically, Pacific hake were part of a large fishery in Central Puget Sound.

Environmental Requirements. Larvae develop in mid-water until they are large enough to move inshore and actively school. Data from the Strait of Georgia suggest that the majority of juveniles remain in inshore waters away from concentrations of adults, but juveniles can occur in mid-water depths as well (Wilson et al. 1994). There are four major spawning stocks along the west coast. Stocks occurring off California, Oregon, Washington, and British Columbia appear to be the most abundant. In Washington, other stocks occur in the Strait of Georgia and in Central Puget Sound (including the Seattle area), both are genetically distinct from the coastal stocks (Wilson et al. 1994). There may also be other discrete stocks within Puget Sound. The largest Puget Sound aggregation of Pacific hake occurs in Saratoga Passage from September through December (West 1997, Wilson et al. 1994). As juveniles mature, fish move to Port Susan and form spawning aggregations (January through March). During the remainder of the year, hake have been observed throughout Puget Sound in smaller schools.

Family Hexagrammidae

This is a small family of marine fishes that are limited in distribution to the North Pacific. They are bottom fishes typically found in shallow water (Hart 1980). One species, the lingcod, is proposed for inclusion in the HCP.

Lingcod -- Ophiodon elongates

Life History. Spawning occurs once a year from mid-December to mid-March with most egg laying finished by the end of January (Shaw and Hassler 1989). Males establish territories in nesting areas and wait for females to deposit their eggs in crevices between large rocks or slightly under a boulder or rocky shelf (Shaw and Hassler 1989). Nesting areas are 3-10 m below the lowest tide level

and where there are strong currents (Shaw and Hassler 1989). Males fertilize the eggs as the female lays them and when spawning is completed the female leaves the area while the male remains to guard the eggs (Shaw and Hassler 1989). The number of eggs laid increases with increasing size of the female (Shaw and Hassler 1989). Incubation time for the eggs is probably 6-8 weeks (Shaw and Hassler 1989). Newly hatched larvae are 7-11.5 mm long and have a small yolk sac that is absorbed in about ten days (Shaw and Hassler 1989). By the end of the first year of life the juveniles average 270 mm long and are 470 mm long by the end of the second year (Shaw and Hassler 1989). Males begin to reach sexual maturity at 520 mm and females at 700 mm long (about 3-5 years) (Hart 1980). The average lifespan is 12-14 years for males and about 15-16 years for females (Shaw and Hassler 1989). The maximum length can be up to 152 cm, but is rarely more than 122 cm (Eschmeyer et al. 1983).

Ecological Role. The larvae are very active as they feed on small copepods and copepod eggs (Shaw and Hassler 1989). As they grow, their diet shifts to larger copepods, fish larvae, and larvaceans (Shaw and Hassler 1989). When they reach 70-80 mm long they begin feeding on juvenile herring and other juvenile fish (Shaw and Hassler 1989). Adult lingcod prey on a variety of fish (mainly juvenile *Sebastes* spp.), cephalopods, gastropods, and crustaceans (Shaw and Hassler 1989). Humans are the main predators of adult lingcod, while adult lingcod, rockfish, and cabezon often feed on lingcod eggs and juveniles (Shaw and Hassler 1989).

Environmental Requirements. Newly hatched larvae are carried with the plankton in the water currents (Hart 1980). When juveniles reach 70-80 mm (about two months old), they congregate in shallow, nearshore locations among seaweeds, eelgrass, and sandy bottoms (Shaw and Hassler 1989). Most adults are relatively sedentary, remaining in place on the bottom (Shaw and Hassler 1989). They move only diurnally to shallower depths with darkness and to deeper water with light (Shaw and Hassler 1989). Lingcod can be found from near-surface to depths of 475 m (Lamb and Edgell 1986), but the majority are in water less than 100 m deep (Shaw and Hassler 1989). They prefer rocky locations with considerable current (Shaw and Hassler 1989).

2.5.2 Forage Fish

Four species of forage fish are proposed for inclusion in the HCP. These species are Pacific herring, sand lance, surf smelt, and eulachon.

Family Clupeidae

Most species of this family are small (less than 30 cm long), silvery, and form schools in shallow water (Eschmeyer et al. 1983). Several groups occur in freshwater and some are anadromous (Eschmeyer et al. 1983). Straining small organisms from the water with their gill rakers is the primary feeding mode of most species, but some select individual planktonic organisms from the water and a few eat small fish (Eschmeyer et al. 1983).

Pacific Herring -- Clupea harengus pallasi

Life History. At least 18 stocks of Pacific herring spawn inside Puget Sound (WDFW 1997a). These herring stocks spawn from late January to early April with the exception of the Cherry Point stock, which spawns through early June (WDFW 1997a). Small (13 mm), transparent larvae hatch after about 2 weeks and are dispersed by currents from the spawning areas (WDFW 1997a). At about three months and 38 mm in length, herring metamorphose into adult form and coloration and begin to school (WDFW 1997a, Lassuy 1989). In their second or third year, they mature and return to spawn and will continue to spawn in successive years (WDFW 1997a). Mortality rates are quite high in all life stages; adults rarely survive beyond age five (WDFW 1997a).

Ecological Role. As larvae, herring feed on zooplankton (copepods) and phytoplankton (diatoms) (Williams 1989). Copepods are the dominant prey item through metamorphosis and as juveniles (Hart 1980). The invertebrate larval communities associated with eelgrass beds are also a major food source (Lassuy 1989). The feeding habits of juveniles and adults once they move into deeper waters are not well known (Lassuy 1989). During their spawning migration and inshore spawning period, adult herring may greatly reduce or stop feeding (Lassuy 1989). Many types of organisms feed on herring eggs; they may be a particularly important food source for shoreline birds (e.g., gulls, coots, ducks) (Lassuy 1989). Herring larvae are preyed on by pelagic invertebrates (e.g., medusa) and by salmon, surfperch, and juveniles and adults of their own species (Lassuy 1989). Less is known about predation of juvenile herring as they move offshore and into deeper waters (Lassuy 1989). Adult herring are susceptible to predation by salmon, seals, sea lions, Orcas, and fish-eating birds while holding inshore before and during spawning (Lassuy 1989; WDFW 1997a). Offshore predators include Pacific hake, sablefish, spiny dogfish, Pacific cod, and salmon (Lassuy 1989).

Environmental Requirements. Most spawning takes place between 0 to –3 m in tidal elevation, although eggs have been found near the upper limits of high tide and to a depth of 12 m (WDFW 1997a). Eggs are found on firm substrates including eelgrass, algae, oyster shells, rocky-sandy bottoms, pilings, and driftwood (WDFW 1997a). Larvae, juveniles and adults occur throughout the water column although first year juveniles that move offshore tend to be found mostly at water depths between 150-200 m (Lassuy 1989). Herring do not migrate large distances, but move onshore and offshore seasonally to spawn and feed (Lassuy 1989). Adults move onshore during winter and spring to holding areas prior to moving to spawning grounds (WDFW 1997a). Adults consistently return to their natal spawning grounds to reproduce and there are known spawning sites in central Puget Sound (Lassuy 1989; WDFW 1997a).

Family Ammodytidae

Species of this family occur in nearshore and offshore surface waters of the North Pacific, North Atlantic, and Indian Oceans (Eschmeyer et al. 1983). There are

about twelve species but only one occurs along the Pacific Coast of North America (Eschmeyer et al. 1983).

Sand Lance -- Ammodytes hexapterus

Life History. Spawning occurs once a year from November to February primarily in inshore areas (WDFW 1997b). The eggs incubate for about four weeks before hatching (WDFW 1997b). Larvae are about 5 mm long upon hatching and are planktonic until reaching about 22 mm in length when they become semi-demersal and start schooling (WDFW 1997b, Auster and Stewart 1986). Sexual maturity is reached at 1-3 years of age (Emmett et al. 1991). Maximum lifespan is about 8 years (Emmett et al. 1991).

Ecological Role. The larval diet includes diatoms, dinoflagellates, copepods, and copepod nauplii (Emmett et al. 1991). With increasing size, juveniles and adults remain plankton feeders but eat larger organisms (Emmett et al. 1991). Diving birds, gulls, seals, and sea lions prey on adult sand lance and they are a significant component in the diet of many fish (e.g., juvenile salmon, Pacific cod, Pacific hake, and dogfish) (Emmett et al. 1991; WDFW 1997b). Humans occasionally harvest sand lance for sport bait (WDFW 1997b).

Environmental Requirements. Spawning occurs at tidal elevations from +1.5 m to about the mean higher high water line on sand to gravel beaches (WDFW 1997b). There are documented sand lance spawning areas throughout Puget Sound, including the central basin (Penttila 1995). During deposition a coat of sand grains adhere to the eggs and may help with moisture retention when the eggs are exposed during low tide (WDFW 1997b). Juveniles rear in bays and nearshore waters (WDFW 1997b). The adults often school near the surface in open water during the day and burrow into sand at night to avoid predation but little is known regarding sand lance movements (WDFW 1997b).

Family Osmeridae

Species of this family are only present in the Northern Hemisphere (Eschmeyer et al. 1983). Most occur in temperate to subarctic marine waters, but a few are anadromous or landlocked in freshwater (Eschmeyer et al. 1983).

Surf Smelt -- Hypomesus pretiosus

Life History. Spawning in Puget Sound occurs during much of the year and perhaps year-round (WDFW 1997c; Lemberg et al. 1997). Eggs incubate for 2-5 weeks before hatching (WDFW 1997c). Larvae are about 3 mm long upon hatching and are planktonic for about three months when they reach about 30 mm in length (WDFW 1997c). Sexual maturity is reached by the second year, but a small proportion will spawn in the first year (WDFW 1997c). Surf smelt are schooling fishes and have a maximum lifespan of about five years (WDFW 1997c).

Ecological Role. Diet consists of planktonic organisms, including crustaceans, comb jellies, and fish larvae (Williams 1989). Surf smelt eggs, juveniles, and

adults experience high levels of predation. Seabirds, marine mammals, and other fishes all prey on adult surf smelt (WDFW 1989). In Washington State, humans take about 100,000 pounds annually in commercial fisheries (WDFW 1997c).

Environmental Requirements. Spawning occurs at a tidal elevation between +2 m and the mean higher high water line on mixed sand to gravel beaches (WDFW 1997c). Juveniles rear in nearshore waters (WDFW 1997c). Adults school offshore and seem to return to the same spawning ground each year (WDFW 1997c). There are documented surf smelt spawning areas throughout Puget Sound, including the central basin (Penttila 1995). Information was not readily available regarding offshore movements and water depths when schooling offshore.

Eulachon -- Thaleichthys pacificus

Life History. Eulachon is an anadromous species found from northern California to the southern Bering Sea (Hay 1999). Spawning occurs in most freshwater rivers once a year during the late winter/early spring (Hart 1980; Lamb and Edgell 1986; Bargmann 1998). Spawning occurs earliest in the Columbia River in January and February and one of the rivers with the latest spawning in April to May is the Fraser River (Hay 1999). A high level of adult mortality follows spawning but it is unknown if all of the adults die (Hart 1980; Bargmann 1998). Eggs, which are small (<1 mm), demersal and adhesive, incubate for 30-40 days before hatching (Hart 1980, Hay 1999). Newly hatched larvae are 5-7 mm long and rapidly drift out to marine waters (Hart 1980). Sexual maturity is reached at three or four years at a length between 108 and 135 mm (Hart 1980). Adults that survive spawning may reach ages well beyond four years (Hart 1980). This species is considered rare in Puget Sound (Emmett et al. 1991).

Ecological Role. Larvae eat phytoplankton and small zooplankton (Emmett et al. 1991). Juveniles and adults eat planktonic crustaceans such as euphausiids and copepods (Hart 1980). The eulachon spawning migration attracts many predators, such as dogfish, sturgeon, halibut, cod, marine mammals, and gulls (Hart 1980). Salmon and other fish feed on the eulachon larvae and juveniles (Hart 1980).

Environmental Requirements. Adults spend most of their lives in the Pacific Ocean and return to silty rivers, like the Columbia River, for spawning during the spring (Emmett et al. 1991). Spawning timing and locations within rivers appears to be influenced by water temperature, current, and turbidity (Bargmann 1998). Adults spend the majority of time close to the bottom but little information regarding water depth range was readily available.

2.5.3 Rockfish

Fourteen species of rockfish are proposed for inclusion in the HCP. In the following sections, information common to all species is presented first, followed by specific information for each individual species.

Family Scorpaenidae

This is the largest family of Scorpaeniformes in the Northeastern Pacific and includes members in the genus *Sebastes* (rockfish) (Eschmeyer et al. 1983). Probably all species of rockfish are venomous (Stein and Hassler 1989). The venom is produced in poison glands associated with some or all of the fin spines (Stein and Hassler 1989). The venom of most Northeastern Pacific species is painful but not dangerous unless an allergic reaction is provoked (Stein and Hassler 1989).

The spawning habits and early life history of individual rockfish species are not well described because the larvae and juveniles are very difficult to identify (Stein and Hassler 1989). Spawning probably occurs once a year, but may occur more than once in some species (Stein and Hassler 1989). Spawning of the various rockfish species occurs sequentially rather than simultaneously, with black rockfish being the earliest spawners (J.Christiansen, Seattle Aquarium, pers. comm.). The females' fecundity increases with increasing size (Stein and Hassler 1989). All species of rockfish have internal fertilization and bear live young (Hart 1980, Stein and Hassler 1989). The newly released larvae spend about two months in the water column feeding on small zooplankton (Stein and Hassler 1989). When the planktonic larvae reach a specific size they recruit to shallow, benthic, nursery habitats (West 1997). Studies of the more common species (copper, quillback, and brown rockfish) indicate that shallow areas with eelgrass, kelp beds, and other vegetation on cobbles and boulders are utilized as nursery habitats (West 1997). Upon reaching adult size, they move to adult habitats (usually rocky reefs, boulders, offshore pinnacles, and other hard, high relief substrates) where they will remain relatively sedentary for many years (as many as 20 years for some species) (West 1997).

Although many rockfish species occur together, they have evolved to avoid competition for limiting resources, such as food, by ecological specialization (Stein and Hassler 1989). Each species, while having similar general preferences for food and habitat, focuses on a small subset of available prey or habitat structure that is not as well utilized by the other co-occurring rockfish species. In general, rockfish are opportunistic carnivores and will eat many animals, including small fish, crustaceans, polychaetes, and molluscs (Stein and Hassler 1989; Williams 1989). As juveniles, rockfish are eaten by many species of fish, including other rockfish, lingcod, wolf eels, and cabezon (Stein and Hassler 1989). Rockfish are found in bays along shore, in kelp beds, and offshore to about 450 m (Eschmeyer et al. 1983).

Brown Rockfish -- Sebastes auriculatus

Life History. Spawning occurs once a year (Stein and Hassler 1989). Eggs mature during the winter, followed by ovulation and fertilization in March and April (Stein and Hassler 1989). Embryos develop quickly and are released from April to July (Stein and Hassler 1989). Larvae are 5-6 mm long at birth (Stein and Hassler 1989). Sexual maturity is reached by 225-260 mm long (about three

years) (Stein and Hassler 1989). The maximum lifespan is unknown but individuals can reach at least 19 years of age and grow up to 550 mm long (Stein and Hassler 1989).

Ecological Role. Crabs and shrimp are the major component in the diet of adult brown rockfish, which also includes small fish, isopods, and polychaetes (Stein and Hassler 1989).

Environmental Requirements. The juveniles, 37-50 mm long, hide in crevices of hard substrates in shallow nearshore waters (Stein and Hassler 1989). They are often around piers and in bays and use estuaries as nursery grounds (Stein and Hassler 1989). Adults are found in shallow water, bays, and offshore to 128 m (Eschmeyer et al. 1983). They are solitary and tend to stay near the bottom in rocky areas with caves and crevices (Stein and Hassler 1989; J. Christiansen, Seattle Aquarium, pers. comm.).

Copper Rockfish -- *Sebastes caurinus*

Life History. Spawning occurs once a year (Stein and Hassler 1989). Eggs mature during the winter and are ready for fertilization sometime between February and May (Stein and Hassler 1989). Fertilization occurs from March to May following ovulation (Stein and Hassler 1989). Parturition occurs as early as April (Lamb and Edgell 1986; Stein and Hassler 1989). Larvae are 5-6 mm long at birth and are pelagic until they are 40-50 mm long (Stein and Hassler 1989). Males reach sexual maturity by 300-400 mm long (3-7 years) (Stein and Hassler 1989). All females are mature by 410 mm long (about eight years) and many are mature by 366 mm long (about four years) (Stein and Hassler 1989). Maximum lifespan is at least 20 years (Stein and Hassler 1989). Maximum length is 570 mm (Eschmeyer et al. 1983; Lamb and Edgell 1986). This is one of the most common rockfish species found in Puget Sound, particularly south Puget Sound (J. Christiansen, Seattle Aquarium, pers. comm.).

Ecological Role. The copper rockfish diet consists of benthic crustaceans, fish, and molluscs (Stein and Hassler 1989). Copper rockfish smaller than 45 mm long eat primarily calanoid copepods, harpacticoids, and zoea (Stein and Hassler 1989). Amphipods, shrimp, caprellids, and other small crustaceans form the diet of 110-155 mm copper rockfish (Stein and Hassler 1989). As they grow, they become increasingly aggressive feeders, preying mostly on fish (Stein and Hassler 1989). Like most rockfish, the juveniles are prey for many other fish species (Stein and Hassler 1989). Seals and other large predators probably eat the adults (Stein and Hassler 1989).

Environmental Requirements. The small, pelagic juveniles hide in surface and mid-depth kelp canopies (Stein and Hassler 1989). Individuals larger than 40-50 mm long become benthic and hide in the relief of hard substrates such as rocks and barnacles (Stein and Hassler 1989). The juveniles may also use bays as nurseries (Stein and Hassler 1989). Mature fish do not move far once they have chosen a “home” location (Stein and Hassler 1989). The adults are almost

always in contact with the bottom and choose substrates of rock or rocky sand (Stein and Hassler 1989).

Greenstriped Rockfish -- *Sebastes elongates*

Life History. Parturition occurs in late spring or early summer (Hart 1980). Larvae are about 5 mm at birth (Hart 1980). Adult length can reach 380 mm (Eschmeyer et al. 1983).

Ecological Role. Diet is probably opportunistic like most *Sebastes* species. Juveniles and small individuals probably suffer predation from other fish.

Environmental Requirements. Adults prefer deep (91-366 m) (Hart 1980), level, mostly sandy or silty bottoms (Lamb and Edgell 1986).

Widow Rockfish -- *Sebastes entomelus*

Life History. Parturition occurs during later winter (Hart 1980; Lamb and Edgell 1986). Sexual maturity is reached at 3 or 4 years of age at a length of about 320 mm (Hart 1980; Lamb and Edgell 1986). Adult length can reach 530 mm (Hart 1980). This species is uncommon in Puget Sound and is found most often offshore on the outer coasts in aggregations (J. Christiansen, Seattle Aquarium, pers. comm.).

Ecological Role. Diet includes plankton and small fish (Hart 1980).

Environmental Requirements. Adults stay in the water column (probably in schools) above deep (91-366 m) (Hart 1980), rocky reefs or steep shorelines (Lamb and Edgell 1986).

Yellowtail Rockfish -- *Sebastes flavidus*

Life History. Parturition occurs during late winter (Hart 1980; Lamb and Edgell 1986). Newly released larvae are about 4.5 mm long (Hart 1980). Sexual maturity is reached at about 5 years of age at a length of about 330 mm (Hart 1980). Adult length can reach 660 mm (Hart 1980). Adults of this species can be found throughout central Puget Sound and are resident year-round in Elliott Bay. Juveniles are typically seen only in the Strait of San Juan de Fuca and the waters surrounding the San Juan Islands in July and August (J. Christiansen, Seattle Aquarium, pers. comm.).

Ecological Role. Diet includes small fish, crustaceans, and squid (Hart 1980).

Environmental Requirements. Adults form schools in shallow (26-46 m), open water (Eschmeyer et al. 1983) along steeply sloping shores or above rocky reefs (Lamb and Edgell 1986). Juveniles are also seen in open water at relatively shallow depths less than 35 m (J. Christiansen, Seattle Aquarium, pers. comm.). Limited information was readily available regarding movements of this species, but it does appear that juveniles and adults inhabit different areas within Puget Sound and the outer Straits (J. Christiansen, Seattle Aquarium, pers. comm.).

Quillback Rockfish -- *Sebastes maliger*

Life History. Parturition occurs around May (Matthews 1987; Williams 1989). Sexual maturity is reached at about 4 years of age (Matthews 1987). Adult length can reach 610 mm (Hart 1980).

Ecological Role. Diet includes amphipods, crabs, shrimp, snails, and small fish (Williams 1989).

Environmental Requirements. Adults prefer rocky reefs and hard, even bottoms of inlets around 15 m deep, but have been found down to 275 m deep (Hart 1980; Lamb and Edgell 1986). This species is usually found at or near the bottom and tends to be solitary (J. Christiansen, Seattle Aquarium, pers. comm.). Information concerning juvenile habitat and movements was not readily available.

Black Rockfish -- *Sebastes melanops*

Life History. Spawning probably occurs once a year and may occur in offshore waters (Stein and Hassler 1989). Eggs develop as early as August (Stein and Hassler 1989). Parturition occurs from February to April and probably as early as January (Stein and Hassler 1989). Larvae are about 5.5 mm long at birth and are pelagic until they are 40-50 mm long (Stein and Hassler 1989). Males reach sexual maturity at sizes between 250 and 430 mm long (about 3 to 10 years) (Stein and Hassler 1989). Females are mature by 300-480 mm long (about 5-11 years) (Stein and Hassler 1989). Maximum lifespan is at least 21 years (Stein and Hassler 1989). Maximum length is 600 mm (Eschmeyer et al. 1983).

Ecological Role. As a midwater species, adult black rockfish avoid competition for food with most other rockfish and eat primarily pelagic nekton (smelt, anchovies, squid) and zooplankton such as salps, mysids, and crab megalops (Stein and Hassler 1989). However, the benthic juveniles must compete with other benthic species and tend to decrease in abundance as the abundance of other species increases (Stein and Hassler 1989).

Environmental Requirements. The small, pelagic juveniles swim in open water or hide in large, offshore kelp beds (Stein and Hassler 1989). As the juveniles grow larger than 40-50 mm long, they move inshore, often to eelgrass beds in estuaries, tide pools, and nearshore depths of less than 20 m (Stein and Hassler 1989). Adults form schools in midwater over kelp-covered rocky reefs to depths of 360 m or more (Lamb and Edgell 1986). However, they are most abundant in waters less than 54 m deep (Stein and Hassler 1989).

Blue Rockfish -- *Sebastes mystinus*

Life History. Parturition occurs in winter (Hart 1980). Sexual maturity is reached at 3 to 5 years of age (Hart 1980). Adult length can reach 530 mm (Hart 1980). This species is not found in inland Puget Sound and only occurs on the outer Washington Coast and outer Straits (J. Christiansen, Seattle Aquarium, pers. comm.).

Ecological Role. Diet includes tunicates, jellies, and fish (Hart 1980).

Environmental Requirements. Adults form schools over deep (183-550 m) (Hart 1980), rocky reefs (Eschmeyer et al. 1983).

China Rockfish -- *Sebastes nebulosus*

Life History. Little is known other than the general life cycle of the genus. Adult length can reach 430 mm (Hart 1980). This species rarely occurs in inland Puget Sound and is found in nearshore waters from 10 to 50 m along the outer Washington coast and Straits (J. Christiansen, Seattle Aquarium, pers. comm.). China rockfish, particularly juveniles, are often mistaken for other rockfish species.

Ecological Role. Diet is probably opportunistic like most *Sebastes* species. Juveniles and small individuals probably suffer predation from other fish.

Environmental Requirements. Adults prefer shallow (less than 92 m), exposed rocky shores or reefs where they can take shelter in crevices when disturbed (Hart 1980). Adults are solitary and territorial and will often remain at a particular site for years (J. Christiansen, Seattle Aquarium, pers. comm.). Information regarding juveniles was not readily available.

Tiger Rockfish -- Sebastes nigrocinctus

Life History. Tiger rockfish can be found from Alaska to central California but they are not common, if found at all, in inland Puget Sound waters (J. Christiansen, Seattle Aquarium, pers. comm.; W. Palsson, WDFW, pers. comm.). Little is known other than the general life cycle of the genus. Adult length can reach 610 mm (Hart 1980). The larva of this species tends to settle out with drift kelp. Tiger rockfish are often antagonistic to other fish and are solitary and territorial (J. Christiansen, Seattle Aquarium, pers. comm.).

Ecological Role. Diet is probably opportunistic like most *Sebastes* species. Juveniles and small individuals probably suffer predation from other fish.

Environmental Requirements. Adults prefer rocky reefs between 10 and 275 m deep (Lamb and Edgell 1986) where they can take shelter in a home crevice that they will aggressively defend (Hart 1980).

Bocaccio -- Sebastes paucispinus

Life History. This species occurs from Alaska to southern California but bocaccio are not often seen in inland Puget Sound waters as adults prefer deep waters (J. Christiansen, Seattle Aquarium, pers. comm.). Spawning occurs twice a year with parturition occurring in November and again in March (Hart 1980). Newly released larvae are 4-6 mm long and are pelagic until they reach a length of about 30 mm (Hart 1980). Sexual maturity is reached at 3 or 4 years of age at a length of about 360 mm (Hart 1980). Adult length can reach 910 mm (Hart 1980).

Ecological Role. Diet includes small fish (Hart 1980).

Environmental Requirements. The pelagic larvae occupy the upper mixed layer of water (Hart 1980). Juveniles of about 30 mm in length move into shallow water (Hart 1980). Adults prefer open water adjacent to deep (73-300 m) reefs (Hart 1980; Lamb and Edgell 1986). Although the habitat of juvenile bocaccio is not well known, they most likely are found in nearshore areas (W. Palsson, WDFW, pers. comm.).

Canary Rockfish -- *Sebastes pinniger*

Life History. This species occurs from Alaska to southern California but does not occur in inland Puget Sound waters. In Washington, canary rockfish occur along the outer coast and through the Straits (J. Christiansen, Seattle Aquarium, pers. comm.). Parturition occurs in January or later (Hart 1980). Sexual maturity is reached at 5 or 6 years of age at a length of about 350 mm (Hart 1980). Adult length can reach 760 mm (Hart 1980). In the Straits, larvae settle out in June to July at a water depth of 5 m or less (J. Christiansen, Seattle Aquarium, pers. comm.).

Ecological Role. Diet is probably opportunistic like most *Sebastes* species. Juveniles and small individuals probably suffer predation from other fish.

Environmental Requirements. Adults prefer rocky bottoms of various depths to 360 m and possibly deeper (Lamb and Edgell 1986). Juveniles inhabit shallower waters and often school just above the bottom (J. Christiansen, Seattle Aquarium, pers. comm.).

Redstripe Rockfish -- *Sebastes proriger*

Life History. Little is known other than the general life cycle of the genus. Adult length can reach 610 mm (Hart 1980).

Ecological Role. Diet is probably opportunistic like most *Sebastes* species. Juveniles and small individuals probably suffer predation from other fish.

Environmental Requirements. Adults prefer areas deeper than 25 m where rocky reefs and steep silt-covered cliff faces meet gently sloping sandy or muddy bottoms (Lamb and Edgell 1986). Little information is known about this species except that both juveniles and adults usually inhabit deep waters.

Yelloweye Rockfish -- *Sebastes ruberrimus*

Life History. This species occurs from southern California north to Alaska and is fairly common at deeper depths in inland Puget Sound (J. Christiansen, Seattle Aquarium, pers. comm.). Parturition occurs in June (Hart 1980). Adult length can reach 910 mm (Hart 1980).

Ecological Role. Diet includes fish (gadids, sand lance, herring, juvenile rockfish), crabs, shrimp, and snails with shrimp being the predominant prey (Williams 1989; J. Christiansen, Seattle Aquarium, pers. comm.).

Environmental Requirements. Adults prefer steep-faced rocky reefs, offshore pinnacles, and boulder fields at depths below 14 m (Lamb and Edgell 1986; Williams 1989). Large adults usually inhabit depths deeper than 30 m and are solitary and tend to hide in crevices and recesses (J. Christiansen, Seattle Aquarium, pers. comm.). Information regarding juvenile habitat use was not readily available.

2.6 Habitats Evaluated

A wide variety of habitats can be found in and along the shorelines of King County. These range from exposed beaches where wind driven waves have created coarse grained shallow subtidal and littoral habitats to inner Elliott Bay where sediment from the Duwamish River has created muddy, shallow subtidal regions. On the north and south sides of points (e.g., West, and Alki Points) and headlands (e.g., Duwamish Head) gyres created by wind and tidal driven currents allow particulate material to settle out of the water column to the seafloor, providing food for benthic infaunal communities.

Each of the three primary areas discussed in this report (i.e., the Brightwater Outfall Siting Area; the WTD Existing Discharge Area; and the Vashon Island area; see Section 1.2) have been divided for discussion purposes into four basic habitat zones. These include the following:

Photic Zone

- Supralittoral: >+ 3 meters mean lower low water (MLLW)
- Intertidal: -1 to +3 meters MLLW
- Shallow Subtidal: -30 to -1 meters MLLW

Aphotic Zone

- Deep Subtidal: > -200 to -30 meters MLLW

Below the major features and vegetation associated with each habitat zone is discussed. In addition, information is summarized on the types of marine animals that are often associated with these habitat zones. The intertidal and shallow subtidal zones are discussed together as they are both part of the marine photic zone.

2.6.1 Supralittoral

The supralittoral zone (i.e., the zone immediately above the intertidal zone) can be referred to as the marine “riparian” zone. Vegetation in this zone includes trees and shrubs, dune grasses, and other salt tolerant vegetation (Dethier 1990). It is at this elevation where erosion protection structures are most often located to protect the adjacent upland property. The ecological functions of this zone have

not been documented in detail. The vegetation provides shade in the upper intertidal zone, which is believed to be important for protecting surf smelt and sand lance eggs deposited high on beaches (D. Penttila, WDFW, pers. comm.). The vegetation probably moderates temperature and minimizes desiccation. New information indicates that insects produced in the riparian zone are frequently found in the stomachs of juvenile salmon that migrate nearshore (Simenstad and Cordell 2000). For purposes of discussion in Sections 3, 4, and 5, we have limited the types of riparian conditions to natural vegetated areas including trees and dunes, and modified shorelines including riprap, concrete and other structures.

2.6.2 Intertidal – Shallow Subtidal

Intertidal-shallow subtidal zone habitats include rocky and soft substrata and vegetation. The zone extends from -1 MLLW down to the depth at which macroscopic benthic plants are no longer found (i.e., the photic zone). At least 157 species of benthic algae have been reported from the central Puget Sound area (Thom et al. 1976). The upper elevations on rocky shorelines are generally characterized by rock weed (*Fucus distichus*), which is a relatively stable component of the rocky shore habitats (Dethier 1990). It is known to harbor amphipods that are often found in the guts of juvenile salmon (C. Levings, Canada Dept. of Fisheries and Oceans, pers. comm.). Mid and lower intertidal rocky areas are characterized by sea lettuce (*Ulva* spp.), and soft brown algae such as *Laminaria* spp. (Thom et al. 1976). They can be extremely productive, fixing and transporting large amounts of carbon to the nearshore ecosystem (Thom and Albright 1990). The shallow subtidal zone in rocky areas also contains kelp forests (*Nereocystis luetkeana*). Although annual in nature, the kelp forests are often sites where adult and juvenile fishes (especially rockfish) congregate.

Sand and mud flats in the region can have floating sea lettuce in the intertidal and shallow subtidal zone (Thom and Albright 1990). They also contain productive microalgal communities. These microalgal communities are known to support abundant prey resources (i.e., harpacticoid copepods, amphipods) for juvenile chum and chinook salmon as well as English sole and Dungeness crab (Thom et al. 1989; Simenstad et al. 1991). Shorebirds and water fowl such as dunlin, least sand pipers, spotted sand pipers bufflehead, common goldeneye, great blue heron, greater yellowlegs, and horned grebe can heavily feed on vegetation and prey on flats (Simenstad et al. 1991). The sand flats are often dominated by bivalve sand clams (*Macoma* spp.) (Armstrong et al. 1976).

Eelgrass (*Zostera marina*) is a rooted angiosperm that forms meadows in the low intertidal and shallow subtidal zone in the region (Thom and Hallum 1990). Eelgrass meadows harbor large number of fish taxa, and often contain juvenile Dungeness crab and salmonids in very high numbers. Together, eelgrass meadows and tideflats form an extremely important feeding and rearing habitat

for juvenile salmon (Thom et al. 1989). A study conducted in Puget Sound in 1987 by Thom et al. (1989) demonstrated linkages between habitat in the intertidal-shallow subtidal zone and juvenile salmonid feeding. Fish were collected over sites where vegetation and prey samples were also collected. The gut contents of fish were analyzed to assess the relative importance of prey in the diet of salmon. The data showed a close coupling between biomass of benthic plants, especially microalgae, and the abundance of salmon prey. The data also showed that early spring is a key period for production of prey and salmon utilization of these prey resources (Figure 2-1). This illustrates the importance of benthic microalgae on tideflats and epiphytic algae on eelgrass to the production of salmon prey. Although this study was conducted in Drayton Harbor near the U.S. Canadian border, it is suspected that this type of habitat/prey coupling occurs on tideflats and eelgrass systems in other parts of Puget Sound.

Within the intertidal and shallow subtidal habitats resides a wide array of benthic macroinvertebrates. Armstrong et al. (1976) recorded between 178 and 211 species of macroinvertebrates from five beaches in the Seattle area. During a recent video-mapping project completed for King County by Battelle (Woodruff et al. 2000), 12 categories of macro invertebrates were recorded and analyzed along 28 km of shoreline between Picnic Point and Shilshole Bay Marina. The study provides an insight to the major macroinvertebrates that may be found in similar and surrounding areas of the Brightwater, WTD, and Vashon Island areas. Of the 3574 individual observations of macroinvertebrates and 195 aggregate observations, the anemone *Metridium gigantium* was the dominant species followed by unidentified sea stars such as *Pisaster* spp*., Pycnopodia helianthoides, Luidia foliolata, Solaster* spp*., Crossaster* spp*., Mediaster aequalis,* and *Henricia leviuscula*. The third largest observation consisted of anemones of the *Urticina* spp. Some of the other macro invertebrates observed in the analyses consisted of sea pens *Ptilosarcus gurneyi,* sea cucumbers *Parastichopus californicus,* and *Cancer* crab of several species. While most categories of macroinvertebrates were observed in several different types of substrate, the most numerous observations occurred in sand followed sequentially by substrates of mixed coarse, eelgrass meadows, and gravel.

2.6.3 Deep Subtidal

The deep subtidal zone is the area in Puget Sound that lies below the level of light penetration and is characterized by narrow shelves and relatively steep slopes that flatten out into the deep central portions of the Sound. The shelf areas below the photic zone are in water depths ranging from 30 to 60 meters. The narrow shelves consist primarily of medium to fine sand, intermixed with a small amount of gravel in shallow water, grading to silty sand with increasing water depth (EHI 1987; Tetra Tech 1990; Striplin et al. 1990, 1991, 1993). At the shallow end of the range the dominant large epifauna are sea pens, *Ptilosarcus gurneyi,* and sea cucumber, *Parasthicopus californicus*. Several species of multirayed sea stars are also found throughout the range including *Solaster*

dawsoni, *Solaster stimpsoni*, *Pycnopodia helianthoides,* and *Crossaster papposus,* as well as the five rayed sea star *Mediaster aequalis* (EHI 1985). The dominant benthic infauna is highly dependent on sediment grains size but generally consists of polychaete *Phyllochaetopterus prolofica*, the ostracod *Euphilomedes carcharodonta*, and the bivalve mollusc *Psephedia lordi* (Word et al. 1981; Striplin et al. 1985; Striplin et al. 1993).

In many parts of Puget Sound very little information is available about slope depths (~60 to ~150 m) because of the difficulty in sampling. This includes many locations in the study area where the slope exceeds 45 degrees, making using of standard samplers extremely difficult (Word et al. 1984a). In areas where surveys can be easily conducted (i.e., outer Elliott Bay), the sediments consist of sand with various amount of silt, depending on the slope. In areas with fairly steep slopes, the sediments consist of silt, often overlying hard clay (Word et al. 1984a). In areas with slopes less than 45 degrees, the dominant large epibenthic invertebrates appear to be *Mediaster aequalis* at the shallow end of the depth range and sea stars in the genus *Luidia* at greater depths. The sea anemone *Metridium senile* also appears in this depth range and extends to water depths in excess of 200 meters (Striplin et al. 1985). The sea whip *Acanthoptilum* spp. begins to appear in the mid portion of the depth range. In areas where very steep slopes are found (i.e., East Passage) very little information is available. The Seahurst Baseline Study conducted in the early 1980s sampled slopes in the East Passage of the Sound (Word et al. 1984a). They found that in water depths of ~ 120 to 150 meters the slopes consisted of silt which appeared to be somewhat stabilized by the large cigar-shaped tubes of polychaetes in the genus *Asychis*. Also captured in some grab samples were the sea stars *Pycnopodia helianthoides*, *Luidia* spp., and the sea whip *Acanthoptilum* spp. The dominant infaunal invertebrates in areas with silty sand were the bivalve molluscs *Crenella decussata*, *Macoma alaskana*, *Nemocardium centifilosum* and the polychaetes in the genus *Prionospio*. At the base of the slopes the dominant infauna were polychaetes in the genera *Prionospio* and *Myriochele*, the bivalve mollusc *Axinopsida serricata*, and ostracods in the genus *Euphilomedes*.

The slope of Puget Sound generally flattens out at water depths of 150 meters. In these water depths the sediments consist of silt with clay. The exceptions to this general rule can be found at the bases of points (i.e., West, Alki, Three Tree Point) where bottom currents are swift enough that fine silts will not settle (Word et al. 1984a, 1984b). Very few large epibenthic invertebrates were found in these water depths during a video survey conducted in 1985 by Evans-Hamilton, Inc. (EHI 1985). The most obvious invertebrate seen in the video footage was the sea whip *Acanthoptilum* spp. Also present, but not seen in video footage, was the burrowing echinoderm *Brisaster latifrons*. This echinoderm is frequently captured in grab samples in large abundance. The dominant infauna at these deep basin depths is also dependent on grain size, however in siltier sediments (approximately 95% of the basin area), the dominants include polychaetes in the genera *Spiophanes*, *Ampharete*, and *Pectinaria*. Dominant molluscs include *Macoma carlottensis* and *Axinopsida serricata;* dominant crustaceans are

Euphilomedes producta and *Eudorella pacifica* (Word et al. 1984a, 1984b; Tetra Tech 1990; Striplin et al. 1990, 1991, 1993).

The distribution of fishes other than the HCP species in the deep subtidal was well documented by Donnelly et al. (1984) during the Seahurst Baseline Study. Using multivariate analysis on fish data collected from several locations and depths over a two-year period he noted that the groupings of offshore demersal fish were primarily determined by water depth and secondarily by season. The largest diversity of fish were found in the 50 and 100 m depth intervals while the community found at the 200 m interval was the least diverse. The most abundant species at the 50 m depth interval included six species of flatfish and five species of roundfish. Four species of flatfish and five of roundfish were most abundant at the 100 m depth interval while three flatfish and two roundfish species were predominant at the 200 m interval.

The distribution of fishes ranked by abundance and water depth are summarized below.

Fish Species		Water Depth		
Common Name	Scientific Name	50 m	100 m	200m
Slender sole	*Lyopsetta exilis*	✔	✔	✔
Dover Sole	*Microstomus pacificus*	✔	✔	✔
Rex sole	*Glyptocephalus zachirus*	✔	✔	
Pacific sanddab	*Citharichthys sordidus*	✔		
Rock sole	*Lepidopsette bilineata*	✔		
English sole	*Parophrys vetulus*	✔	✔	✔
Plainfin midshipman	*Porichtys notatus*	✔	✔	
Roughback sculpin	*Chitonotus pugetensis*	✔		
Shiner Perch	*Cymatogaster aggregata*	✔		
Pacific tomcod	*Microgadus proximus*	✔		
Walleye Pollock	*Theragra chalcogramma*	✔	✔	✔
Ratfish	*Hydrolagus colliei*		✔	✔
Spiny dogfish	*Squalus acanthias*		✔	
Blackbelly eelpout	*Lycodopsis pacifica*		✔	

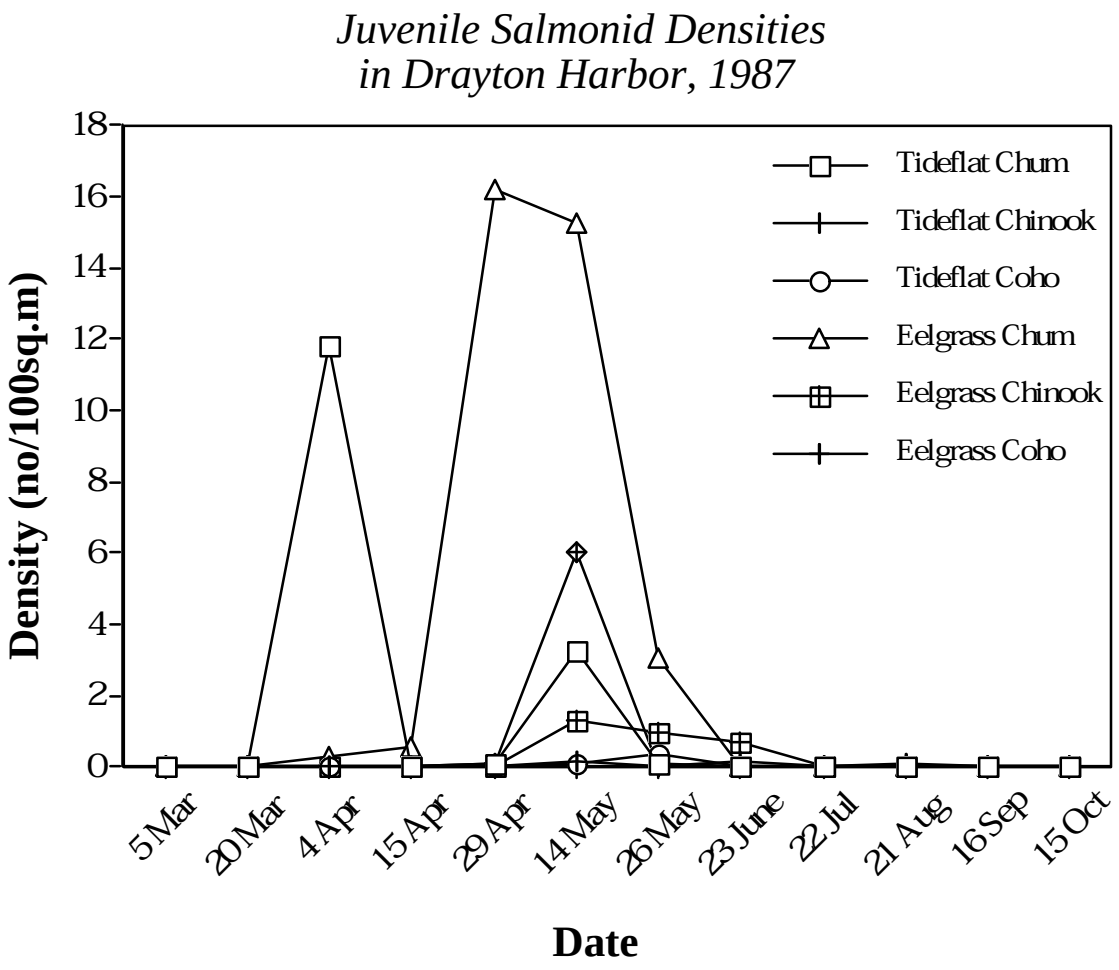

Figure 2-1. Densities of chinook and coho salmon in Drayton Harbor associated with tideflat and eelgrass habitat types

3.0 Brightwater Outfall Siting Area

The following section provides known information regarding habitat distribution and usage of the various habitats in the Brightwater Outfall Siting Area by the species covered in this report (listed in Section 2.0). Readily known distribution and relative abundance for the covered species in the Brightwater Outfall Siting Area are also provided. Data gaps are identified in this section where appropriate; however, a detailed discussion regarding data gaps is provided in Section 6.0.

A comprehensive examination of the physical oceanographic characteristics of the Brightwater Outfall Siting Area is beyond the scope of this report. A general review of the entire study area has been conducted by Evans-Hamilton, Inc. and is available in a separate document (Ebbesmeyer and Cannon 2000). Therefore, information regarding physical oceanography is not provided in this report. Water and sediment chemistry data in the Brightwater Outfall Siting Area are also beyond the scope of this report. This information is available in King County Water Quality Status Reports for Marine Waters (King County 1999, 2000b), Washington Department of Ecology's SEDQUAL database, Washington Department of Ecology's Marine Water Quality Reports (Newton et al. 1997, 1998), as well as through reports that will be produced by the County's Marine Outfall Siting Study team.

3.1 Physical Setting

The Brightwater Outfall Siting Area (Area 1) extends from Mukilteo to Golden Gardens Park at Meadow Point (see Figure 1-1). There are diverse habitats within this area including sandy beaches, stream mouths, and rocky reefs. The supralittoral portion of the nearshore (>+3 m MLLW) supports the bed and tracks of the Northern Pacific Rail Road. There are several beaches in this area heavily used by the public, such as Golden Gardens, Carkeek Park, and Picnic Point. Marinas in this area include the Shilshole Bay Marina and Edmonds Marina, as well as the Edmonds ferry dock. The deepest water depth in the Brightwater Outfall Siting Area, and also the deepest depth in Puget Sound, is 285 m in the main channel off Point Jefferson. The shallow subtidal zone generally consists of sands, gravel, and cobble with outcroppings of rocks and some rocky reefs. The seafloor shelf in the Brightwater Outfall Siting Area is somewhat shallow with water depths of 20-30 m. At this point the shelf steepens substantially, dropping into the slope portion of the aphotic zone. A bathymetry map is presented to provide more information regarding the slopes and depths of the seafloor in the Brightwater Outfall Siting Area (see Figure 3-1).

3.2 Habitat Distribution

In this section, the general distributions of the major habitats are presented. Some information is also provided on the types of fauna associated with these habitats (e.g., eelgrass). The habitats are discussed under three subheadings: supralittoral, intertidal and shallow subtidal, and finally the deep subtidal. For more information on the types of fauna associated with these habitats, see Section 2.6.

3.2.1 Supralittoral

Vegetated habitats in the supralittoral zone have not been comprehensively surveyed. The shoreline in the Brightwater Outfall Siting Area typically consists of high and low bank bluffs, with a gravel and coarse sand beach below. The vegetation along undisturbed shorelines often consists of trees, such as fir and alder, and many vascular plants, grasses, and shrubs. Data from the Washington Department of Natural Resources (WDNR) 1999 Shorezone Database[3] (WDNR 1999) indicate that seawalls predominantly border the shoreline in the Brightwater Outfall Siting Area (see Figure 3-2). Overhanging vegetation occurs in some of the areas bordered by seawalls. Seawalls and shoreline armoring impact the benthic community during construction and changes in bottom substrate and vegetation result from the changes in wave and current patterns following construction (Williams and Thom in prep.). Seawalls can reduce the intertidal zone and soft bottom communities, increase rocky shore communities, and may impact fish migration, predation, and habitat.

3.2.2 Intertidal through Shallow Subtidal

The intertidal and shallow subtidal zones in the Brightwater Outfall Siting Area contain a wide variety of substrate types and vegetation. The distributions of some of the major vegetation taxa in the nearshore habitats are shown in Figures 3-3 through 3-7 and are discussed in more detail in the following paragraphs.

Although there are at least 157 species of benthic algae that have been reported (Thom et al. 1976), there are two taxa of seaweed *Fucus gardneri* (rock weed) and *Ulva* spp. (sea lettuce) that predominate on the beaches in the Brightwater Outfall Siting Area. *Fucus* is always found attached to more stable rocks ranging from small cobble through boulders (Thom 1983). *Fucus* is very common but generally patchy in the Brightwater Outfall Siting Area (Figure 3-3), indicating extensive high intertidal rocky substrate (Detheir 1990). This can include both natural substrate (e.g., cobbles and boulders) and artificially placed hard structures (e.g., rip rap and concrete). *Ulva* is found almost continuously along the shoreline of the Brightwater Outfall Siting Area (Figure 3-4). It occurs

[3] WDNR Shorezone Database is based on aerial surveys conducted by helicopter. The data on geological features and habitats were then translated into an ArcView Database. For purposes of this report, only general features of the supralittoral zone were extracted.

primarily in patches but is found in continuous beds near Edmonds and Shilshole Bay. *Ulva* typically attaches to pebbles or larger-sized substrata but may also be found in viable free-floating patches deposited along beaches. It is within these exposed and semi-exposed rocky habitats that a wide variety of species are found, including recreational and commercially important bivalves (Armstrong et al. 1976, Dethier 1990). Fish species that use prey produced in these habitats include coho salmon, cutthroat trout, Dolly Varden, and river lamprey (Simenstad et al. 1991)

Laminaria spp. is rare throughout most of the region (Figure 3-5). It is found mostly in patches in both the low intertidal and shallow subtidal zones of the southern region (Thom et al. 1976). Kelp is also rare in the region according to the WDNR Shore zone Database (WDNR 1999) and surveys conducted in 1999 by Battelle Marine Sciences Laboratory for King County (Woodruff et al. 2000), with the densest patches near Edmonds and Shilshole marina (Figures 3-6 and 3-7). Because it needs to attach to stable rocks, the distribution of kelp coincides with the more typical rocky substrates found in the deeper intertidal and shallow subtidal habitats.

Intertidal eelgrass (predominately *Zostera marina*) is very common in the Brightwater Outfall Siting Area, but is generally patchy (Figures 3-6 and 3-7). Eelgrass is moderate to dense and more or less continuously distributed in the shallow subtidal zone between Picnic Point and Shilshole Bay. Eelgrass commonly occurs in shallow soft bottom tide flats, along channels and in the shallow subtidal fringe. These eelgrass communities serve as habitat for many different species and provide feeding and refuge habitats for chum salmon, lingcod, herring, sand lance, and surf smelt (Dethier 1990; Simenstad et. al 1991). Although this report focuses on these and other species of concern (see Section 2), eelgrass habitat hosts many other species of importance such as perch, crab (Dethier 1990), and various other invertebrates (Simenstad, et. al 1991) that serve as prey resources for salmonids (See Appendix A). Eelgrass distributions depicted in Figures 3-6 and 3-7 indicate that a transition occurs from the predominant coarser rocky substrates in the lower intertidal and upper subtidal substrates to finer grained sediment types (e.g., sand, mixed fines, silt, and mud) that support eelgrass in the lower shallow subtidal habitats (Dethier 1990).

Tideflats, consisting of unconsolidated sands, silts, and clays, occur throughout the Brightwater Outfall Siting Area, but have not been mapped completely. They are widest in the middle portion of embayments such as near Richmond Beach, Carkeek Park and West Point (Armstrong et al. 1976). Infaunal communities in the Brightwater Outfall Siting Area contain a number of amphipod and other crustaceans, as well as many species of bivalves, such as *Macoma* spp., (Armstrong et al. 1976). The crustacea are prey for juvenile salmonids (See Appendix A). Tideflats are proven to contain productive microalgae as well as prey resources (e.g., harpacticoids, copepods, and amphipods) for juvenile chinook and chum salmon (Simenstad et al 1991).

3.2.3 Deep Subtidal

Very little habitat data have been generated for the deep subtidal portion of the Brightwater Outfall Siting Area. Surface sediment maps compiled by Roberts (1979) indicate that sediment in the upper edge of the deep subtidal consists of sand with some silt. The depths presented here, based on Robert's data, are approximate because depth data were not presented on his maps. Sediment samples collected in about 40 m of water off of the Richmond Beach Outfall contained large amounts of rounded cobble mixed with coarse sand. The dominant organisms at all five stations were the tube-building polychaete *Phyllochaetopterus prolifica* and the ostracod *Euphilomedes carcharodonta* (Word et al. 1981). Sediment samples collected by the Puget Sound Ambient Monitoring Program (PSAMP) off of Mukilteo, South Picnic Point, and Richmond Beach were consistent with the Roberts data in that sand was the primary sediment type (Tetra Tech 1990; Striplin et al. 1990, 1991, 1993). The dominant infaunal invertebrates at these locations were similar to the 1981 survey with the addition of the bivalve mollusc *Psephedia lordi* at the Mukilteo and South Picnic Point locations.

There is very little information available documenting habitat characteristics in the intermediate water depths in the Brightwater Outfall Siting Area.

Robert's maps indicate that from just north of Edmonds through Richmond Beach the sediment grades from sand to a mix of sand and silt with increasing water depth. The maps do not extend to the central portion of the deep Puget Sound Basin. PSAMP sampled one station at the base of the slope in 182 m of water off of Norma Beach and the sediment consisted of an even mix of silt and clay and was dominated by the polychaetes *Pectinaria californiensis*, the bivalve molluscs *Macoma carlottensis* and *Axinopsida serricata* and the crustaceans *Euphilomedes producta* and *Eudorella pacifica* (Tetra Tech 1990). A second PSAMP station located in 260 m of water along the west side of the central basin (where Admiralty Inlet enters the central basin) contained sand with large amounts of molluscan shell debris. These shells were 3-4 cm in length and were *Macoma calcarea*, a species typically found in shallow water. Their presence at this location is indicative of the strong bottom water currents in this portion of the central basin. This station, located in the deepest part of the central basin, was dominated by bivalve mollusc *Macoma carlottensis* and the ostracod *Euphilomedes producta*.

3.3 Species Distribution and Occurrence

The distribution and occurrence information presented below for the HCP covered species is based upon documented information cited in available literature and/or personal communication with biologists/experts from local, state, and federal agencies. Much of the distribution data for fishes are based upon trawl and video data and are dependent upon the time of year, depth, and

location sampled. Many pelagic fish, such as yellowtail and black rockfish, are rarely documented in trawl surveys as the sampling method favors capturing semi-demersal or demersal fish such as lingcod, Pacific cod, and quillback rockfish. The absence of pelagic and other species from trawl and video data does not preclude those species from inhabiting waters in the Brightwater Outfall Siting Area, and is instead a reflection of the sampling method. Most of the data for marine birds are based upon seasonal aerial surveys and seasonal land surveys and are dependent upon favorable sighting conditions, time of year surveyed, species wariness, and location surveyed.

3.3.1 Marine Mammals and Birds

Orca -- *Orcinus orca*

The southern resident Orca whale community, particularly the J pod, is known to occasionally enter inland Puget Sound waters in search of prey. For the past several years, Orcas have been seen in central Puget Sound in the fall, particularly in September and October (K. Koski, Whale Museum, pers. comm.). They have been seen in central Puget Sound from June through October, but as stated above, the most frequent occurrences are in the fall as the whales follow the salmon runs (Balcomb and Goebal 1976; Balcomb 1982; Olesiuk et al. 1990). Thus, the whales travel through the waters of the Brightwater Outfall Siting Area as they travel south following their prey.

The J, K, and L pods currently consist of 19, 17, and 47 whales, respectively (A. Traxler, Whale Museum, pers. comm.). Transient whales have not been documented in the Brightwater Outfall Siting Area and are not known to occur in inland Puget Sound waters.

Harbor Porpoise -- *Phocoena phocoena*

The inland Washington stock of harbor porpoises are seen along the Straits and outer coasts with no confirmed sightings south of Admiralty Inlet for the last several years, and sightings south of the Straits extremely rare (Calambokidis et al. 1992; B. Hanson, NMML, pers. comm.). During a yearlong survey in 1996, no harbor porpoises were seen in Puget Sound even though sighting conditions were favorable (Osmek et al. 1997). In 1994, there were two harbor porpoise strandings in south Puget Sound and it is likely that poor health caused these two porpoises to enter the sound (Osmek et al. 1997). There have been no documented harbor porpoise sightings in the Brightwater Outfall Siting Area. NOAA’s National Marine Mammal Laboratory began cyclical surveys in 1991, and distribution and abundance of both harbor and Dall's porpoises were surveyed in 1996 and are scheduled to be surveyed again in 2001. The minimum population estimate of the inland Washington harbor porpoise stock in the draft 2000 marine mammal stock assessment report is 2,545 porpoises (Forney et al. 2000).

Steller Sea Lion -- *Eumetopias jubatus*

Most Steller (or northern) sea lions in Washington State occur along the coast from Cape Flattery to the mouth of the Columbia River. Steller sea lions are also found in the San Juan Islands and Strait of Juan de Fuca. Some Steller sea lions do occur in the inland waters of Puget Sound, but in small numbers. They are migratory and may be seen at any time of the year, but appear to be the most abundant during summer and fall (Gearin at al. 1988; Chumbley 1993). There are no Steller sea lion rookeries in the Brightwater Outfall Siting Area.

As Steller sea lions are migratory, they may occur in the Brightwater Outfall Siting Area as they travel south from the San Juan Islands and the Strait of Juan de Fuca. They also use navigational buoys and jetties as haul out sites (Jeffries et al. 2000). In September 2000, King County staff observed a large male Steller sea lion hauled out on the jetty of the Shilshole Bay Marina in the southern portion of the Brightwater Outfall Siting Area.

Common Murre -- *Uria aalge*

Common murres are permanent residents of the Washington Coast and are seen most frequently in the San Juan Islands, Strait of Juan de Fuca and in smaller numbers in Puget Sound (Angell and Balcomb 1982). The Washington State Department of Fish and Wildlife's (WDFW's) PSAMP bird component uses aerial surveys to evaluate bird populations. WDFW's surveys found that from 1992 through 1999 the number of common murres found in the Brightwater Outfall Siting Area in the winter ranged from 0 to 25 animals per square kilometer (animals/km^2) (Figure 3-8) (WDFW 2000). In the summer months, the average number of common murres ranged from 0 to 257 animals/km^2 (Figure 3-9). Because of the small size and wariness of the bird species counted in this survey, the absence of sightings does not preclude the presence of these birds in the survey area in greater numbers than those observed (WDFW 2000).

Common murres have been noted in the southern portion of the Brightwater Outfall Siting Area for the Seattle Christmas Bird Count (CBC) annual survey every year since 1983. The survey area is limited to a 15-mile diameter circle centered near downtown Seattle conducted in a 24-hour period (H. Opperman, Seattle Audubon Society, pers. comm.). Numbers for murres in the CBC survey varied from year to year with 7 birds being the lowest and 225 birds being the highest (H. Opperman, Seattle Audubon Society, pers. comm.).

Marbled Murrelet -- *Brachyramphus marmoratus*

This species is a fairly common winter visitor in the Strait of Juan de Fuca and the San Juan Islands but a less common visitor to Puget Sound. They are most commonly seen in the San Juan Islands and adult birds may be seen throughout the year with the largest concentrations in the fall and winter (Angell and Balcomb 1982). WDFW (2000) found that from 1992 through 1999 the winter observations of marbled murrelets in the Brightwater Outfall Siting Area revealed no birds within this area (Figure 3-10). In the summer months, from 1 to 4 birds

were observed in the area south of Everett (Figure 3-11). Marbled murrelets are small, wary, diving birds and the lack of sightings and the low numbers observed in the WDFW surveys may not accurately reflect the distribution and abundance of this species within the study areas. Marbled murrelets have only been seen in the southern portion of the Brightwater Outfall Siting Area in 8 out of 17 years since the start of the Seattle CBC annual survey in 1983. The number of birds has ranged from 1 to 17, but usually only 1 to 3 birds have been seen in years when this species was present (H. Opperman, Seattle Audubon Society, pers. comm.).

Harlequin Duck -- *Histrionicus histrionicus*

Harlequin ducks are permanent Washington residents that breed inland along rivers and streams in the Cascades, including eastern King and Snohomish Counties. Males gather in small flocks in Puget Sound in late summer and then the females bring their young from the rivers and streams to winter with the males from October to May (Angell and Balcomb 1982). The largest concentrations are seen near Protection Island and Marrowstone Island where molting birds gather to feed and rest in June and July (Angell and Balcomb 1982). The Dungeness National Wildlife Refuge is an important wintering habitat for harlequin ducks and as such they are a regular winter visitor in the central Puget Sound Basin. WDFW (2000) found that from 1992 through 1999 the number of harlequin ducks in the Brightwater Outfall Siting Area in the winter ranged from 0 to 10 animals per square kilometer (see Figure 3-12). In the summer months, no harlequin ducks were counted in this area (see Figure 3-13). As noted previously, the lack of sightings in the WDFW surveys could be due to the small size and wary nature of these birds (Angell and Balcomb 1982). Harlequin ducks have been noted in the southern portion of the Brightwater Outfall Siting Area for the Seattle CBC survey every year since 1983, with 18 being the lowest number counted and 59 birds being the highest (H. Opperman, Seattle Audubon Society, pers. comm.).

3.3.2 Salmonids

Bull Trout -- *Salvelinus confluentus*

Little is known of the distribution and abundance of bull trout in Puget Sound estuaries and nearshore waters. There are no documented reports of bull trout in the Brightwater Outfall Siting Area. However, anadromous bull trout have been documented or are thought to occur in the Skagit River, Skykomish River, Green River, and possibly the Lake Washington watersheds; therefore, it is likely that bull trout use the subtidal and nearshore waters in the Brightwater Outfall Siting Area as a migratory pathway (WDFW 1998). Spring to mid-late summer is the most likely time that bull trout would be found in the Brightwater Outfall Siting Area as spring is when both juveniles and adults enter estuarine areas and remain until mid-late summer before returning to freshwater (WDFW 1998; Kraemer 1994).

Chinook, Chum, Coho, Sockeye, Salmon and Cutthroat Trout – *Oncorhynchus* spp. --- Juvenile

There is limited information regarding juvenile salmonid distribution in the Brightwater Outfall Siting Area. However, it is likely these species use the nearshore and offshore waters as a migratory pathway (and as rearing habitat for some species, including chinook), as these salmonids have documented populations in rivers and streams surrounding the Brightwater Outfall Siting Area.

Beach seining surveys were conducted from June to August 2000 by King County (Mavros and Brennan, in prep.) at two beaches in the Brightwater Outfall Siting Area: Picnic Point and Richmond Beach. These surveys documented wild and hatchery juvenile chinook salmon in the nearshore area at Picnic Point in July and August and also at Richmond Beach from June to August. Juvenile steelhead trout were also found at Picnic Point in July and August and at Richmond Beach in August. No other salmonids were found at Picnic Point but two juvenile coho were seen at Richmond Beach in June.

Chinook, Chum, Coho, Sockeye, Salmon and Cutthroat Trout – *Oncorhynchus* spp. --- adult

A compilation of distribution data for Puget Sound fishes through 1973 by Miller and Borton (1980) shows observations of chinook and chum salmon within most sections of the Brightwater Outfall Siting Area. There were also observations of coho and sockeye salmon in nearshore and offshore waters in the Brightwater Outfall Siting Area prior to 1973. Miller and Borton reported cutthroat trout were present throughout the nearshore waters of the Brightwater Outfall Siting Area. Although abundance data were not presented for the Miller and Borton report, the widespread occurrence of cutthroat trout indicates a degree of abundance for this species in this area (see Figures B-6 through B-10 in Appendix B).

The 1992 Washington State Salmon and Steelhead Stock Inventory (SASSI) conducted by WDFW (1993) did not document populations of chinook, chum, coho, and sockeye salmon in streams or rivers within the Brightwater Outfall Siting Area. However, rivers and streams surrounding the study area revealed populations of both chinook and chum, some of which were listed as healthy with consistent returns (WDFW 1993b). It is likely that the migratory pathway of all these salmonids includes the waters in the Brightwater Outfall Siting Area.

Steelhead -- Oncorhynchus mykiss

Several isolated observations of steelhead in the Brightwater Outfall Siting Area prior to 1973 were documented as shown in Figure B-11, Appendix B (Miller and Borton 1980). These observations were nearshore with a cluster near the entry to the Lake Washington waterways. Although not in the Brightwater Outfall Siting Area, major rivers in Puget Sound, such as the Skagit, Skykomish, and Green Rivers, support populations of winter and summer-run steelhead and it is likely

that their migratory pathways include waters in the Brightwater Outfall Siting Area (Pauley et al. 1986).

3.3.3 Lamprey

There is very little distribution and abundance information for the two species of lamprey addressed in this report.

Pacific Lamprey (*Entosphenus tridentatus)* and River Lamprey *(Lampetra ayresi)*

At this time there are no site-specific data for Pacific and River lampreys in the Brightwater Outfall Siting Area. However, these lampreys are known to exist in Washington waters and therefore may be present in the Brightwater Outfall Siting Area streams and marine waters (Hart 1980; Wydoski and Whitney 1979).

3.3.4 Invertebrates

Northern Abalone -- *Haliotis kamtschatkana*

No known site-specific information was readily available for Puget Sound. The northern abalone is generally not found in estuaries and there were no documented occurrences in the Brightwater Outfall Siting Area. This species is primarily found on the outer coast and in the Straits and the farthest south the northern abalone has been seen is by the Keystone ferry dock on the western side of Whidbey Island (R. Anderson, Seattle Aquarium, pers. comm.).

Olympia Oyster -- *Ostrea conchaphila*

Site-specific information of the Olympia oyster in the Brightwater Outfall Siting Area is not known and there were no documented occurrences. However, Olympia oysters do occur in inland Puget Sound waters but are abundant only in southern Puget Sound (Cook et al. 1998). They most likely do settle out in other areas in Puget Sound in relatively low abundance; however, it is not enough to sustain a breeding population. This is because Olympia oysters spawn in water temperatures from 13 to 16 ^{o}C (Couch and Hassler 1989) and the waters in the Brightwater Outfall Siting Area are colder than spawning requirements (King County 2000b), thus preventing an abundance of this species in the area.

3.3.5 Marine Fish

Of the 24 species of marine fishes addressed in this report, nine were observed and identified in the Brightwater Outfall Siting Area. These observations are based on data from WDFW's Technical Report No. 79 (WDFW 1992) (Figure 3-14), WDFW's video and trawl surveys (Figure 3-15) and video surveys conducted by Battelle Marine Sciences Laboratory for King County (Woodruff et al. 2000) (Figure 3-16). These data sources also noted at least two additional

species, however, they were not positively identified. These unidentified species were grouped as baitfish (herring or sand lance) and rockfish (*Sebastes* spp.).

The marine fish species are listed in Table 3-1 along with their distribution, the primary habitat on which they were most often observed, the depth range at which they were observed, and their relative abundance within the Brightwater Outfall Siting Area. The fact that a species was not observed does not mean that it was not present. These species are mobile and many tend to hide in cracks and crevices. In addition, many of these species have cryptic coloration making them difficult or impossible to see even when they are in the open. Seasonal variation in food resources, life history stages (e.g., spawning, juvenile recruitment), or environmental conditions can also affect the presence, distribution, and abundance of these fish species. Much of the fish information was derived from video and trawl surveys, which are limited to few sampling locations and low sampling frequency. In addition, many species that occur primarily in open and mid-water habitats or are active at night will be underestimated due to survey method.

Ground Fish

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

No specific records of green or white sturgeon in the Brightwater Outfall Siting Area were found, but Miller and Borton (1980) did report two records of green/white sturgeon occurrences somewhere within Puget Sound (see Figures B-3 and B-4, Appendix B). Because the specific locations were unknown, it is possible that they were in the Brightwater Outfall Siting Area.

Pacific Cod -- *Gadus macrocephalus*

Occurrences of Pacific cod in the Brightwater Outfall Siting Area were reported by Miller and Borton (1980) (see Figure B-15, Appendix B) and also by WDFW (Figure 3-15 and Appendix C). Pacific cod were observed from Edmonds south, with most observations near Meadow Point.

Palsson et al. (1997) designated the Pacific cod stock status for Puget Sound as “critical.” They suggested the Pacific cod fishery was over-utilized and estimated the 1991 population abundance at 47,000 individuals (down from 1.6 million estimated in 1987).

Walleye Pollock -- *Theragra chalcogramma*

In addition to information from the WDFW surveys (see Figure 3-15 and Appendix C), Miller and Borton (1980) reported observations of walleye pollock throughout the Brightwater Outfall Siting Area, especially in the southern end (see Figure B-17, Appendix B). Quinnell and Schmitt (1991) found walleye pollock most abundant at depths between 38 and 73 m.

Palsson et al. (1997) designated the walleye pollock stock status for Puget Sound as “critical.” They suggested the walleye pollock fishery was over-utilized and

estimated the 1991 population abundance at 99,000 individuals (down from 3.5 million estimated in 1987).

Pacific Hake -- *Merluccius productus*

In addition to distribution data from the WDFW survey (Figure 3-15 and Appendix C), Miller and Borton (1980) reported observations of Pacific hake throughout the Brightwater Outfall Siting Area, especially in the southern end (see Figure B-16, Appendix B). Quinnell and Schmitt (1991) found Pacific hake most abundant at depths between 75 and 110 m.

Most of the south-central Puget Sound Pacific hake spawn to the north of the Brightwater Outfall Siting Area in Port Susan (Palsson et al. 1997). It is probable that Pacific hake of all ages pass through the Brightwater Outfall Siting Area on their way to or from the spawning area, especially during spawning season (spring).

Lingcod -- *Ophiodon elongates*

In addition to the observations during the Battelle video survey (Woodruff et al. 2000) and WDFW video and trawl surveys (Figure 3-15 and Appendix C), Miller and Borton (1980) reported observations of lingcod near Edwards Point and Meadow Point (see Figure B-33, Appendix B). Quinnell and Schmitt (1991) found lingcod most abundant at depths between 9 and 37 m or greater than 110 m.

Palsson et al. (1997) designated the lingcod stock status for Puget Sound as "above average." They suggested the lingcod fishery was fully utilized and estimated the 1991 population abundance at 7,000 individuals (equal to the estimation in 1987).

Forage Fish

Pacific Herring -- *Clupea harengus pallasi*

In addition to data from WDFW trawl surveys (Figure 3-15 and Appendix C), Miller and Borton (1980) reported observations of Pacific herring throughout the Brightwater Outfall Siting Area, especially in the southern end (see Figure B-5, Appendix B). Herring were not distinguished from sand lance during the Battelle video surveys (Woodruff et al. 2000), and were reported as either herring or sand lance (Figure 3-16). Quinnell and Schmitt (1991) found Pacific herring most abundant in shallow water (9-37 m) and estimated an abundance of nearly 1.5 million individuals in the central Puget Sound area in 1987.

While there are no documented Pacific herring spawning grounds within the Brightwater Outfall Siting Area (Figure 3-14), spawning grounds are documented to the south (Quartermaster Harbor), west (Port Orchard/Madison), and north (Port Susan) (Lemberg et al. 1997). It is probable that Pacific herring of all ages pass through the Brightwater Outfall Siting Area on their way to or from the

spawning grounds, especially during spawning season (late January through early June).

Sand Lance -- *Ammodytes hexapterus*

Miller and Borton (1980) reported observations of sand lance near Edwards Point, Point Wells and in the southern end of the Brightwater Outfall Siting Area near Meadow Point, where most observations have been documented (see Figure B-18, Appendix B). There are also documented spawning grounds near Edwards Point and Meadow Point (see Figure 3-14). Currently King County and WDFW are further evaluating the presence of spawning grounds in the Brightwater Outfall Siting Area.

Beach seining surveys were conducted from June to August 2000 by King County (Mavros and Brennan, in prep) at two beaches in the Brightwater Outfall Siting Area: Picnic Point and Richmond Beach. These surveys documented sand lance in the nearshore areas at Richmond Beach and Picnic Point during all three months. The highest number of sand lance observed per set ranged from 500 fish in June at Richmond Beach to 300 in July at Picnic Point.

Surf Smelt -- *Hypomesus pretiosus*

Miller and Borton (1980) reported observations of surf smelt near Edwards Point and in the southern end of the Brightwater Outfall Siting Area near Meadow Point, where most observations have been documented (see Figure B-13, Appendix B). There are also documented spawning grounds near Edwards Point and Meadow Point (Figure 3-14). Currently King County and WDFW are further evaluating the presence of spawning grounds in the Brightwater Outfall Siting Area.

The beach seining surveys conducted from June to August 2000 by King County (Mavros and Brennan, in press) at two beaches in the Brightwater Outfall Siting Area (Picnic Point and Richmond Beach) documented surf smelt in the nearshore areas at both beaches. Surf smelt were only seen at Picnic Point in July (the highest number of fish per set was 10) but were seen during all three months at Richmond Beach with the highest number per set being 100.

Eulachon -- *Thaleichthys pacificus*

The only observations of Eulachon in the Brightwater Outfall Siting Area are the few records reported by Miller and Borton (1980). Their three observations were in the southern end of the Brightwater Outfall Siting Area near Meadow Point (see Figure B-14, Appendix B).

Rockfish

The following rockfish species covered in the HCP are distributed along the outer Washington coasts and in the Straits surrounding the San Juan Islands — but are not known to occur in inland Puget Sound waters or in the Brightwater Outfall Siting Area: blue, widow, china, and tiger rockfish (W. Palsson, WDFW, pers.

comm.; J. Christiansen, Seattle Aquarium, pers. comm.). The other rockfish species covered in the HCP are discussed below.

Brown Rockfish -- *Sebastes auriculatus*

Miller and Borton (1980) reported observations of brown rockfish in the southern end of the Brightwater Outfall Siting Area near Meadow Point (see Figure B-19, Appendix B). Quinnell and Schmitt (1991) found brown rockfish most abundant at depths between 9 and 37 m and estimated an abundance of about 22,000 individuals in the central Puget Sound area in 1987.

Copper Rockfish -- *Sebastes caurinus*

The WDFW surveys (Figure 3-15 and Appendix C) and Miller and Borton (1980) (see Figure B-20, Appendix B), reported observations of copper rockfish in the Brightwater Outfall Siting Area with most observations occurring in shallow waters near Edwards Point, Point Wells, and Meadow Point. Quinnell and Schmitt (1991) found copper rockfish most abundant at depths between 9 and 37 m and estimated an abundance of about 88,000 individuals in the central Puget Sound area in 1987.

Greenstriped Rockfish -- *Sebastes elongates*

Greenstriped rockfish have been observed near Edmonds and in the southern end of the Brightwater Outfall Siting Area near Meadow Point (Miller and Borton 1980; see Figure B-21, Appendix B). WDFW did not observe this species at any of their video or trawl sampling locations in the Brightwater Outfall Siting Area. Adults of this species prefer deep waters (generally > 91 m) and the distribution of juveniles is not known (Hart 1980).

Yellowtail Rockfish -- *Sebastes flavidus*

Miller and Borton (1980) reported observations of yellowtail rockfish in the southern end of the Brightwater Outfall Siting Area near Meadow Point (see Figure B-23, Appendix B). In addition, schools of adult yellowtail rockfish are commonly seen throughout the Brightwater Outfall Siting Area year-round in the water column at depths usually less than 46 m (Eschmeyer et al. 1983; J. Christiansen, Seattle Aquarium, pers. comm.). Juveniles are not seen in the Brightwater Outfall Siting Area but are found in the Straits in July and August (J. Christiansen, Seattle Aquarium, pers. comm.).

Quillback Rockfish -- *Sebastes maliger*

In addition to the data from Battelle and WDFW surveys (see Figures B-15 and B-16, Appendix B), Miller and Borton (1980) reported observations of quillback rockfish near Edwards Point and in the southern end of the Brightwater Outfall Siting Area near Meadow Point (see Figure B-24, Appendix B). The WDFW trawl and video surveys found quillback rockfish throughout the Brightwater Outfall Siting Area, most often in rocky nearshore areas (Figure 3-15 and Appendix C). Quinnell and Schmitt (1991) found quillback rockfish most

abundant at depths between 38 and 73 m and estimated an abundance of about 740,000 individuals in the central Puget Sound area in 1987.

Black Rockfish -- *Sebastes melanops*

Miller and Borton (1980) reported observations of black rockfish in the Brightwater Outfall Siting Area near Edwards Point, Point Wells, and Meadow Point (see Figure B-25, Appendix B). WDFW trawl surveys did not find black rockfish in the Brightwater Outfall Siting Area; however, it is not likely that this species would be found in trawl surveys, as this is a mid-water species. WDFW video surveys also did not find this species in the Brightwater Outfall Siting Area, however, this species was seen nearby in shallow water (< 12 m) at the southeastern end of Whidbey Island in rocky substrate (Figure 3-15 and Appendix C).

Bocaccio -- *Sebastes paucispinus*

Miller and Borton (1980) reported an observation of bocaccio in the southern end of the Brightwater Outfall Siting Area near Meadow Point (see Figure B-29, Appendix B). This species was not found in the WDFW video and trawl surveys, possibly as a function of habitat use. This is primarily a deep, open water species (Hart 1980).

Canary Rockfish -- *Sebastes pinniger*

Miller and Borton (1980) reported canary rockfish near Shilshole Bay in the southern portion of the Brightwater Outfall Siting Area (see Figure B-30, Appendix B). However, this species was not found in the WDFW video and trawl surveys and is rarely seen south of Hood Canal. This species is primarily found along the outer coasts and in the Straits (J. Christiansen, Seattle Aquarium, pers. comm.). In addition, surveying is difficult because this is mainly a deep, open water species(Hart 1980).

Redstripe Rockfish -- *Sebastes proriger*

Miller and Borton (1980) reported observations of redstripe rockfish in the southern end of the Brightwater Outfall Siting Area near Meadow Point (see Figure B-31, Appendix B). WDFW did not observe redstripe rockfish in the Brightwater Outfall Siting Area during their video or trawl surveys. However, there was an observation for this species in the northeastern portion of the Kitsap Peninsula (Figure 3-15 and Appendix C) and it is possible that this species could occur in the Brightwater Outfall Siting Area. Quinnell and Schmitt (1991) found redstripe rockfish most abundant at depths between 75 and 110 m and estimated an abundance of about 5,000 individuals in the central Puget Sound area in 1987.

Yelloweye Rockfish -- *Sebastes ruberrimus*

Miller and Borton (1980) reported observations of yelloweye rockfish in the southern end of the Brightwater Outfall Siting Area near Meadow Point (see Figure B-32, Appendix B). This solitary species is occasionally seen in the

Brightwater Outfall Siting Area in rocky crevices in deep waters (>18 m) (J. Christiansen, Seattle Aquarium, pers. comm.).

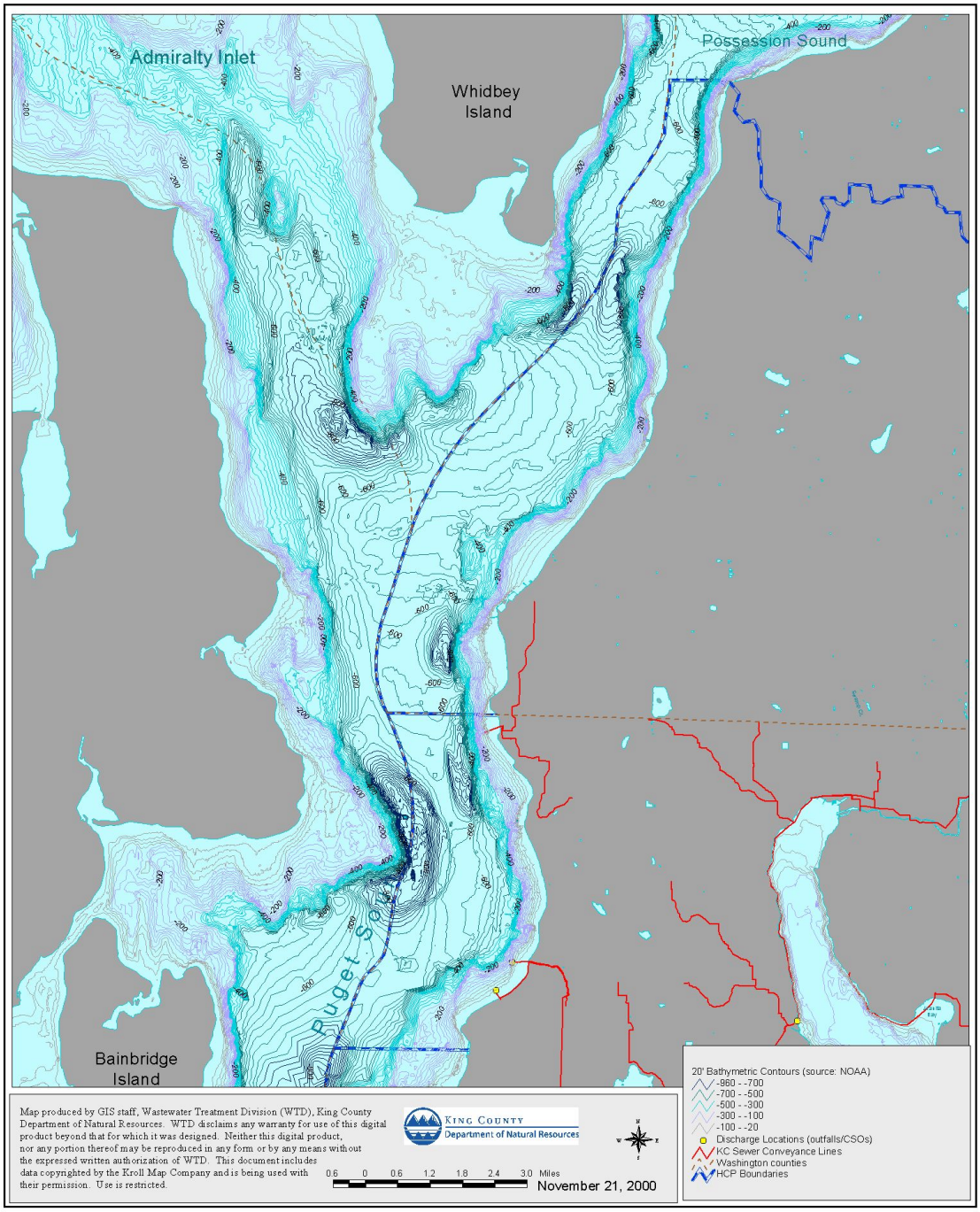

Figure 3-1. Bathymetric contours in the Brightwater Outfall Siting Area

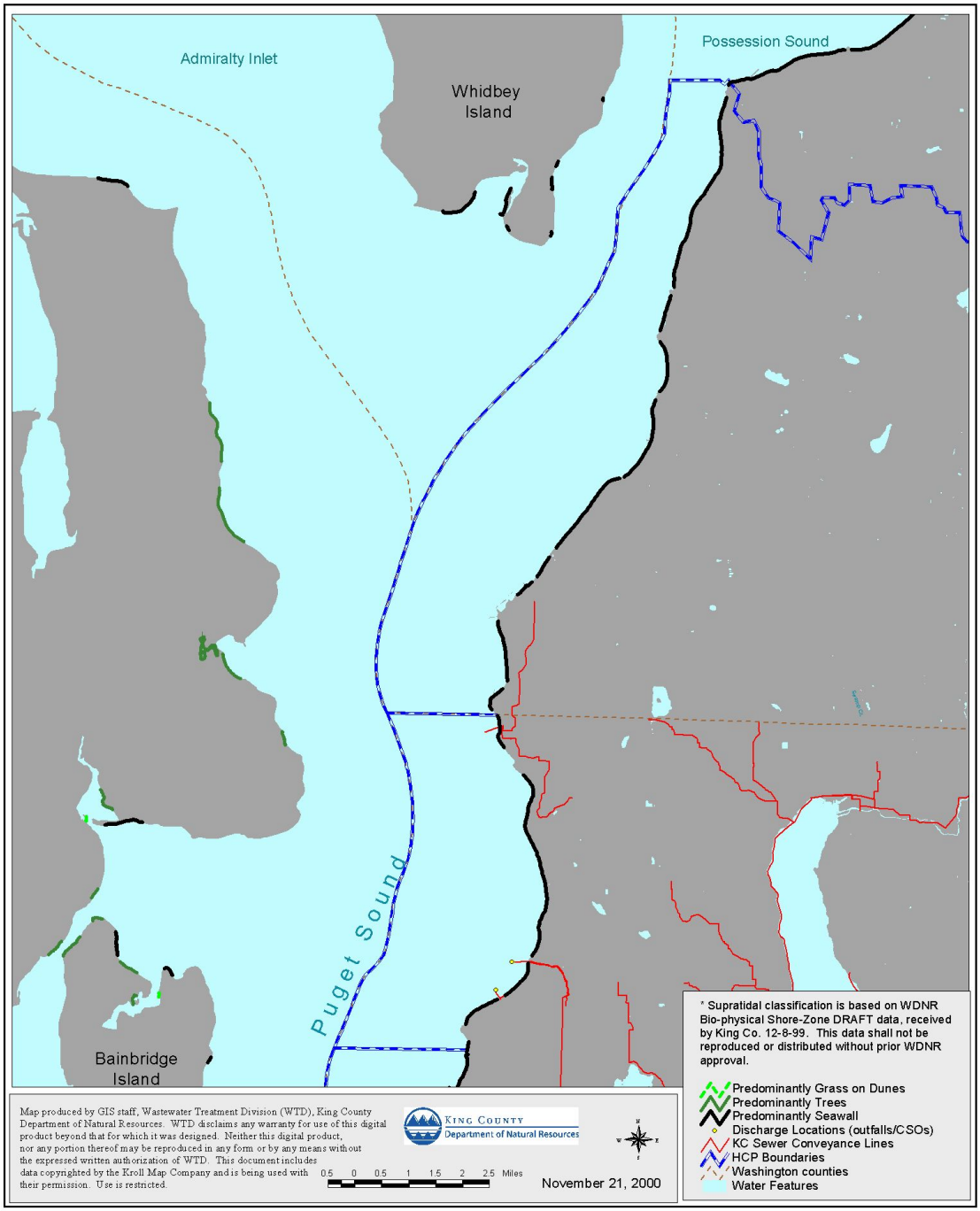

Figure 3-2. Supralittoral zone in the Brightwater Outfall Siting Area

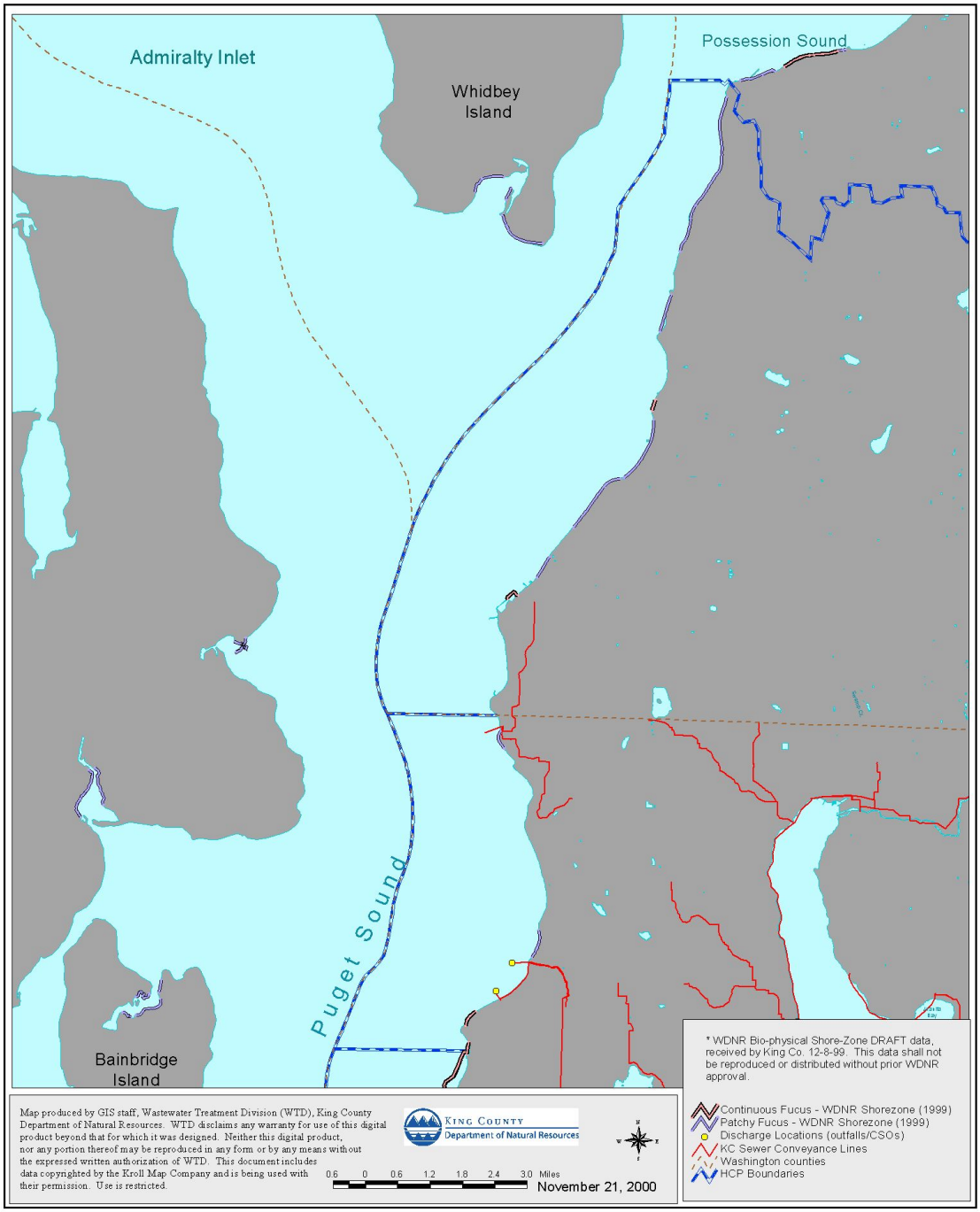

Figure 3-3. Distributions of rockweed (*Fucus*) in the intertidal zone of the Brightwater Outfall Siting Area

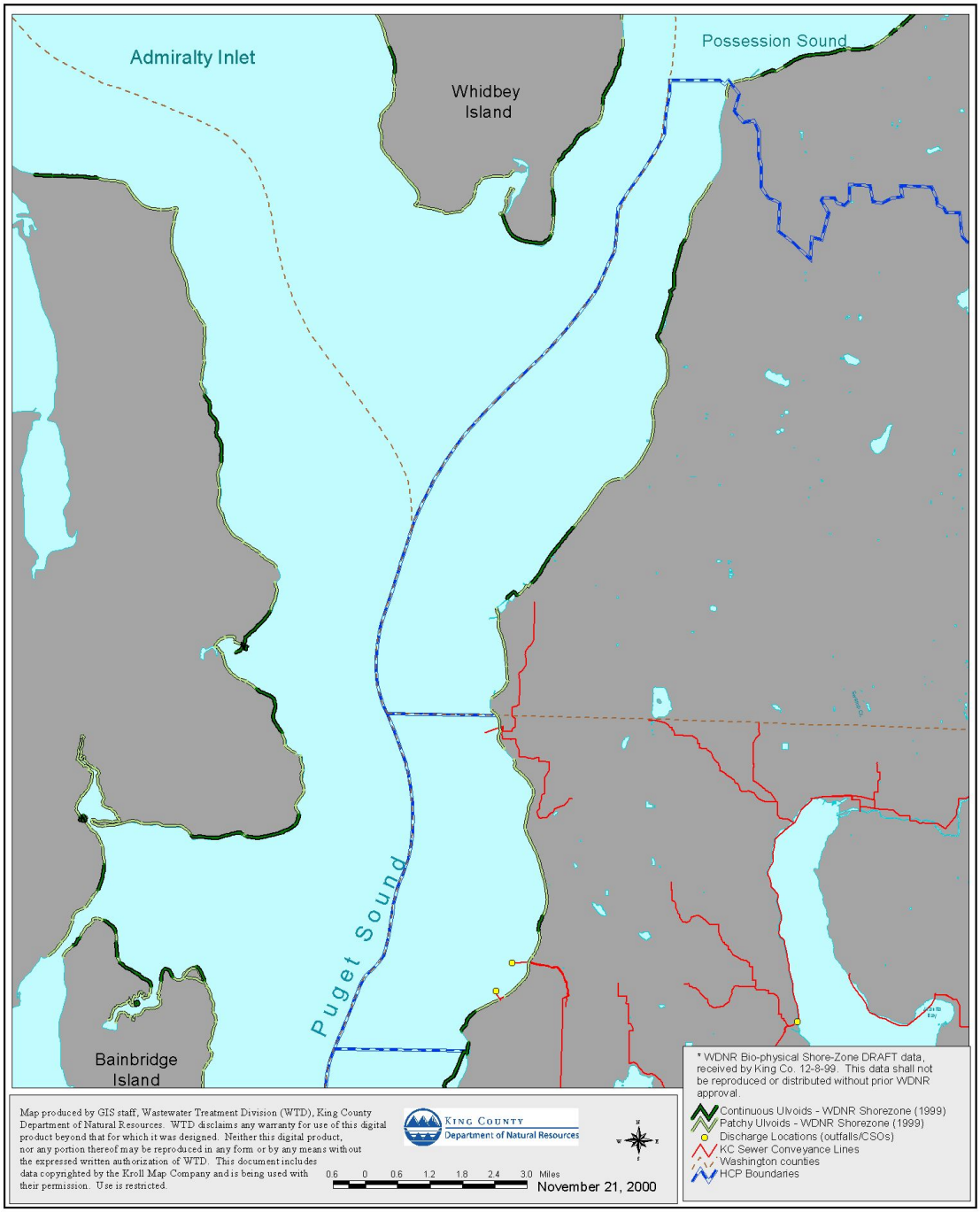

Figure 3-4. Distributions of Ulvoids in the intertidal zone through the shallow subtidal zone of the Brightwater Outfall Siting Area

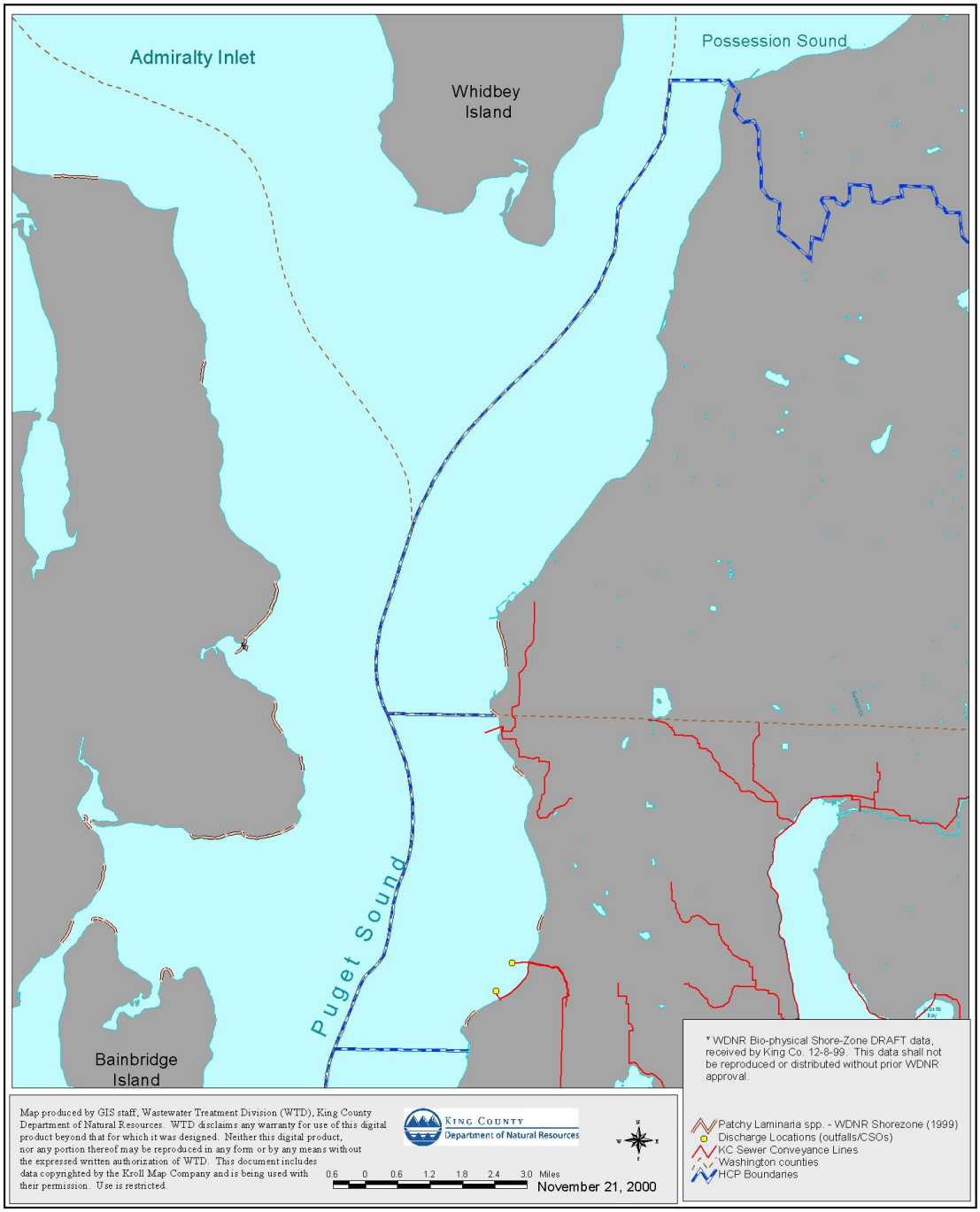

Figure 3-5. Distributions of *Laminaria* spp. in the intertidal zone through the shallow subtidal zone of the Brightwater Outfall Siting Area

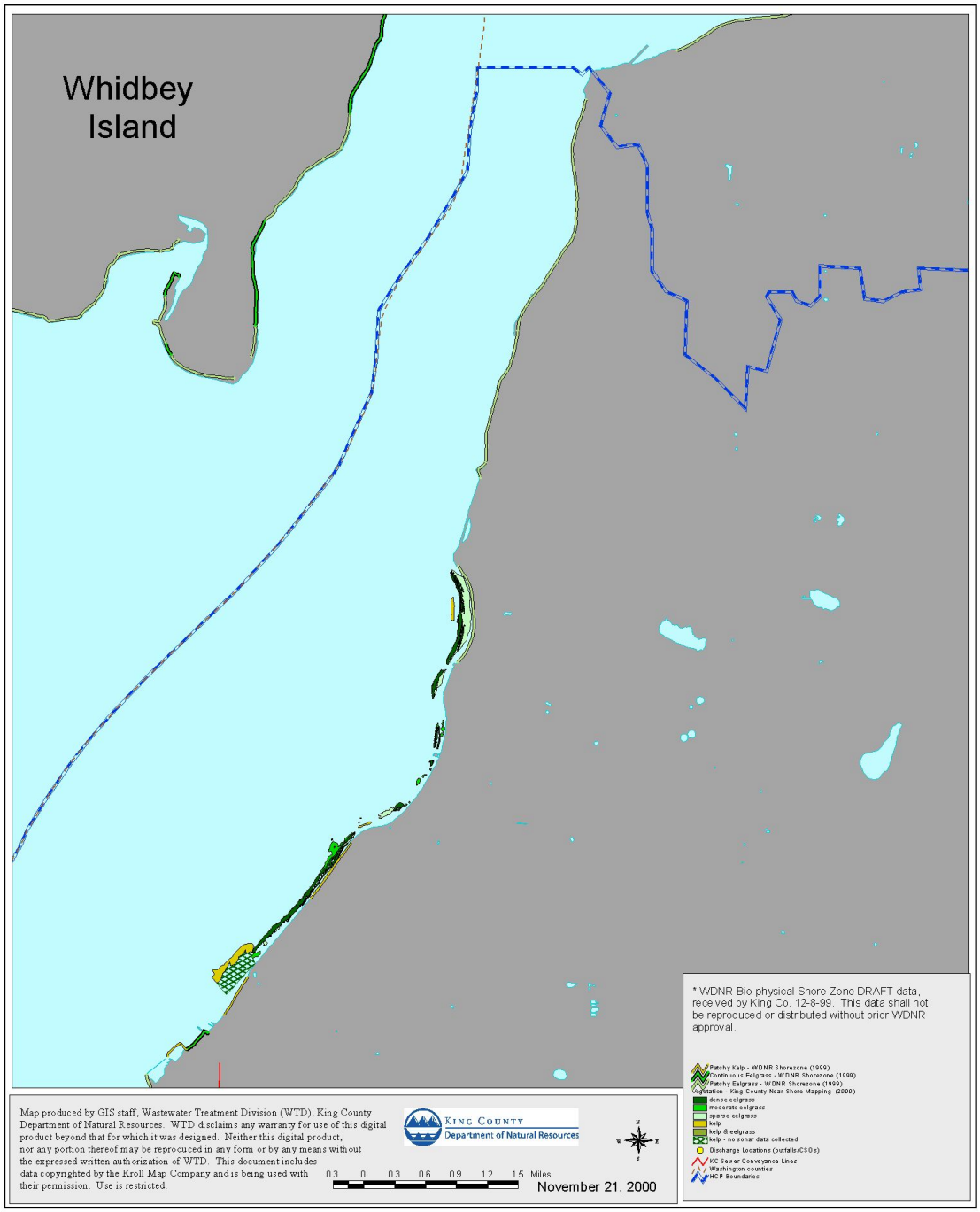

Figure 3-6. Distributions of eelgrass (*Zostera marina*) and kelp (*Nereocystis luetkeana)* in the intertidal zone through the shallow subtidal zone in the northern half of the Brightwater Outfall Siting Area

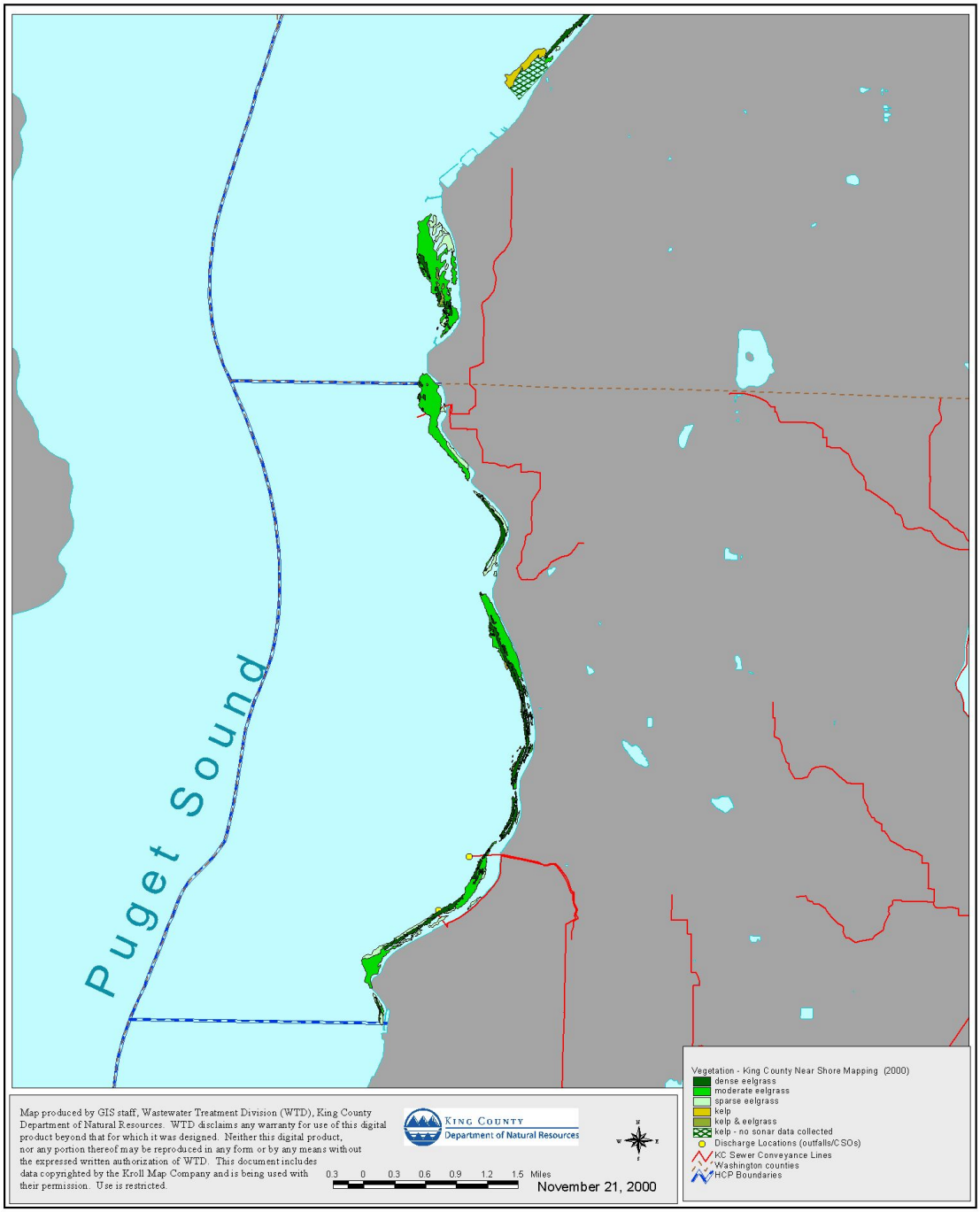

Figure 3-7. Distributions of eelgrass (*Zostera marina*) and kelp (*Nereocystis luetkeana)* in the intertidal zone through the shallow subtidal zone in the southern half of the Brightwater Outfall Siting Area

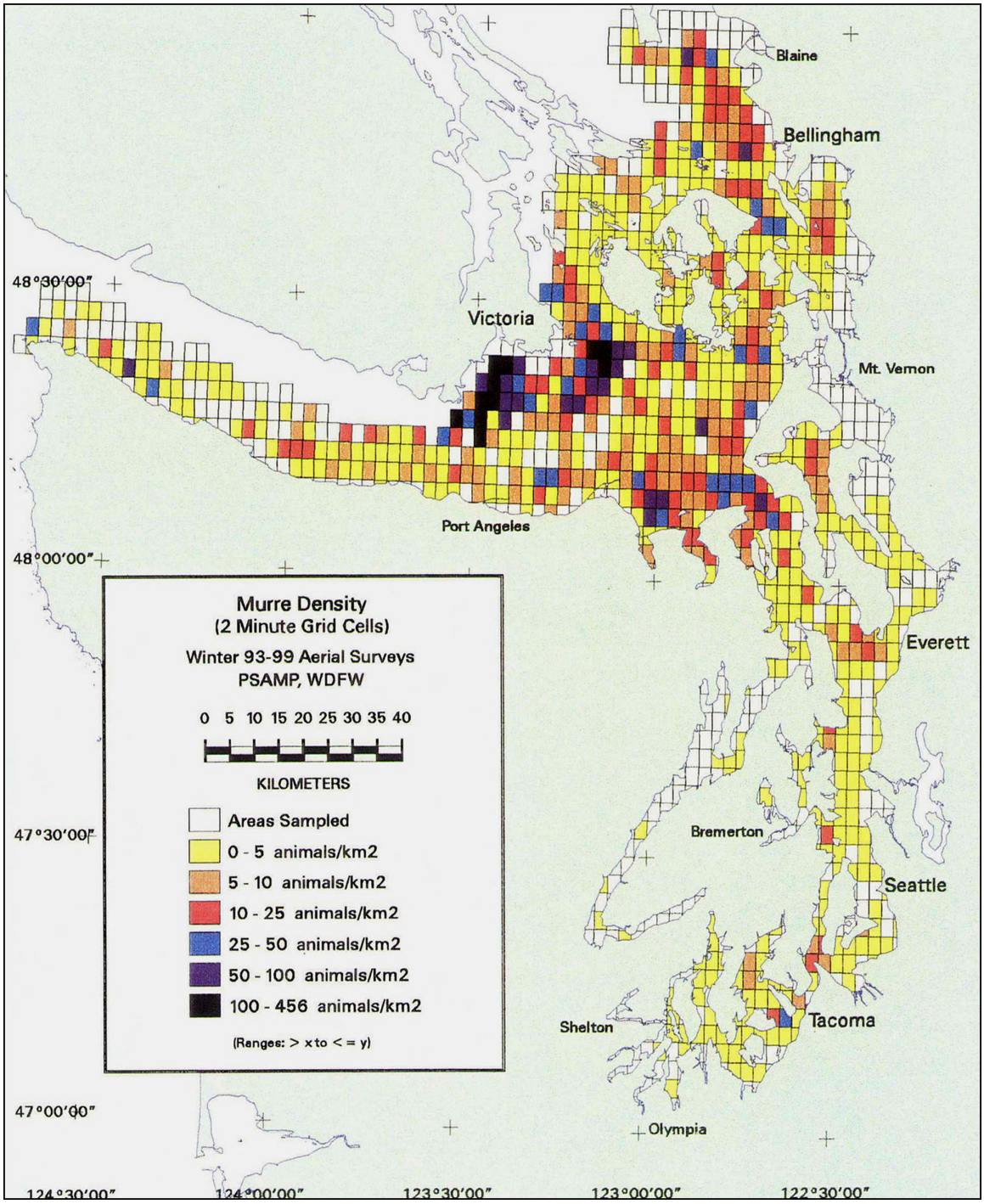

Figure 3-8. Density of common murres in winter

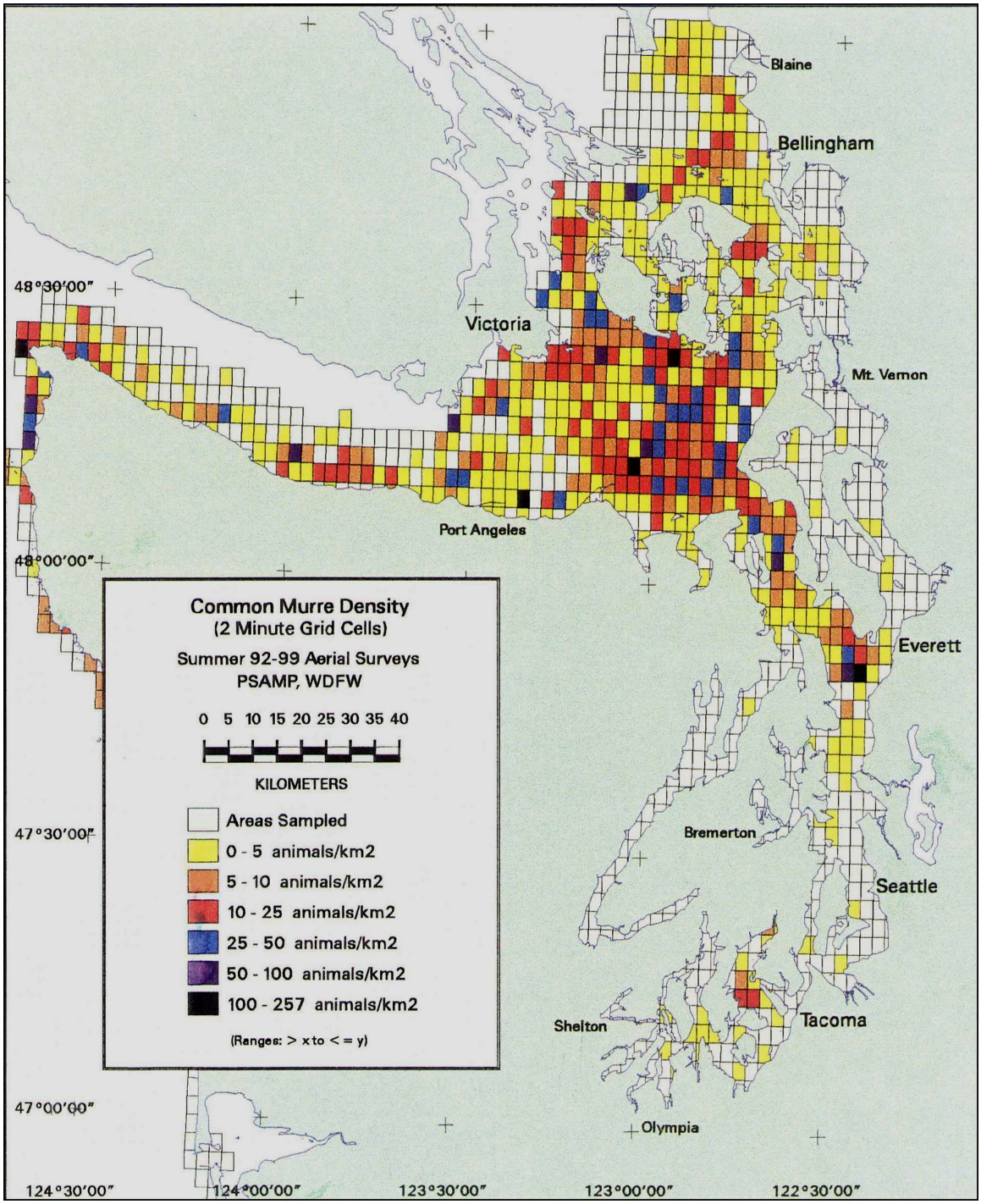

Figure 3-9. Density of common murres in summer

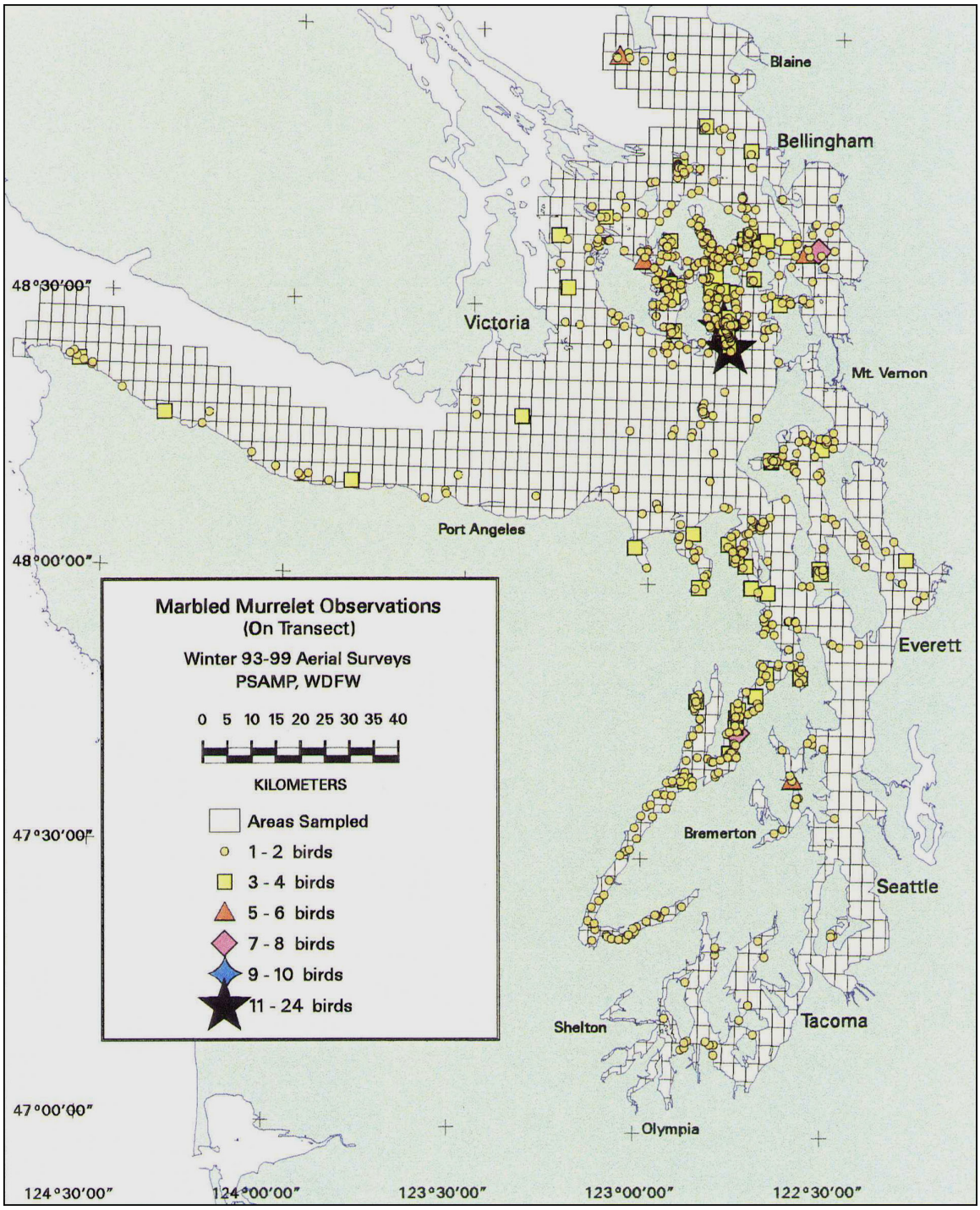

Figure 3-10. Density of marbled murrelets in winter

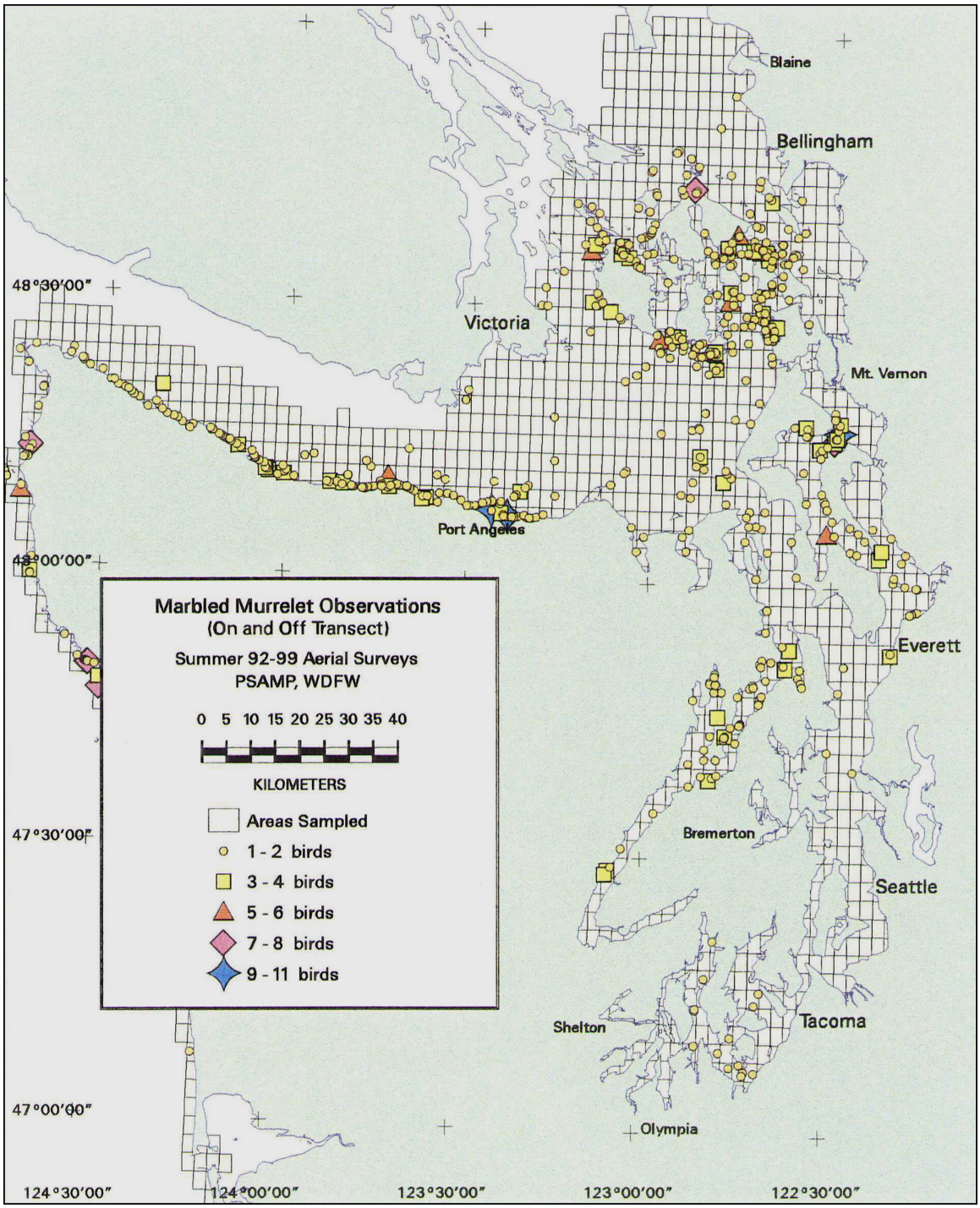

Figure 3-11. Density of marbled murrelets in summer

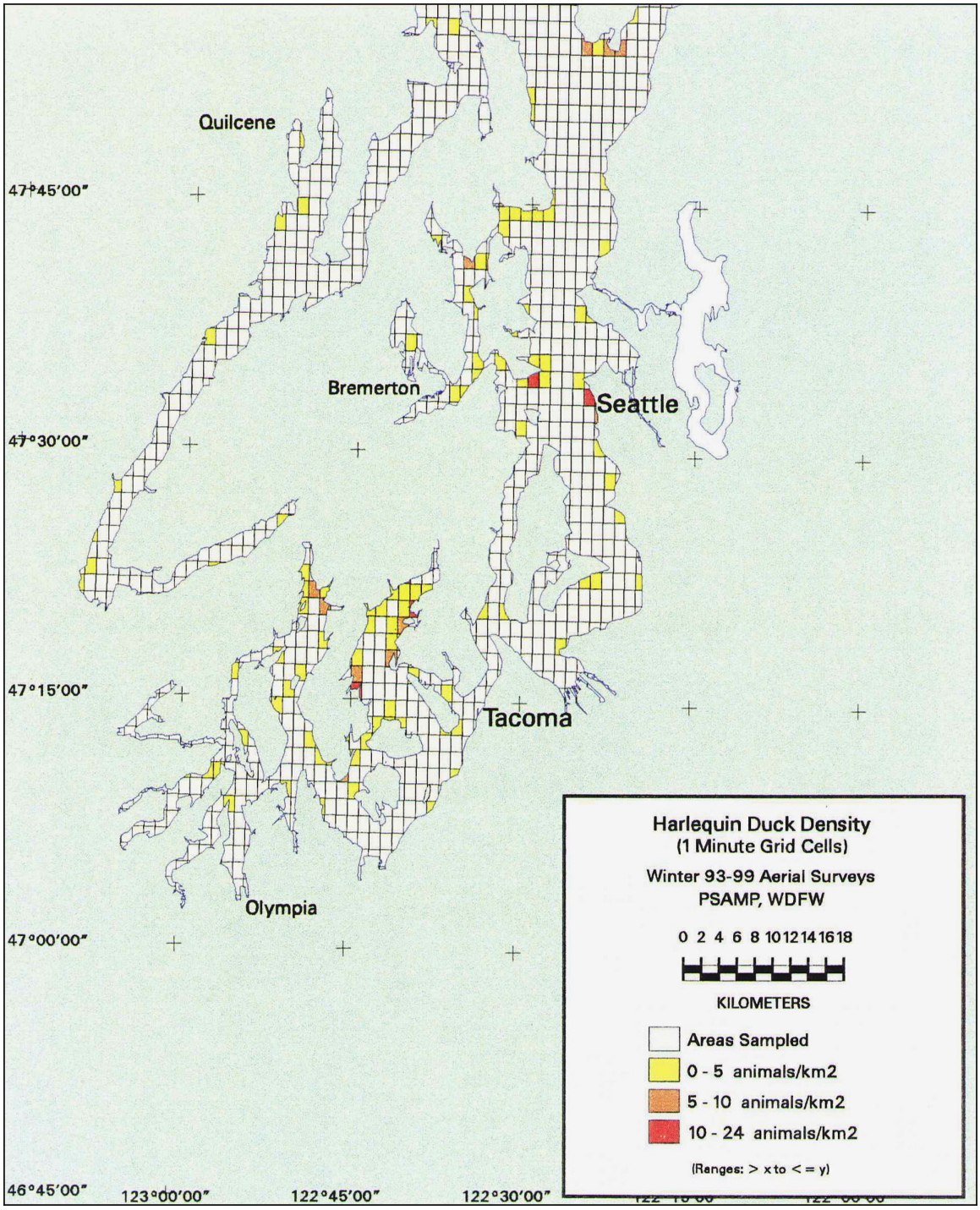

Figure 3-12. Density of harlequin ducks in winter

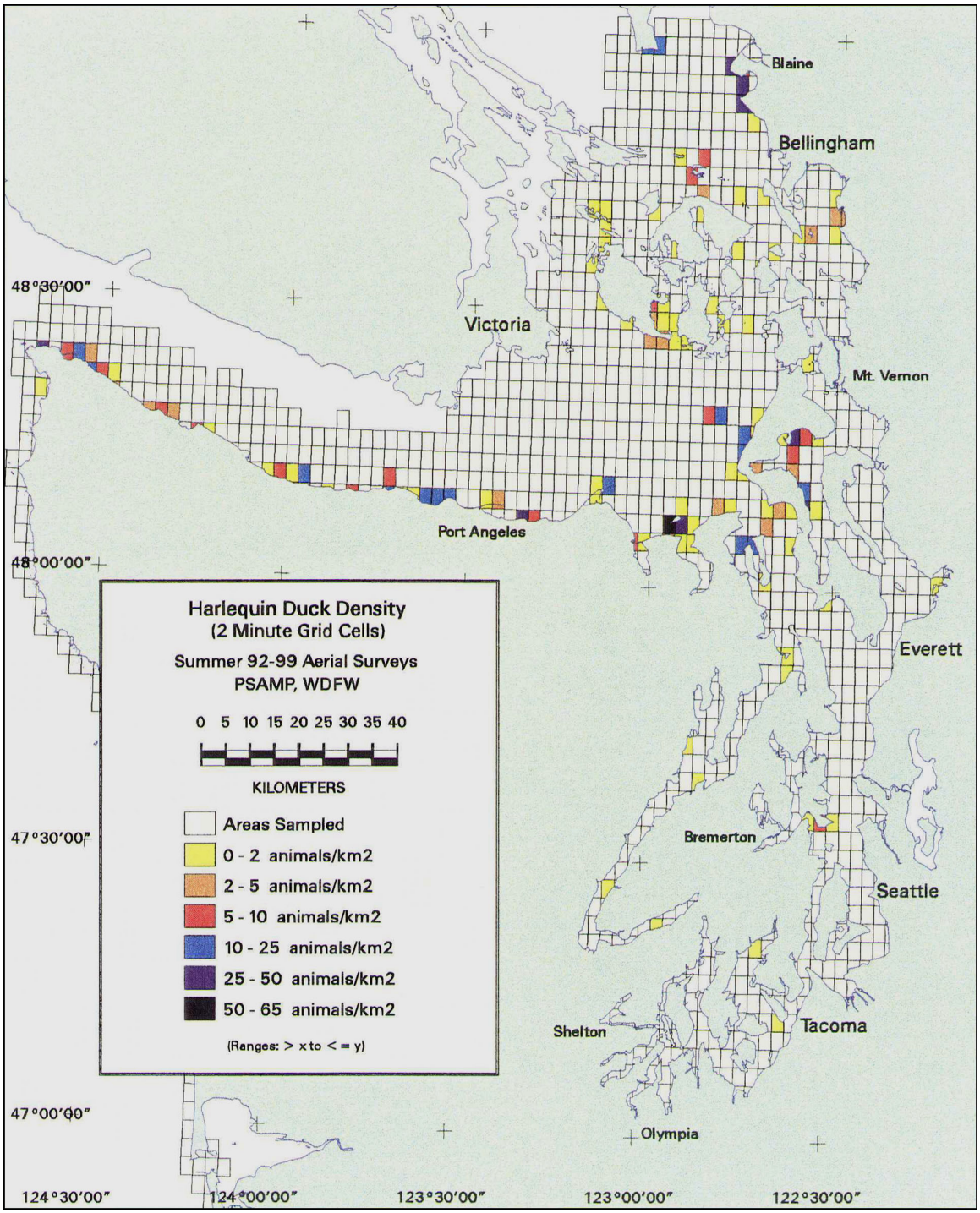

Figure 3-13. Density of harlequin ducks in summer

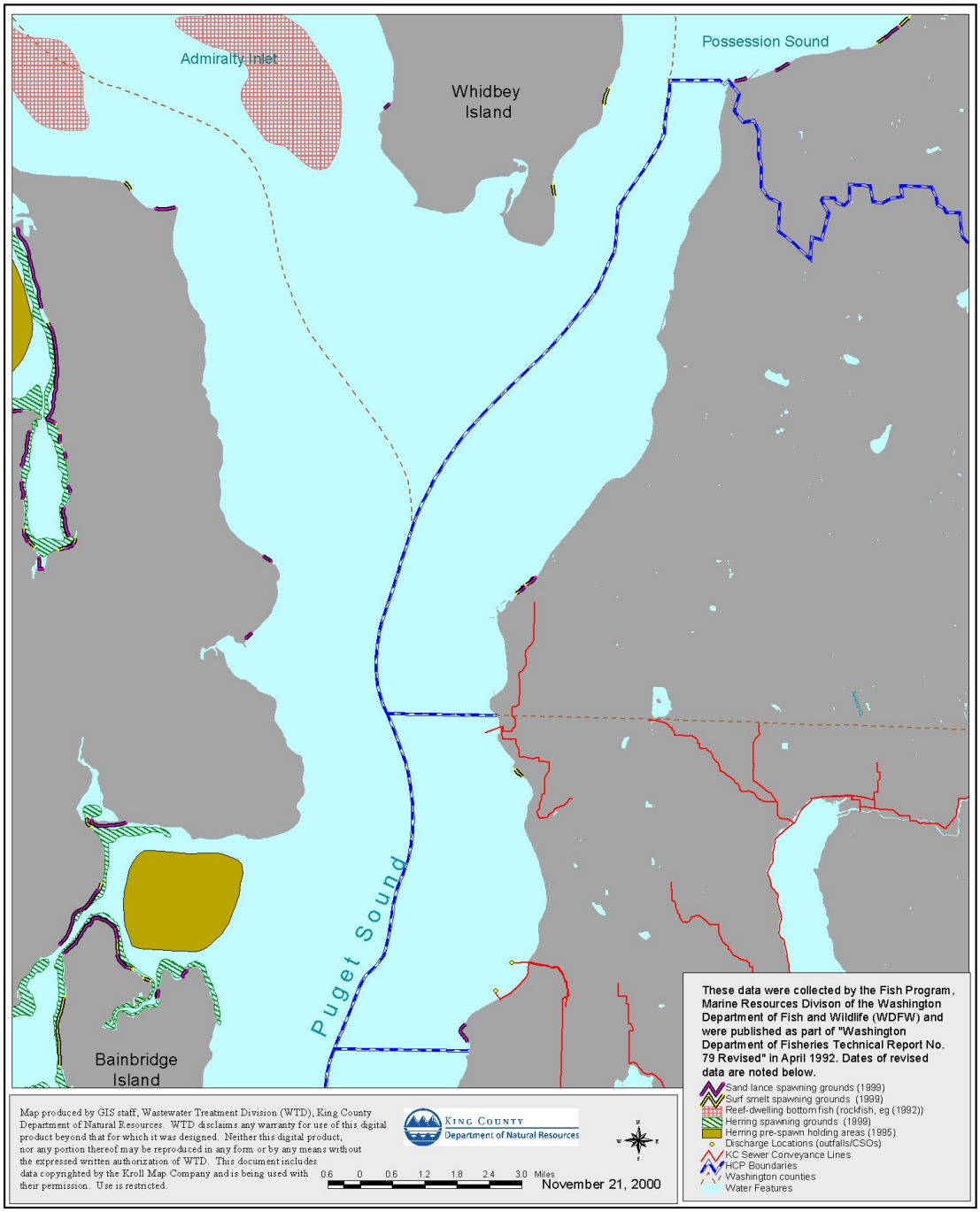

Figure 3-14. Forage fish spawning and holding areas and bottom fish/reef-dwelling habitats in the Brightwater Outfall Siting Area

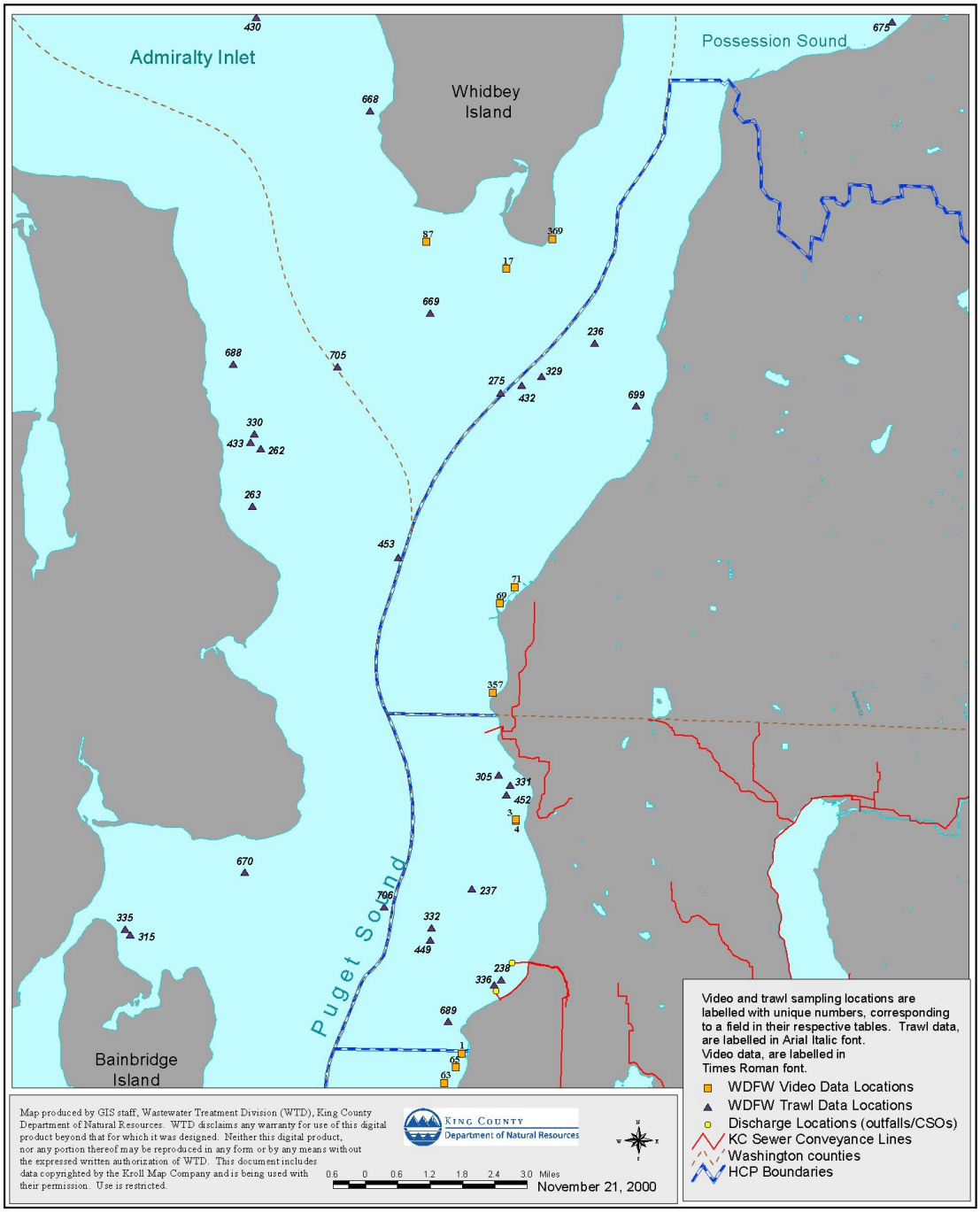

Figure 3-15. WDFW trawl and video marine fish data in the Brightwater Outfall Siting Area. See Appendix C for fish species noted at each location.

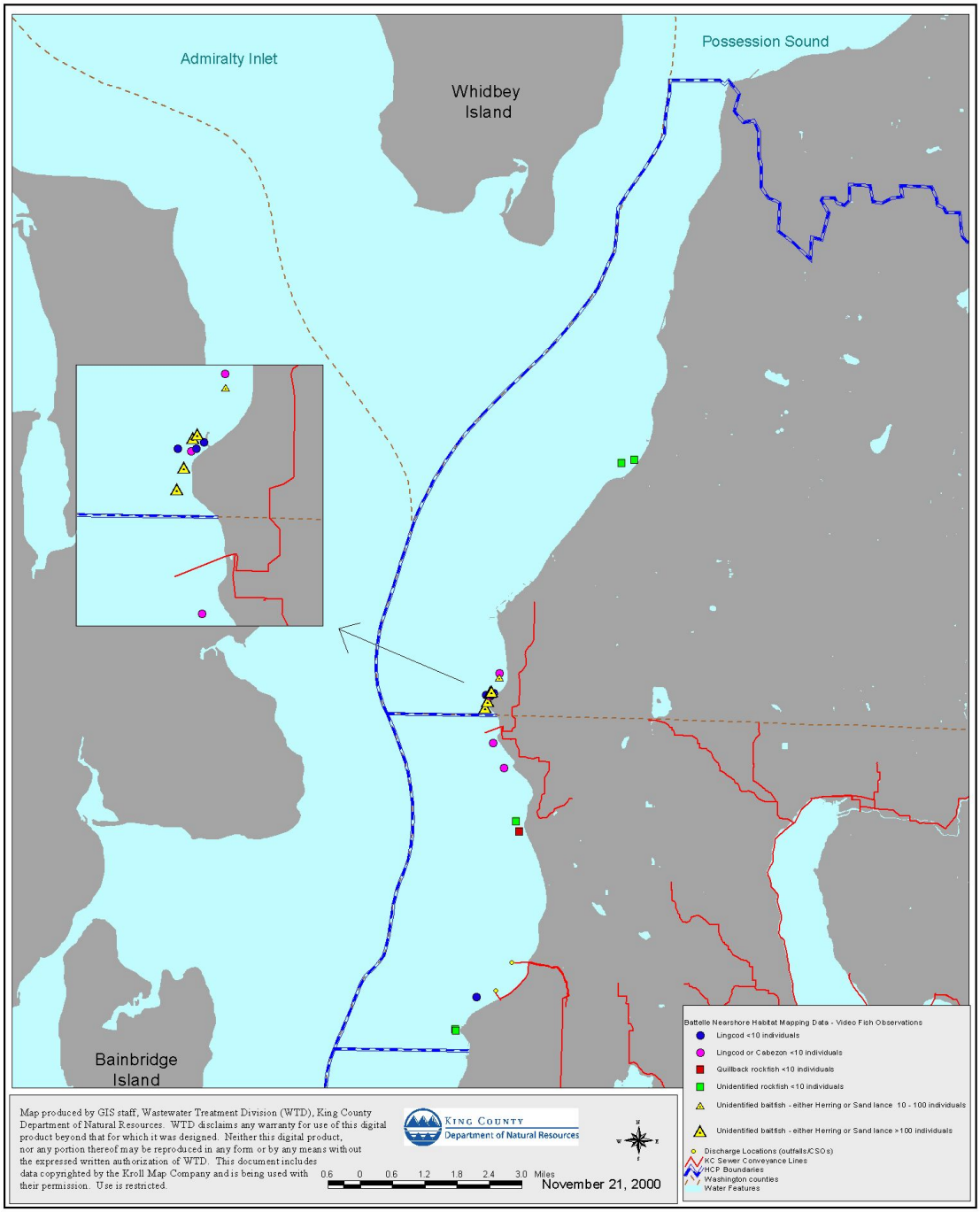

Figure 3-16. Battelle video marine fish data in the Brightwater Outfall Siting Area

Table 3-1. Marine fish species observed in the Brightwater Outfall Siting Area.[1]

Common Name	Genus species	Distribution	Primary habitat	Depth range (ft)	Average density (ind/m^2)	Relative abundance[2]
Green Sturgeon	*Acipenser medirostris*	none observed	NA	NA	NA	NA
White Sturgeon	*Acipenser transmontanus*	none observed	NA	NA	NA	NA
Pacific Cod (S & C P.S.)	*Gadus macrocephalus*	offshore from Edmonds, N & offshore from Meadow Pt, Meadow Pt	sand	30->360	0.0003[a]	5
Walleye Pollock (S. P.S.)	*Theragra chalcogramma*	N & offshore from Edmonds, S of Pt Wells, offshore between Pt Wells & Meadow Pt, Meadow Pt	NA	126->360	0.002[a]	9
Pacific Hake (C P.S.)	*Merluccius productus*	N & offshore from Edmonds, offshore from Edwards Pt, S of Pt Wells, N & offshore from Meadow Pt	NA	126->360	0.002[a]	12
Lingcod	*Ophiodon elongatus*	N side of Edwards Pt, N of Pt Wells, Pt Wells, S of Pt Wells, Meadow Pt	artificial structures	34-41	0.066[b]	7
Pacific Herring	*Clupea harengus pallasi*	N of Edmonds, offshore from Edwards Pt, S of Pt Wells, Meadow Pt	NA	126->360	0.0002[a]	4
Sand Lance	*Ammodytes hexapterus*	Spawning grounds (1 Nov to 15 Feb): N side Elliot Pt, N side Edwards Pt, Meadow Pt	sand gravel beaches for spawning	upper inter-tidal	NA	probably abundant during spawning
Unidentified Baitfish	*Herring or Sand Lance*	Pt Wells, between Pt Wells & Meadow Pt	NA	NA	NA	8
Surf Smelt	*Hypomesus pretiosus*	Spawning grounds (all year, mostly fall and winter in this area): N side of Edwards Pt, S of Pt Wells	very coarse sand to pea gravel beaches for spawning	upper inter-tidal		none observed during surveys, probably abundant during spawning
Eulachon	*Thaleichthys pacificus*	none observed	NA	NA	NA	NA

Table 3-1. Marine fish species observed in the Brightwater Outfall Siting Area.[1]

Common Name	Genus species	Distribution	Primary habitat	Depth range (ft)	Average density (ind/m^2)	Relative abundance[2]
Brown Rockfish	*Sebastes auriculatus*	none observed	NA	NA	NA	NA
Copper Rockfish	*Sebastes caurinus*	N side of Edwards Pt, Pt Wells, S of Pt Wells, Meadow Pt	artificial structures	21-41	0.079[b]	4
Greenstriped Rockfish	*Sebastes elongatus*	near Edmonds	mixed coarse	246-360	0.0001[a]	1
Widow Rockfish	*Sebastes entomelus*	none observed	NA	NA	NA	NA
Yellowtail Rockfish	*Sebastes flavidus*	none observed	NA	NA	NA	NA
Quillback Rockfish	*Sebastes maliger*	N & offshore from Edmonds, N & N side of Edwards Pt, Pt Wells, S of Pt Wells, Meadow Pt	boulders	17-66	0.609[b]	16
Black Rockfish	*Sebastes melanops*	none observed	NA	NA	NA	NA
Blue Rockfish	*Sebastes mystinus*	none observed	NA	NA	NA	NA
China Rockfish	*Sebastes nebulosus*	none observed	NA	NA	NA	NA
Tiger Rockfish	*Sebastes nigrocinctus*	none observed	NA	NA	NA	NA
Bocaccio	*Sebastes paucispinus*	none observed	NA	NA	NA	NA
Canary Rockfish	*Sebastes pinniger*	none observed	NA	NA	NA	NA
Redstripe Rockfish	*Sebastes proriger*	none observed	NA	NA	NA	NA
Yelloweye Rockfish	*Sebastes ruberrimus*	none observed	NA	NA	NA	NA
Unidentified Rockfish	*Sebastes spp.*	N & offshore from Edmonds, Edmonds, Edwards Pt, Pt Wells, S of Pt Wells, Meadow Pt	artificial structures	17-34	0.001[a]	8

NA - Not Available

[1]Based on data from Tech Report 79, Battelle, and WDFW.

[2]Relative abundance indicates the number of times a given species was observed during the surveys.

[a]Based on WDFW trawl surveys (Palsson data).

[b]Based on WDFW video surveys (Palsson data).

4.0 WTD Existing Discharges Area

The following section provides known information regarding habitat distribution and usage of the various habitats in the WTD Existing Discharges Area by the species covered in this report (listed in Section 2.0). Readily known distribution and relative abundance information for the covered species in the WTD Existing Discharges Area are also provided. Data gaps are identified in this section where appropriate; however, a detailed discussion regarding data gaps is provided in Section 6.0.

As stated in Section 3.0, a comprehensive examination of physical oceanographic characteristics in the WTD Existing Discharges Area is beyond the scope of this report but is available in a separate document (Ebbesmeyer and Cannon 2000). Water and sediment chemistry data in the WTD Area are also beyond the scope of this report but are available in the documents listed in Section 3.0.

4.1 Physical Setting

The WTD Existing Discharges Area (Area 2) extends from the King/Snohomish County boundary in the north to the northern tip of Vashon Island in the south, including Elliott Bay (see Figure 1-1). There is some overlap with the Brightwater Outfall Siting Area from Golden Gardens north to the county boundary. There are diverse habitats in the area, including sand and gravel beaches, stream mouths, two major freshwater inputs (Lake Washington Ship Canal and Duwamish River), and an urbanized embayment (Elliott Bay). In the northern portion of the area, the supralittoral area (>3 m MLLW) supports the bed and tracks of the Northern Pacific Railroad. Shilshole Bay is located to the north of West Point and the supralittoral zone in this area is highly developed with a marina and several restaurants. The King County West Point Wastewater Treatment Plant is located above the supralittoral zone at West Point; and the steep bluffs above Magnolia bound the supralittoral from West Point to Smith Cove (Elliott Bay Marina). Inner Elliott Bay (which includes the Seattle waterfront) and the Duwamish estuary are heavily urbanized with riprap, docks and piers. The south side of Elliott Bay, from Duwamish Head to the lower part of the WTD Existing Discharges Area, is mostly bulkheaded and residential in nature. The deepest water depth in the WTD Existing Discharges Area is approximately 243 m just north of West Point. Figure 4-1 provides information regarding slopes and depths of the seafloor in the WTD Existing Discharges Area.

4.2 Habitat Distribution

In this section, the general distributions of the major habitats are presented. Some information is also provided on the types of fauna associated with these habitats (e.g., eelgrass). The habitats are discussed under three subheadings: supralittoral, intertidal and shallow subtidal, and finally the deep subtidal. For more information on the types of fauna associated with these habitats see Section 2.6.

4.2.1 Supralittoral

Seawall or other shoreline armoring structures (Figure 4-2) predominantly border the shoreline in the WTD Existing Discharges Area. There are likely areas of overhanging vegetation in some of the areas bordered by seawalls. There is a small amount of treed shoreline at West Point. The seawalls and shoreline armoring in this area, as previously mentioned in Section 3.2.1, have had influences on the benthic community (Williams and Thom, in prep). Seawalls have most likely reduced the intertidal zone and soft bottom communities, increasing the rocky shore communities and their associated habitats.

4.2.2 Intertidal through Shallow Subtidal

The intertidal and shallow subtidal zones in the WTD Existing Discharges Area contain all major habitat types typically found in central Puget Sound (e.g., eelgrass meadows, kelp forests, flats, tidal marshes, and subestuaries). However, there is considerable alteration of habitats through shoreline armoring, dock structures, removal of riparian habitat, and dredging and filling. In particular, the Duwamish River estuary and Elliott Bay are heavily altered. Very little of the original natural habitats remain in these areas.

Intertidal and shallow subtidal substrates in the WTD Existing Discharges Area are composed primarily of various grades of sand with a mix of gravel, cobble, and small rocks. The breakwater protecting the Shilshole Marina rests in about 20 m of water and provides a hard substrate with crevices for many types of invertebrates (such as crabs, shrimp, barnacles, snails, and limpets) and fish (such as sculpins, greenlings, and gunnels). The breakwater also provides substrate for many types of marine vegetation, which are discussed in detail below. In inner Elliott Bay, substrates are the same as in other parts of the area; however, the sand contains an even mix of sand and silt caused by fine particulate material from the Duwamish River.

The distributions of some of the major vegetation taxa used to depict the nearshore habitats in the WTD Existing Discharges Area are shown in Figures 4-3 through 4-9.

Fucus sp. is common but patchy. It forms dense continuous beds along the breakwater at Shilshole Marina and along rocky shorelines in Elliott Bay (Figure 4-3). *Ulva* spp. is found very frequently along the shoreline of the WTD Existing Discharges Area (Figure 4-4). It occurs primarily in patches but is also found in continuous beds. It is within these exposed and semi-exposed rocky habitats that wide a variety of species are found. Examples of species covered in this report found within these habitats include coho salmon, cutthroat trout, Dolly Varden, and river lamprey (Simenstad et. al. 1991).

Laminaria spp. is common but patchy throughout most of the region (Figure 4-5) and is closely associated with the *Fucus* sp. shown in Figure 4-3. Kelp, based on the WDNR Shorezone Database (WDNR 1999) and the 1999 surveys conducted by Battelle Marine Sciences Laboratory for King County (Woodruff et al. 2000), is common but patchy in the region (see Figures 4-6 and 3-7).

Eelgrass is very common but patchy over most of the area (Figures 4-7 and 3-7). The presence of eelgrass would indicate that, as that in Section 3.2.2, sediment types are finer grained. As stated in Section 3.2.2, eelgrass serves as habitat for many different species and provides different functions for these species (Simenstad et. al 1991).

Like the Brightwater Outfall Siting Area, tideflats are common in the WTD Existing Discharges Area but have not been mapped completely. One tideflat in the Area that has received scientific study is at Alki beach (Armstrong et al. 1976; Stober and Chew 1984; Thom and Albright 1990). The infaunal communities in the WTD Existing Discharges Area are an important source of zooplankton, crustaceans, and amphipod species to juvenile salmonid diets (see Appendix A). These tideflats are productive areas for microalgae and serve as important feeding habitat for juvenile chinook and chum salmon (Thom et al. 1984; Simenstad et al 1991).

4.2.3 Deep Subtidal

The deep subtidal zone in the WTD Existing Discharges Area has been extensively studied since the late 1970s, especially in the southern portion of the area. Thom et al. (1979) sampled 121 stations along 20 transects from West Point to Three Tree Point. Ten transects were clustered around West Point with five stations along each transect. The remaining 71 stations were located along nine transects spread throughout the area from West Point to Three Tree Point. The King County (formerly know as METRO) Toxicant Pretreatment Planning Study (TPPS) program (Commiskey et al. 1984) sampled 71 stations along 18 transects from West Point to inner Elliott Bay. The Duwamish Head Baseline Study (Word et al. 1984b) sampled 83 stations along 18 transects. Eighteen of the 132 stations sampled as part of the Seahurst Baseline Study (Word et al. 1984a) were located in the WTD Existing Discharge Area. The results of the Duwamish Head and Seahurst studies show that along the shelf, with the

exception of inner Elliott Bay, the primary habitat consisted of coarse to medium sand.

The transition between the shelf and slope portions of the deep subtidal is not as evident in the WTD Existing Discharges Area compared to the Brightwater and Vashon Island Areas. The substrate along the shelf grades from sand to sandy-silt as the depth of the water increases. Rocky outcropping can be found at the shelf/slope break and there is an abandoned dredged material disposal site off Magnolia Bluff adjacent to Four Mile Rock. The habitat in the central deep basin is characterized primarily by soft silt and clay except at the immediate base of West and Alki Points. The habitats off these two points contain a greater portion of sand. The deep subtidal in inner Elliott Bay also consists of silts and clays except at the location of the confined open water dredged material disposal site in the middle of the bay.

The dominant organisms were similar to what was seen in the Brightwater Outfall Siting Area, although in less abundance. These included the polychaete *Phyllochaetopterus prolifica*, the bivalve molluscs *Psephedia lordi* and *Megacrenella columbiana*, and the ostracod *Euphilomedes carcharodonta*. The habitats along the eastern shelf of inner Elliott Bay contained a mix of fine sand and silt. The dominant organisms in this area tended to be pollution-tolerant species. Their presence indicated that the sediments in the region were becoming organically enriched. Dominant organisms included the polychaetes *Capitella capitata*, *Aphelochaeta* spp., and *Notomastus tenuis*. Dominant bivalve molluscs included *Macoma carlottensis* and *Axinopsida serricata*. The dominant crustaceans were *Euphilomedes carcharodonta* and *Euphilomedes producta*.

4.3 Species Distribution and Occurrence

The distribution and occurrence information presented below for the proposed HCP species is based upon documented information cited in available literature and/or personal communication with biologists/experts from local, state, and federal agencies. Much of the distribution data for fishes are based upon trawl and video data and are dependent upon time of year, depth, and location sampled. Many pelagic fish, such as yellowtail and black rockfish, are rarely documented in trawl surveys as the sampling method favors capturing semi-demersal or demersal fish such as lingcod, Pacific cod, and quillback rockfish. The absence of pelagic and other species for trawl and video data does not preclude those species from inhabiting waters in the WTD Existing Discharges Area. The majority of data for marine birds are based upon seasonal aerial and land surveys and are dependent upon favorable sighting conditions, time of year surveyed, species wariness, and location surveyed.

4.3.1 Marine Mammals and Birds

Orca -- *Orcinus orca*

Of the three resident Puget Sound Orca pods, the J pod is most likely to be observed in the WTD Existing Discharges Area. The whales follow seasonal salmon runs with yearly sightings clustered from June through October (Balcomb 1982; Olesiuk et al. 1990). For example, groups of 16-17 whales have been sighted off Alki Point in October and groups of 16-17 whales have also been sighted off Point Jefferson in September (Balcomb and Goebal 1976). In recent years, the J pod has been observed in the WTD Existing Discharges Area off West Seattle and West Point during the fall months, following the salmon runs (K. Koski, Whale Museum, pers. comm.). Transient whales are not known to occur in inland Puget Sound waters (Forney et al. 2000).

Harbor Porpoise -- *Phocoena phocoena*

There have been no confirmed sightings of harbor porpoises south of Admiralty Inlet (including the WTD Existing Discharges Area) during the last several years (Calambokidis et al. 1992; B. Hanson, NMML, pers. comm.). A survey during favorable sighting conditions in 1996 found no harbor porpoises in Puget Sound (Osmek et al. 1997).

Steller Sea Lion -- *Eumetopias jubatus*

Steller sea lions are found in small numbers in the inland waters of Puget Sound. Documented sightings in central Puget Sound have been in the WTD Existing Discharges Area, including sightings near tribal fishing nets in Elliott Bay and the Duwamish River between October and January (Chumbley 1993; Gearin at al. 1988). Steller sea lions have also been seen near or on navigational buoys and the National Marine Fisheries Service/National Marine Mammal Laboratory sea lion trap in Shilshole Bay in small numbers (1-2 individuals) (M. Lance, WDFW, pers. comm.).

Common Murre -- *Uria aalge*

WDFW (2000) reported that from 1992 through 1999 the number of common murres in the WTD Existing Discharges Area in the winter ranged from 0 to 5 animals/km^2 (Figure 3-8). In the summer months, the average number of common murres also ranged from 0 to 5 animals/km^2; however, there were more areas with no sightings than in the winter months (Figure 3-9). Murres have been seen every year during the Seattle CBC annual survey since 1983, with numbers ranging from 7 to 225 birds (H. Opperman, Seattle Audubon Society, pers. comm.).

Marbled Murrelet -- *Brachyramphus marmoratus*

Marbled murrelets have shown a gradual decline over recent years and have been seen in the WTD Existing Discharges Area only during 8 of the last 17 yearly Seattle CBC Surveys. The number of murrelets observed ranged from 1 to 17,

but usually only 1 to 3 birds were noted when this species was present (H. Opperman, Seattle Audubon Society, pers. comm.). WDFW (2000) reported no marbled murrelets in the WTD Existing Discharges Area during winter surveys from 1992 through 1999 (Figure 3-10). In the summer months, 1 to 2 birds were observed in the area (Figure 3-11).

Harlequin Duck -- *Histrionicus histrionicus*

WDFW (2000) found that from 1992 through 1999 the number of harlequin ducks in the WTD Existing Discharges Area in the winter ranged from 0 to 24 animals/km^2 (Figure 3-12). In the summer months, no harlequin ducks were observed in the area (Figure 3-13) Harlequin ducks have been seen in the WTD Existing Discharges Area every year since 1983 during the Seattle CBC annual survey. The counts ranged from 18 to 59 birds (H. Opperman, Seattle Audubon Society, pers. comm.).

4.3.2 Salmonids

Bull Trout -- *Salvelinus confluentus*

The distribution and abundance of bull trout in Puget Sound, including nearshore waters is not well understood. Populations of bull trout have been documented in rivers and streams that enter the nearshore waters of the WTD Existing Discharges Area. Isolated observations of bull trout have been made during the last decade at the mouth of the Duwamish River estuary and seaward of the Lake Washington Ship Canal (King County 2000a). Miller and Borton (1980) documented Dolly Varden at the mouth of the Lake Washington Ship Canal and around Shilshole Bay (see Figure B-12, Appendix B). As Dolly Varden are closely related to bull trout and it is difficult to distinguish the two species without genetic testing, it is possible that these fish were bull trout. Approximately eight adult bull trout were captured in Shilshole Bay/Lake Washington Ship Canal in Spring 2000 and seven were captured in the Turning Basin region of the Duwamish River in September 2000 (B. Mavros, King County, pers. comm.).

Chinook Salmon -- *Oncorhynchus tshawytscha*

In the WTD Existing Discharges Area, a number of site-specific studies have been conducted since the early 1980's on juvenile chinook abundance, feeding, and residence time in the Duwamish River estuary (Parametrix 1980, 1982, 1983, 1984, Meyer et al. 1981). Densities in the Duwamish River estuary ranged from less than 1 to 266 per 30.5 m (net length) beach seine haul (Meyer et al. 1981) to 270 per 37 m beach seine hauls (Taylor et al. 1999). Greatest densities have been reported over shallow, sloping, relatively soft mud beaches. Purse seine samples, which sample the water column in deep areas, captured 19 times fewer juvenile chinooks than beach seine samples from shallow shoreline areas in the Duwamish River. Density peaked in mid-May to early June following hatchery plants upstream. Juvenile chinook have also been caught by beach seines and

purse seines in Smith Cove, located at the north end of Elliott Bay (Taylor et al. 1999). Densities in this area have been comparable to those in the main part of the Duwamish estuary. Preliminary results from 1998 sampling indicate that juvenile chinook salmon were the second most abundant salmon species preceded by chum salmon (Taylor et al. 1999).

King County conducted beach-seining surveys in the southern portion of the WTD Existing Discharges Area at Fauntleroy from June to August 2000. Juvenile chinook (less than fifteen) were observed in June and July but none were seen in August (Mavros and Brennan, in prep.). Miller and Borton (1980) reported observations of chinook salmon within most sections of the WTD Existing Discharges Area, but abundance data were not reported (see Figure B-9, Appendix B). Beach seine surveys conducted off of West Point and Alki Point in 1975 and 1976 reported chinook salmon numbers of 24 and 34, respectively (Stober and Pierson 1984).

WDFW reported 1995 sport catch data for chinook salmon in an area that included all the WTD Existing Discharges Area, Bainbridge Island, and Bremerton. Over 13,000 chinook salmon were caught in this area, mainly in August. However, these data do not distinguish between hatchery and wild salmon (Manning et al. 1999).

WDFW (1993) documented populations of summer and fall chinook in streams and rivers within the WTD Existing Discharges Area. Adult chinook salmon return to these rivers to spawn and will be found in the marine waters surrounding the area. Adults tend to stay in shallow nearshore areas before entering natal rivers and streams (Stober and Pierson 1984). Abundance data from WDFW (1993) was based upon the number of fish that survived natural and fisheries impacts (escapements) to make up a spawning population in rivers or streams. The number of escapements in this survey represented a larger population of adult fish returning to the waters of the WTD Existing Discharges Area than previously documented. The escapements for Issaquah and East Fork Issaquah creeks were up to 5,000 individuals, with spawning of a native stock with wild production in late September through October. The escapement was unknown for the tributaries of North Lake Washington creeks with native spawners returning in September through October. The Cedar River supported a native stock with wild production with an escapement of up to 4,300 individuals. The healthy Duwamish/Green River population spawned from September through October with an escapement of up to 11,500 individuals from a mixed stock of composite production. Newaukum Creek also supported a mixed stock with up to 3,000 escapements (WDFW 1993b).

Additional data available for the Green River showed postseason abundance estimates of summer/fall chinook stock at 17,781, 12,545, and 17,131 individuals in 1992, 1993, and 1994, respectively (PFMC 1997). These abundance estimates include estimated net catch, sport catch, and escapements.

Chum Salmon -- *Oncorhynchus keta*

Site-specific studies in the WTD Existing Discharges Area on juvenile chum abundance, feeding, and residence time have been conducted in the Duwamish River estuary since the early 1980's. Densities in the Duwamish River estuary ranged from less than 1 to more than 300 individuals per 30.5 m beach seine haul (Meyer et al. 1981). The period of peak chum salmon abundance was between March and April. Very few chum have been collected in purse seines offshore of the beach seine sites. In 1998 at Smith Cove, densities of juvenile chum salmon have been reported up to 438 individuals per 37 m beach seine haul (Taylor et al. 1999). King County conducted beach-seining surveys at Fauntleroy from June to August 2000, where juvenile chum (less than five) were observed only in June (Mavros and Brennan, in prep.).

Adult chum salmon were found within the WTD Existing Discharges Area prior to 1973 (Miller and Borton 1980). Observations were clustered around the waterways to Lake Washington and in Elliott Bay and the Duwamish Waterway (see Figure B-6, Appendix B). Although distribution data were presented in this data set, abundance data were not available. Beach seine surveys conducted off of West Point and Alki Point in 1975 and 1976 reported chum salmon numbers of 92 and 41, respectively (Stober and Pierson 1984).

WDFW reported 1995 sport catch data for chum salmon in an area that included all the WTD Existing Discharges Area, Bainbridge Island, and Bremerton. Just over 600 chum salmon were caught in this area from September to January; however, these data did not distinguish between hatchery and wild salmon (Manning et al. 1999).

The 1992 SASSI report documented populations of fall chum in streams and/or rivers within the WTD Existing Discharges Area (WDFW 1993b). The marine waters of this area are utilized by adult chum salmon as they return to these rivers to spawn. Adults use nearshore areas to mill prior to river and stream entry (Stober and Pierson 1984). The SASSI report confirmed that Duwamish/Green River waters support populations of chum salmon. The escapements for Duwamish/Green River were unknown and the status of these fall spawners (a mixed stock of composite production) was also unknown (WDFW 1993b).

Coho Salmon -- *Oncorhynchus kisutch*

In the early 1980's in the WTD Existing Discharges Area, coho salmon smolts were collected by beach seines in tidal channels of the Duwamish River and densities were generally low (Parametrix 1980, 1982, 1983, 1984, Meyer et al. 1981). These relatively low densities peaked in early May to early June corresponding to coho salmon released at the Soos Creek hatchery (Meyer et al. 1981). Coho smolts have been caught in Elliott Bay in beach and purse seines, with numbers ranging from 1 to 413 coho per seine set (Parametrix 1980). For the beach seining surveys conducted by King County in the WTD Existing Discharges Area at Fauntleroy from June to August 2000, juvenile coho (less

than five) were observed in June and August and none were observed in July (Mavros and Brennan, in prep).

Miller and Borton (1980) reported adult coho salmon throughout the WTD Existing Discharges Area. Observations were reported throughout the waters leading to Lake Washington and through Elliott Bay and the Duwamish Waterway (see Figure B-7, Appendix B). Beach seine surveys conducted off of West Point and Alki Point in 1975 and 1976 reported coho salmon numbers of 168 and 25, respectively (Stober and Pierson 1984).

WDFW reported 1995 sport catch data for coho salmon in an area that includes all the WTD Existing Discharges Area, Bainbridge Island, and Bremerton. Almost 14,000 coho salmon were caught, primarily in September, in this area. However, these data do not distinguish between hatchery and wild salmon (Manning et al. 1999). WDFW (1993) reported that Lake Washington/Sammamish tributaries and the Duwamish/Green River had populations of coho salmon. The Lake Washington/Sammamish tributaries stock was listed as depressed by WDFW, with unknown escapements of these late October through mid-December spawners. The Cedar River escapements of late October through early March spawners were reported as unknown, but the status was considered healthy. The Green River/Soos Creek escapements were up to 12,500 fish, with spawning from late October through mid-December for this healthy mixed stock. The Green River/Newaukum Creek stock was listed as depressed, with unknown escapements for these late October through mid-January spawners.

Cutthroat trout -- Oncorhynchus clarki

A compilation of distribution data for Puget Sound fishes through 1973 showed very few observations of cutthroat trout within the WTD Existing Discharges Area (Miller and Borton 1980). The noted observations were in nearshore waters near the mouth of the waterways leading to Lake Washington (see Figure B-10, Appendix B). Juvenile cutthroat trout (less than five) were observed in June during beach seining surveys conducted by King County in the WTD Existing Discharges Area at Fauntleroy from June to August 2000. None were observed in July or August (Mavros and Brennan, in prep).

Although the status of most Puget Sound cutthroat trout populations is unknown, cutthroat trout do occur in drainages in the WTD Existing Discharges Area, including the Lake Washington and Cedar River watersheds (Johnson et al. 1999). Cutthroat trout migrating to streams and rivers use nearshore estuarine waters in the area for food and shelter.

Sockeye salmon -- *Oncorhynchus nerka*

When data for Puget Sound fishes through 1973 was compiled by Miller and Borton (1980), sockeye salmon were reported in waters leading to Lake Washington (see Figure B-8, Appendix B). Sockeye were not found south of the vicinity of Lake Washington waterways. The number of sockeye escapements in

the Cedar River was estimated by WDFW (1993) to be between 76,000 and 365,000 individuals for the years 1967 to 1991. The sockeye population spawning in the Cedar River is the largest sockeye population in the contiguous United States (Gustafson et al. 1997). The Lake Washington/Sammamish Tributaries escapements ranged from 3,600 to 29,700 individuals from 1982 through 1991. The number of Lake Washington beach spawners ranged from 54 to 1032 during the years 1984 through 1992 (WDFW 1993b). Beach seining surveys conducted by King County in the WTD Existing Discharges Area at Fauntleroy from June to August 2000 found juvenile sockeye (less than five) in June only (Mavros and Brennan, in prep).

Manning et al. (1999) reported 1995 sport catch data for sockeye salmon in an area that includes all the WTD Existing Discharges Area, Bainbridge Island, and Bremerton. Only eight sockeye salmon were caught in September in this area.

Steelhead -- *Oncorhynchus mykiss*

Steelhead were found within the WTD Existing Discharge Area when data for Puget Sound fishes through 1973 were compiled but no abundance data were reported (Miller and Borton 1980). The observations were clustered around the waterways to Lake Washington and in Elliott Bay and the Duwamish Waterway (see Figure B-11, Appendix B). Juvenile steelhead (less than five) were only observed in June at Fauntleroy during beach seining surveys conducted by King County in the WTD Existing Discharges Area from June to August 2000 (Mavros and Brennan, in prep).

There are known winter-run steelhead populations in the Green, Puyallup, and Nisqually Rivers and summer-run populations in the Green River (Pauley et al. 1986). Steelhead migrating to the Green River, and likely those fish migrating to south sound rivers, travel through marine waters in the WTD Existing Discharges Area.

4.3.3 Lamprey

Pacific Lamprey (*Entosphenus tridentatus*) and River Lamprey *(Lampetra ayresi)*

There is very little distribution and abundance data for lampreys in Puget Sound. Wydoski and Whitney (1979) noted that a newly metamorphosed Pacific lamprey was found in Lake Washington in the 1970's. Stober and Pierson (1984) documented a river lamprey in the lower Duwamish River and Miller and Borton (1980) noted two occurrences in Elliot Bay (see Figure B-2, Appendix B). No other distribution information was readily available.

4.3.4 Invertebrates

Northern Abalone (*Haliotis kamtschatkana*) and Olympia Oyster (*Ostrea conchaphila*)

There were no documented occurrences of either the northern abalone or the Olympia oyster in the WTD Existing Discharges Area. As stated in Section 3.3.4, the northern abalone is generally not found in estuaries and is primarily found on the outer coast and in the Straits (Sloan and Breen 1988). Although it is possible that isolated occurrences of Olympia oysters may be found in the WTD Existing Discharges Area, the numbers are not enough to sustain a breeding population as water temperatures in the Area are colder than spawning requirements (Couch and Hassler 1989) (see Section 3.3.4).

4.3.5 Marine Fish

Of the 24 species of marine fishes addressed in this report, eight were observed and identified in the WTD Existing Discharges Area by WDFW video and trawl surveys (Figure 4-8). In addition, the WDFW Technical Report No. 79 identifies known forage fish spawning grounds in the WTD Existing Discharge Area (Figure 4-9) (WDFW 1992).

The marine fish proposed for coverage in this report are listed in Table 4-1 along with their distribution range, primary habitat on which they were most often observed, the depth range at which they were observed, and their relative abundance within the WTD Existing Discharges Area. As stated in Section 3.3.5, the fact that a species was not observed does not mean that it was not present. These species are mobile and many tend to hide in cracks and crevices. In addition, many have cryptic coloration making them difficult or impossible to see even when they are in the open. Seasonal variation in food resources, life history stages (e.g., spawning, juvenile recruitment), or environmental conditions can also affect the presence, distribution, and abundance of fish species.

Ground Fish

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

There were no documented records of green sturgeon in the WTD Existing Discharges Area, but Miller and Borton (1980) did report two records of green sturgeon occurrences somewhere within Puget Sound (the specific locations were not noted). There are two records of a white sturgeon seen in the WTD Existing Discharges Area. Miller and Borton (1980) reported a white sturgeon near Duwamish Head and DeLacy and Borton (1972) reported a white sturgeon in the Seattle area (see Figure B-4, Appendix B).

Pacific Cod -- *Gadus macrocephalus*

Miller and Borton (1980) reported observations of Pacific cod throughout the WTD Existing Discharges Area, particularly in Elliott Bay and from West Point

north to the county line (see Figure B-15, Appendix B). During 1975-76 beach seine and otter trawl surveys, a single Pacific cod was caught off West Point at a depth of 25 m, 17 were caught off Alki Point at depths from 37 to 45 m, and 1 was caught in the lower Duwamish River (Stober and Pierson 1984). Two additional Pacific cod were caught in eelgrass off Alki Point during 1976-77 beach seine surveys (Stober and Pierson 1984). For the Stober and Pierson surveys, Pacific cod was one of the most abundant species found along the pilings and riprap surrounding Piers 90 and 91 in Elliott Bay (Stober and Pierson 1984). WDFW trawl survey data documented Pacific cod throughout the WTD Existing Discharges Area in both nearshore and offshore waters (Figure 4-8 and Appendix C).

Walleye Pollock -- *Theragra chalcogramma*

Miller and Borton (1980) reported observations of walleye pollock throughout the WTD Existing Discharges Area (see Figure B-17, Appendix B). During 1975-1976 beach seine and otter trawl surveys, 18 walleye pollock were caught off West Point from depths up to 95 m and 47 were caught off Alki Point at depths up to 70 m (Stober and Pierson 1984). Four additional walleye pollock were caught in eelgrass off Alki Point during 1976-77 beach seine surveys (Stober and Pierson 1984). Stober and Pierson (1984) noted that walleye pollock were associated with pilings and riprap at depths between 11 and 18 m near Terminal 37 in the Duwamish River (Stober and Pierson 1984). WDFW trawl data shows pollock throughout the WTD Existing Discharges Area from north to south but does not show this species occurring in shallow nearshore waters (see Figure 4-8 and Appendix C).

Pacific Hake -- *Merluccius productus*

Miller and Borton (1980) reported observations of Pacific hake throughout the area north of Alki Point to the northern limit of the WTD Existing Discharges Area (see Figure B-16, Appendix B). During 1975-76 beach seine and otter trawl surveys, a single Pacific hake was caught off West Point at a depth of 95 m and three were caught off Alki Point at a depth of 70 m (Stober and Pierson 1984). WDFW trawl data indicated Pacific hake throughout the WTD Existing Discharges Area from north to south but did not show this species occurring in shallow nearshore waters (Figure 4-8 and Appendix C). However, Pacific hake are seasonally abundant in nearshore waters (less than 21 m) in Elliott Bay (J. Christiansen, Seattle Aquarium, pers. comm.).

Lingcod -- *Ophiodon elongates*

Miller and Borton (1980) reported observations of lingcod throughout the WTD Existing Discharges Area from Alki Point to north of Meadow Point (see Figure B-33, Appendix B). WDFW trawl survey data showed lingcod in the WTD Existing Discharges Area near Magnolia and video survey data showed lingcod at two inner Elliott Bay locations (see Figure 4-8 and Appendix C). All observations were in nearshore waters less than 17 m.

Forage Fish

Pacific Herring -- Clupea harengus pallasi

Miller and Borton (1980) reported observations of Pacific herring throughout the WTD Existing Discharges Area, especially near Elliott Bay (see Figure B-5, Appendix B). WDFW trawl data document herring from inner Elliott Bay to the northern boundary of the WTD Existing Discharges Area (Figure 4-8 and Appendix C). Quinnell and Schmitt (1991) found Pacific herring most abundant in shallow water (9-37 m) and estimated an abundance of nearly 1.5 million individuals in the central Puget Sound area in 1987.

While there are no documented Pacific herring spawning grounds within the WTD Existing Discharges Area, spawning grounds are documented to the south (Quartermaster Harbor), west (Port Orchard/Madison), and north (Port Susan) (Figure 4-9) (Lemberg et al. 1997). It is probable that Pacific herring of all ages pass through the WTD Existing Discharges Area on their way to or from the spawning grounds, especially during spawning season (late January through early June).

Sand Lance -- *Ammodytes hexapterus*

Miller and Borton (1980) reported sand lance between Alki Point and Duwamish Head, lower Duwamish River, and from West Point north to the county line (see Figure B-18, Appendix B). During 1975-76 beach seine surveys, 247 sand lance were caught off West Point, while 1,250 sand lance were caught in eelgrass off Alki Point during 1976-77 surveys (Stober and Pierson 1984). King County conducted beach-seining surveys in the southern portion of the WTD Existing Discharges Area at Fauntleroy from June to August 2000. Sand lance were seen in abundance in June and July, with over 1,000 documented in July. None were seen in August (Mavros and Brennan, in prep).

Figure 4-9 shows documented sand lance spawning grounds in the WTD Existing Discharges Area. These areas are located on the north side of Alki Point, Fauntleroy cove, and at Golden Gardens (WDFW 1992). The area from Alki Point south to the southern boundary of the WTD Existing Discharges Area has been extensively surveyed for forage fish spawning habitat. However, the remaining WTD Existing Discharges Area has not been thoroughly surveyed and it is possible there are additional sand lance spawning grounds in this area (Penttila 2000).

Surf Smelt -- *Hypomesus pretiosus*

Miller and Borton (1980) reported observations of surf smelt near Alki Point, the mouth of the Duwamish River, and from West Point north to Richmond Beach (see Figure B-13, Appendix B). Stober and Pierson (1984) observed surf smelt in shallow water around eelgrass and sandy bottoms at Alki Point and West Point.

Figure 4-9 shows documented surf smelt spawning grounds in the WTD Existing Discharges Area. These spawning areas are located just north of Fauntleroy, the

north side of Alki Point, and just south of Richmond Beach (WDFW 1992). As with sand lance, the area from Smith Cove north to the northern boundary of the WTD Existing Discharges Area has not been thoroughly surveyed and it is possible there are additional surf smelt spawning grounds in this area (Penttila 2000).

Eulachon -- *Thaleichthys pacificus*

There was little information available regarding distribution of eulachon in the WTD Existing Discharges Area. Miller and Borton (1980) reported three observations of eulachon near Golden Gardens and Carkeek (see Figure B-14, Appendix B) and Stober and Pierson (1984) reported two eulachon in the lower Duwamish River during 1975-76 surveys. This is considered a rare species in Puget Sound (Emmett et al. 1991).

Rockfish

The following rockfish species proposed for coverage in the HCP are distributed along the outer Washington coasts and in the Straits surrounding the San Juan Islands but are not known to occur in inland Puget Sound waters or in the WTD Existing Discharge Area: blue, widow, china, and tiger rockfish (W. Palsson, WDFW, pers. comm.; J. Christiansen, Seattle Aquarium, pers. comm.).

Figure 4-9 shows an area in the southwestern portion of the WTD Existing Discharges Area (between Vashon Island and Blake Island) where reef-dwelling bottom fish are known to occur (WDFW 1992). Although individual species are not included in this data set, it is probable that some of the rockfish species proposed for coverage in the HCP are found in this area. Other rockfish species covered in this report are discussed below.

Brown Rockfish -- *Sebastes auriculatus*

Miller and Borton (1980) reported brown rockfish from Meadow Point to West Point, Elliot Bay, and Alki Point (see Figure B-19, Appendix B). During 1975-76 beach seine and otter trawl surveys, 56 brown rockfish were caught off West Point at depths between 25 and 95 m and 31 were caught off Alki Point at depths up to 70 m (Stober and Pierson 1984). Two brown rockfish were caught in eelgrass off Alki Point during 1976-77 beach seine surveys (Stober and Pierson 1984). Brown rockfish were also observed near Piers 91 and 90 and Terminal 37 in Elliott Bay and the lower Duwamish River (Stober and Pierson 1984). Brown rockfish were seen from West Seattle north to Shilshole Bay, including inner Elliott Bay, during WDFW video surveys (Figure 4-8 and Appendix C). All occurrences were in nearshore waters.

Copper Rockfish -- *Sebastes caurinus*

Miller and Borton (1980) reported copper rockfish throughout the WTD Existing Discharges Area (see Figure B-20, Appendix B). During 1975-76 beach seine and otter trawl surveys, two copper rockfish were caught off West Point at depths of 25 and 45 m and three were caught off Alki Point in shallow water (Stober and

Pierson 1984). Copper rockfish were also observed near Piers 91 and 90 and Terminal 37 in Elliott Bay and the Duwamish River (Stober and Pierson 1984). WDFW video surveys documented copper rockfish from the southern portion of the WTD Existing Discharges Area north to Shilshole Bay (Figure 4-8 and Appendix C). All occurrences were in relatively shallow waters (less than 24 m).

Greenstriped Rockfish -- *Sebastes elongates*

Miller and Borton (1980) reported greenstriped rockfish from Meadow Point to West Point and Alki Point (see Figure B-21, Appendix B). There were no other greenstriped rockfish documented in the WTD Existing Discharge Area.

Yellowtail Rockfish -- *Sebastes flavidus*

Miller and Borton (1980) reported yellowtail rockfish near Meadow Point, offshore from Smith Cove, and north of Alki Point (west of Duwamish Head) (see Figure B-23, Appendix B). Adults of this species are commonly seen throughout the year in nearshore areas in the WTD Existing Discharges Area, including Elliott Bay (J. Christiansen, Seattle Aquarium, pers. comm.).

Quillback Rockfish -- *Sebastes maliger*

Miller and Borton (1980) reported quillback rockfish from Meadow Point to West Point, Elliott Bay, and Alki Point (see Figure B-24, Appendix B). During 1975-76 beach seine and otter trawl surveys, 84 quillback rockfish were caught off West Point at depths between 25 and 95 m and 45 were caught off Alki Point at depths up to 70 m (Stober and Pierson 1984). One quillback rockfish was caught in eelgrass off Alki Point during 1976-77 beach seine surveys and several were seen near Piers 91 and 90 in Elliott Bay during diving transects (Stober and Pierson 1984). WDFW found quillback rockfish throughout the WTD Existing Discharges Area, including Elliott Bay, during video and trawl surveys (Figure 4-8 and Appendix C). Quillback rockfish were found in relatively shallow waters (less than 24 m) in nearshore areas.

Black Rockfish -- *Sebastes melanops*

Miller and Borton (1980) reported black rockfish from Meadow Point to north of West Point, north of Smith Cove, and Elliott Bay (see Figure B-25, Appendix B). Stober and Pierson (1984) observed a single black rockfish near the surface during diving transects off the end of Pier 91 in Elliott Bay. There were no other reports of black rockfish in the WTD Existing Discharges Area.

Bocaccio -- *Sebastes paucispinus*

Miller and Borton (1980) reported bocaccio near Meadow Point and north of Alki Point (west of Duwamish Head) (see Figure B-29, Appendix B). There were no other reports of bocaccio in the WTD Existing Discharges Area. This is an open water species with adults preferring deep waters (73-300 m) and is seldom seen in either video or trawl surveys (Hart 1980). However, waters within the WTD

Existing Discharges Area provide the necessary habitat for this species and it is possible that bocaccio occur in this area.

Canary Rockfish -- *Sebastes pinniger*

Miller and Borton (1980) reported canary rockfish near Shilshole Bay in the northern portion of the WTD Existing Discharges Area (see Figure B-30, Appendix B). However, this species was not found in the WDFW video and trawl surveys and is rarely seen south of Hood Canal. This species is primarily found along the outer coasts and in the Straits (J. Christiansen, Seattle Aquarium, pers. comm.). In addition, surveying is difficult because this is mainly a deep, open water species (Hart 1980).

Redstripe Rockfish -- *Sebastes proriger*

Miller and Borton (1980) reported redstripe rockfish near Meadow Point and in Elliott Bay (see Figure B-31, Appendix B). During 1975-76 otter trawl surveys, two redstripe rockfish were caught off West Point at depths of 45 and 70 m and fifteen were caught off Alki Point at a depth of 45 m (Stober and Pierson 1984). There were no other documented reports of redstripe rockfish in the WTD Existing Discharges Area.

Yelloweye Rockfish -- *Sebastes ruberrimus*

Miller and Borton (1980) reported yelloweye rockfish near Meadow Point, West Point, Smith Cove, and the northeast side of Elliott Bay (see Figure B-32, Appendix B). This species is occasionally seen in the WTD Existing Discharges Area in deeper waters (greater than 25 m) (J. Christiansen, Seattle Aquarium, pers. comm.).

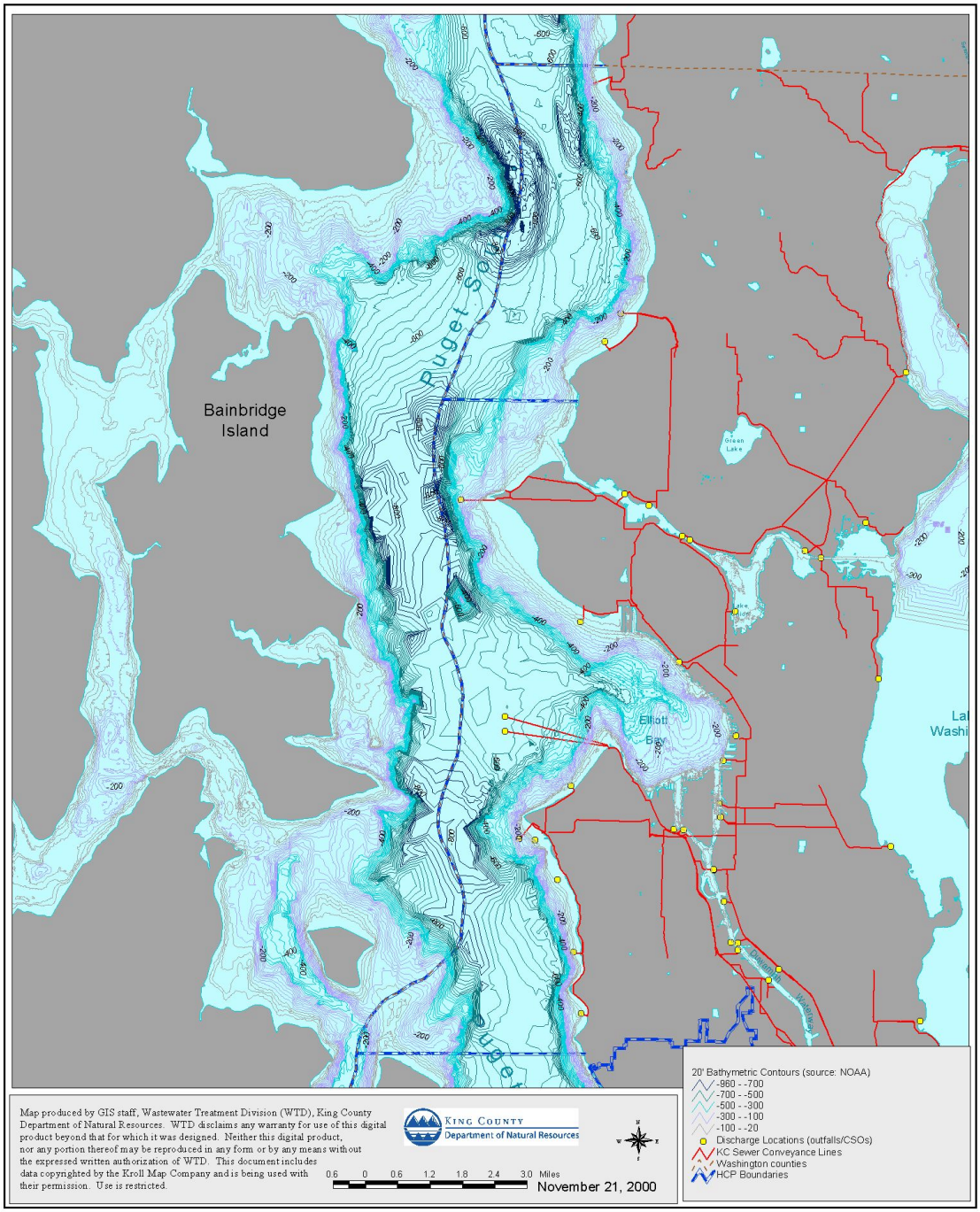

Figure 4-1. Bathymetric contours in the Brightwater Outfall Siting Area

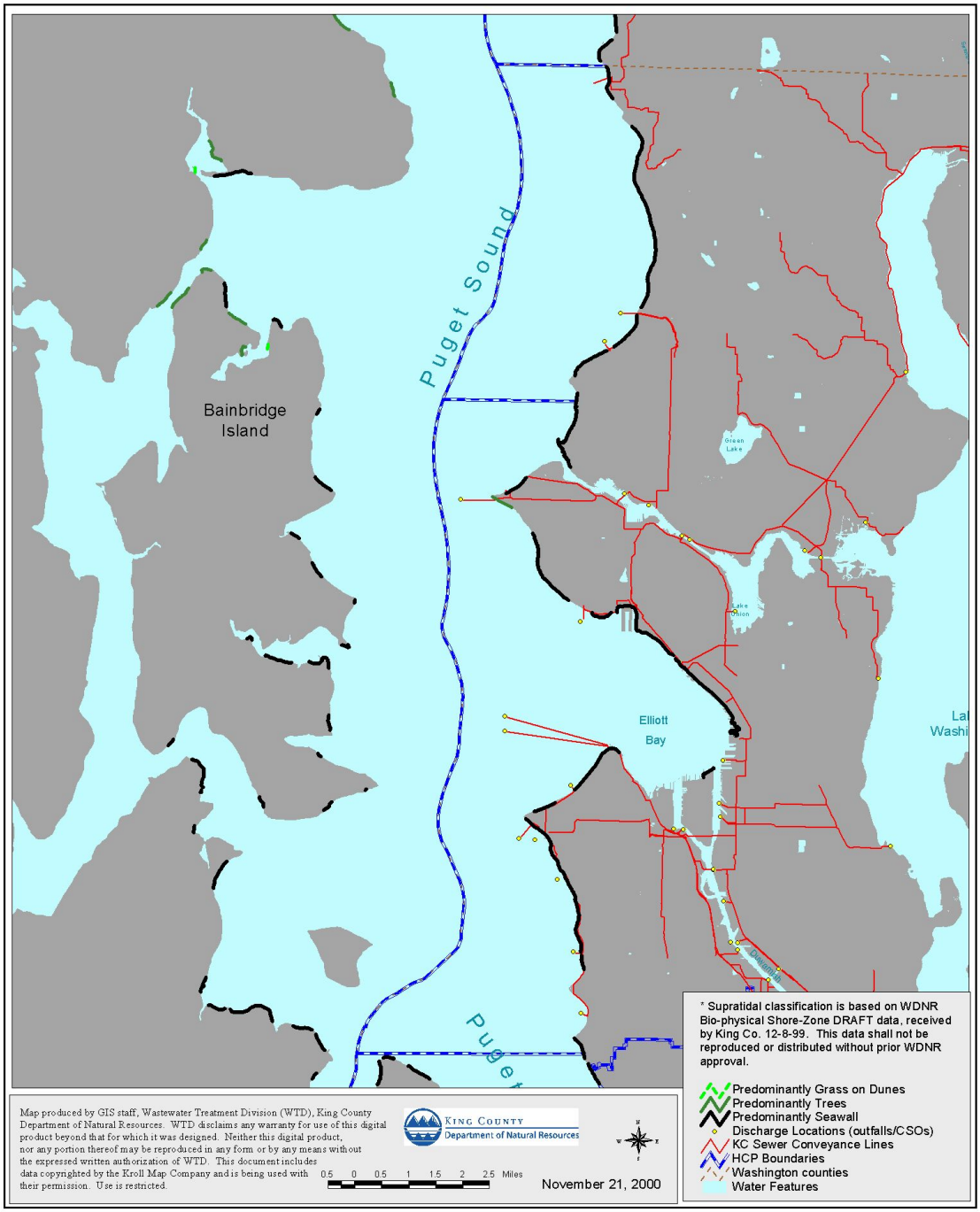

Figure 4-2. Supralittoral zone in the WTD Existing Discharges

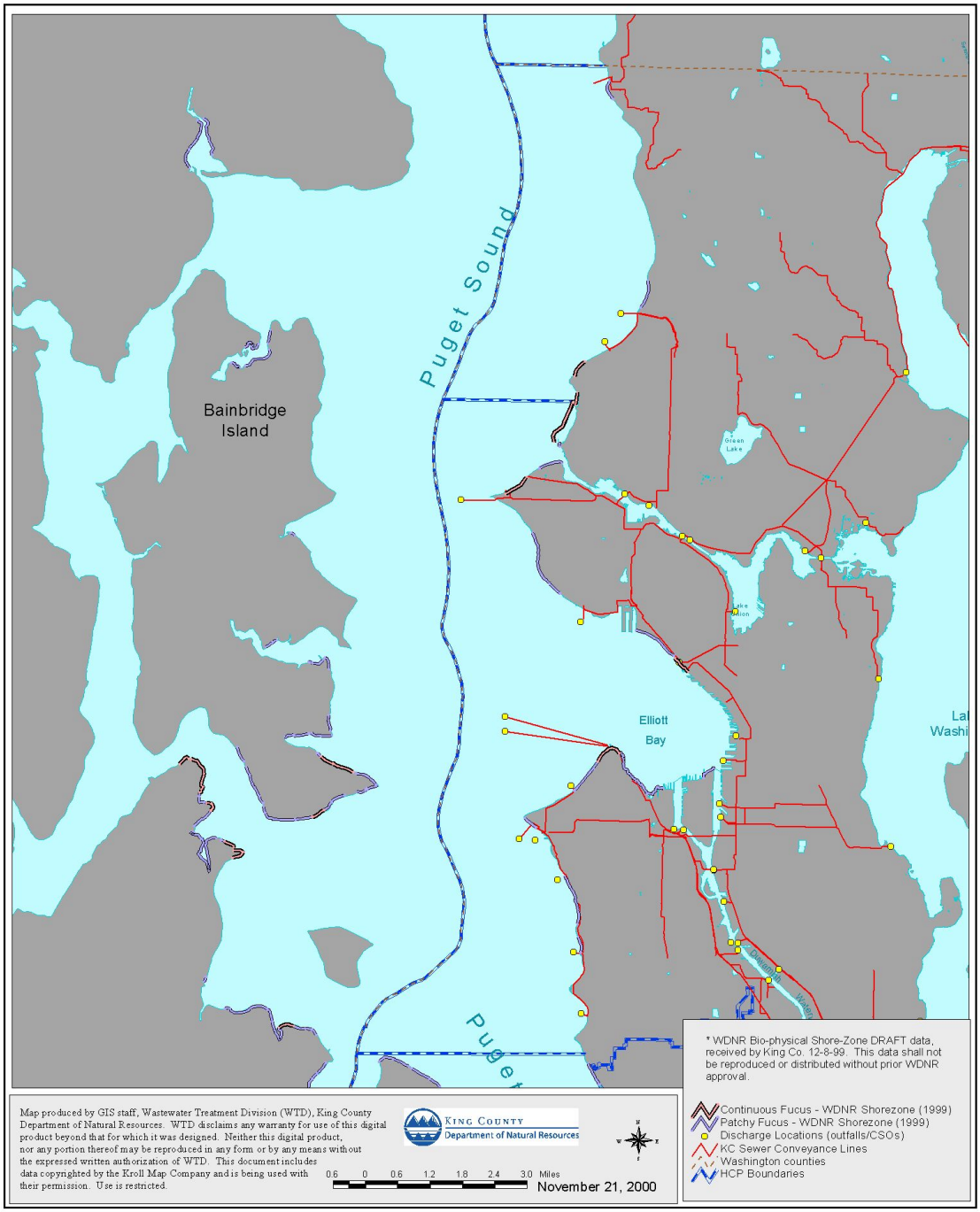

Figure 4-3. Distributions of rockweed (*Fucus*) in the intertidal zone of the WTD Existing Discharges Area

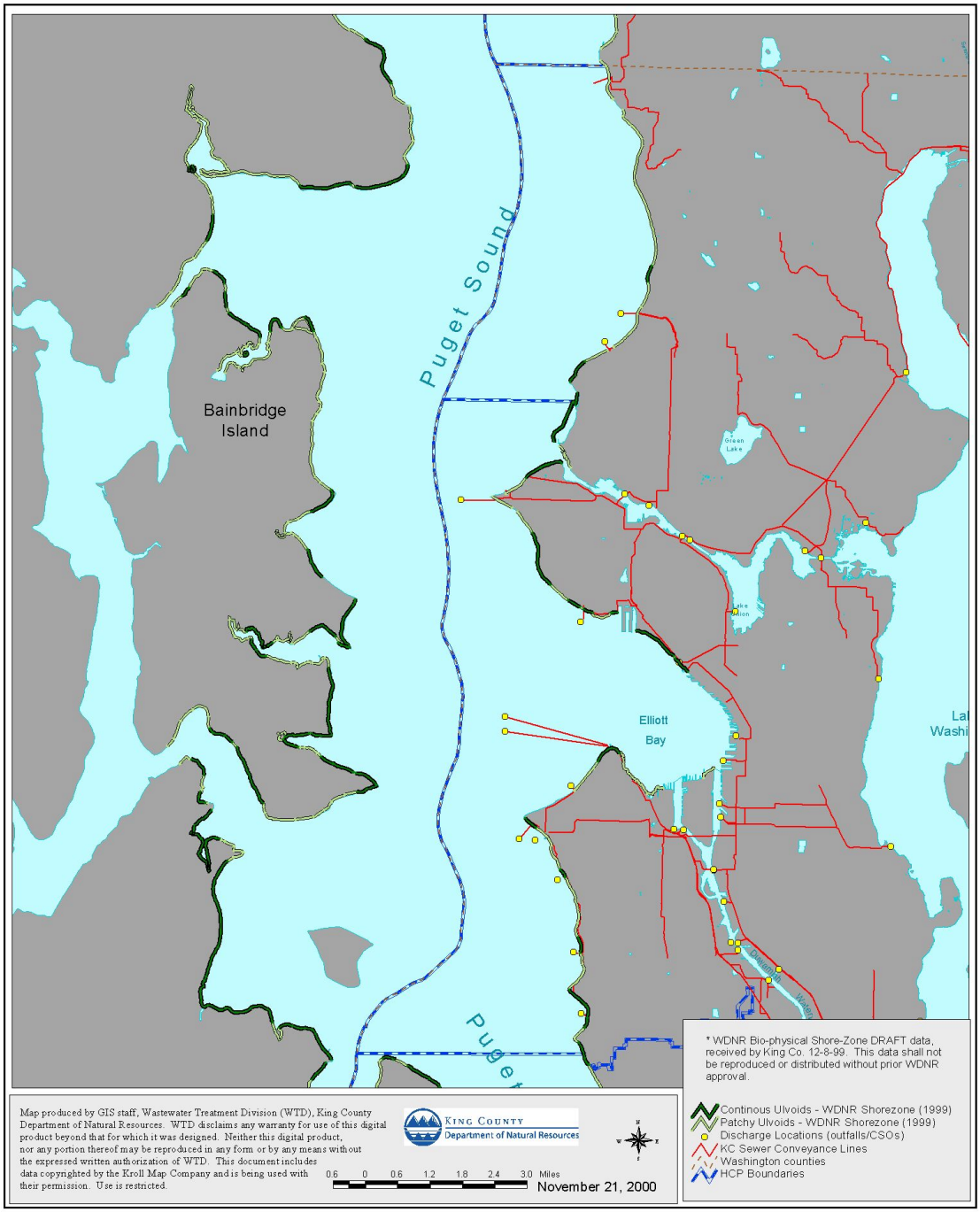

Figure 4-4. Distributions of Ulvoids in the intertidal zone through the shallow subtidal zone of the WTD Existing Discharges Area

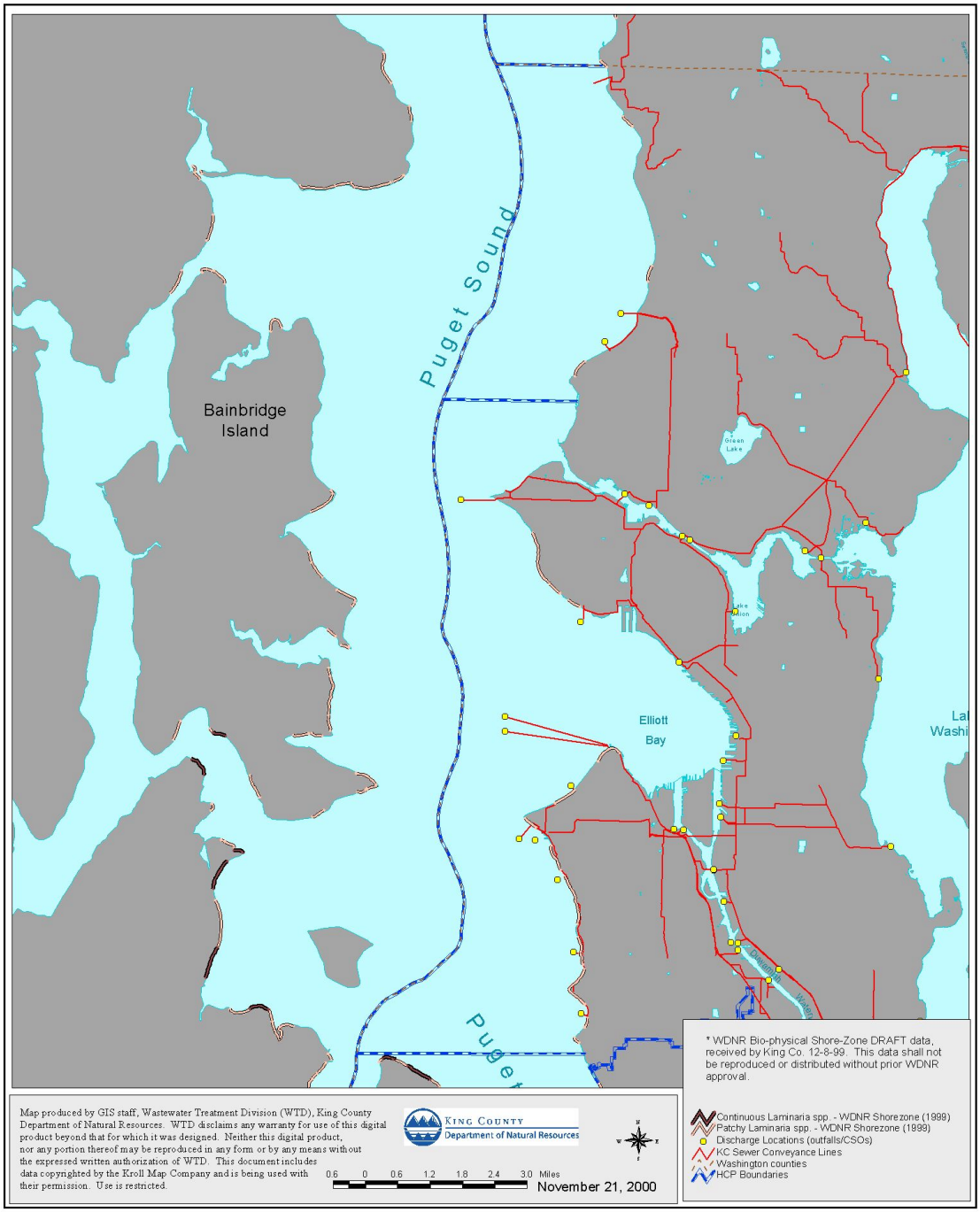

Figure 4-5. Distributions of *Laminaria* spp. in the intertidal zone through the shallow subtidal zone of the WTD Existing Discharges Area

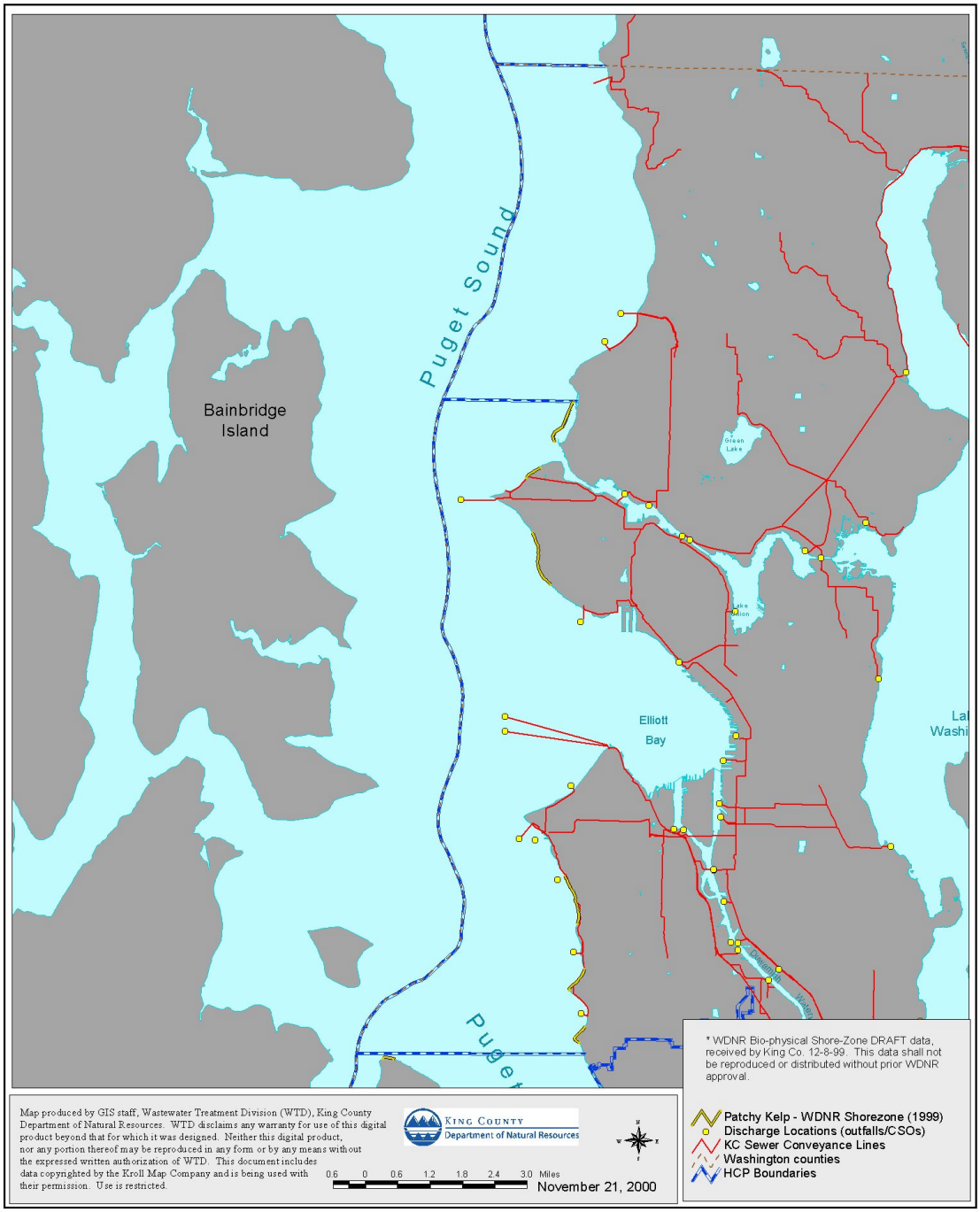

Figure 4-6. Distributions of kelp (*Nereocystis luetkeana)* in the intertidal zone through the shallow subtidal zone of the WTD Existing Discharges Area

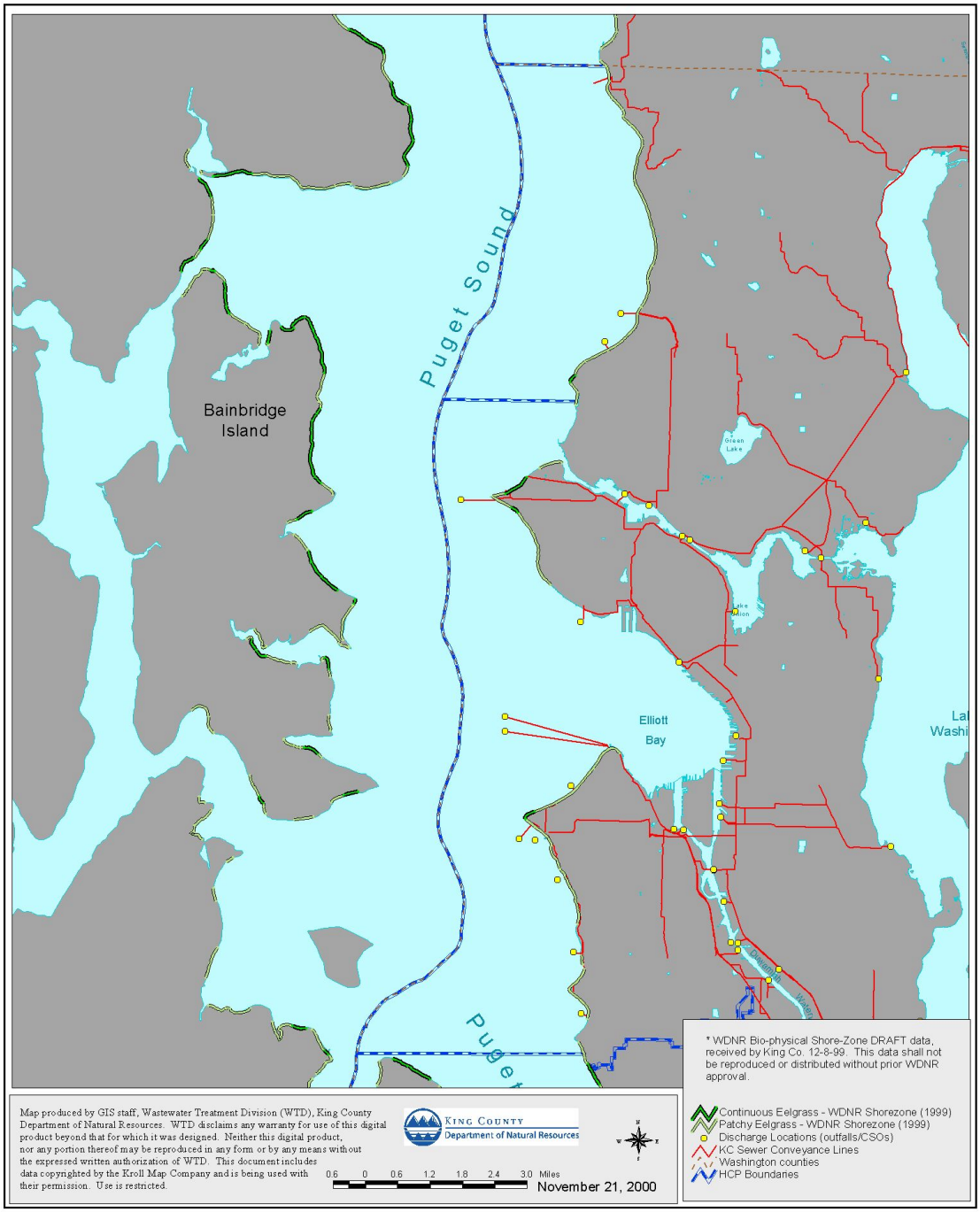

Figure 4-7. Distributions of eelgrass (*Zostera marina*) in the intertidal zone through the shallow subtidal zone of the WTD Existing Discharges Area

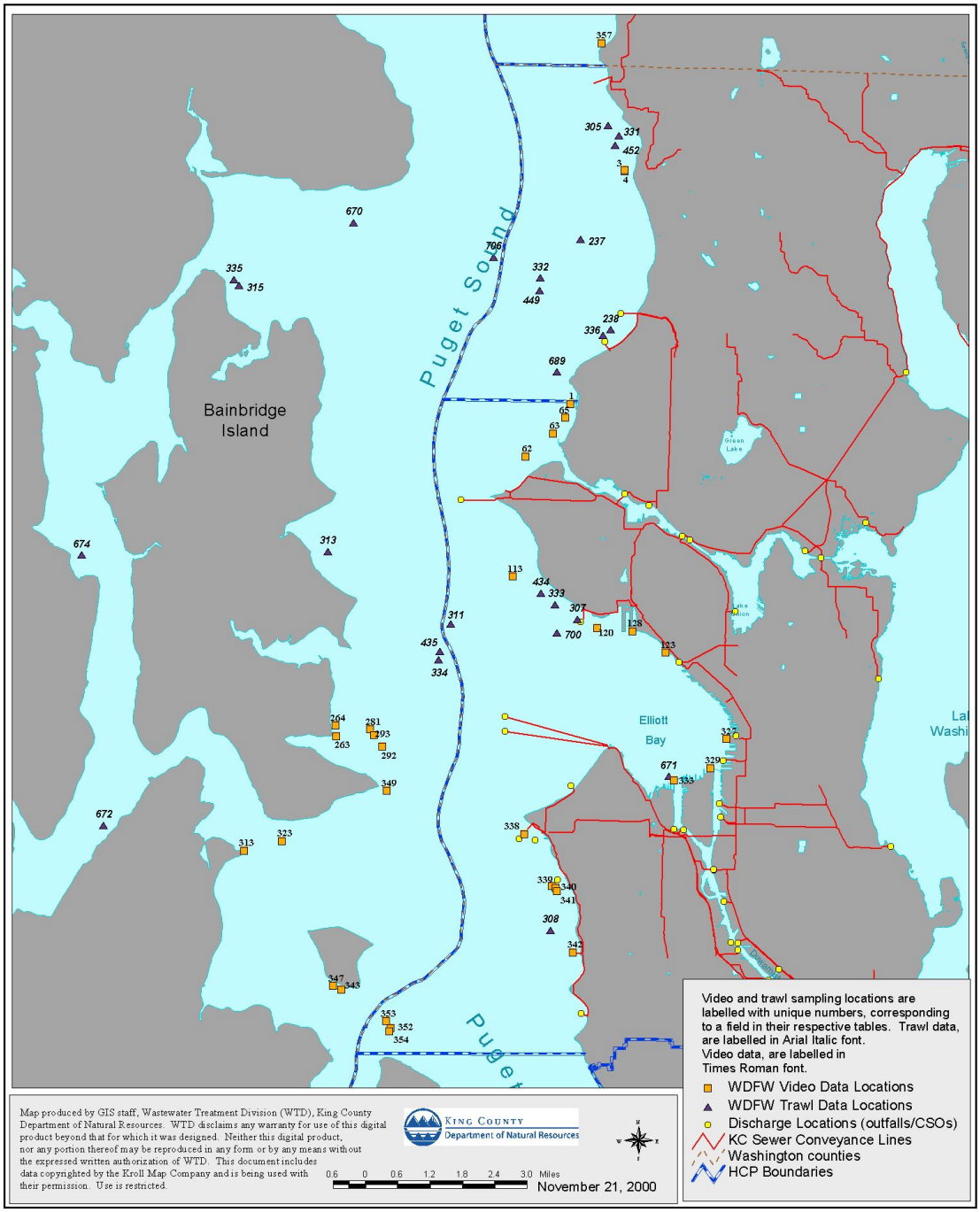

Figure 4-8. WDFW trawl and video marine fish data in the WTD Existing Discharges Area. See Appendix C for fish species noted at each location.

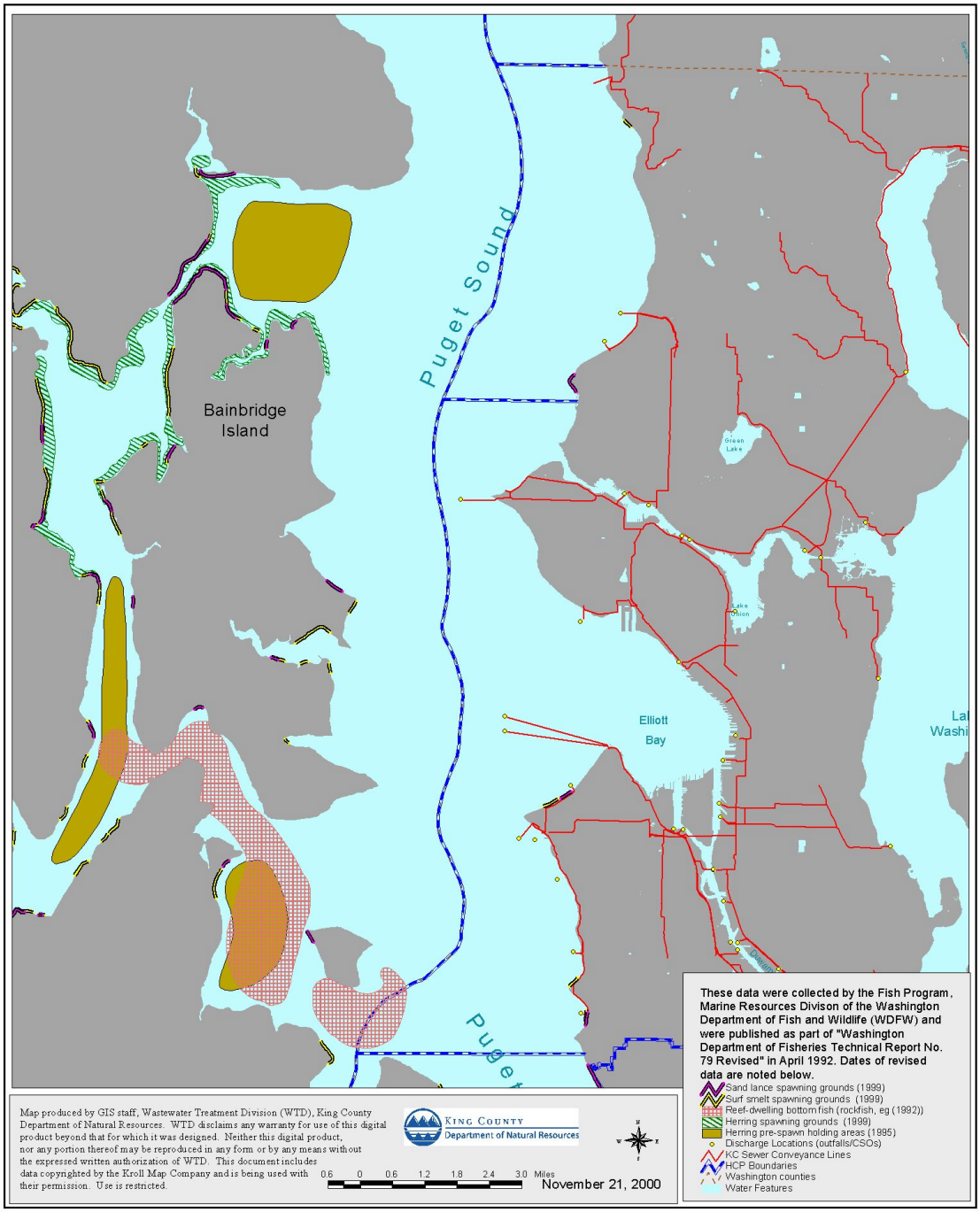

Figure 4-9. Forage fish spawning and holding areas and bottom fish/reef-dwelling habitats in the WTD Existing Discharges Area

Table 4-1. Marine fish species observed in the WTD Existing Discharges Area.[1]

Common Name	Genus species	Distribution	Primary habitat	Depth range (ft)	Average density (ind/m^2)	Relative abundance[2]
Green Sturgeon	*Acipenser medirostris*	none observed	NA	NA	NA	NA
White Sturgeon	*Acipenser transmontanus*	none observed	NA	NA	NA	NA
Pacific Cod (S & C P.S.)	*Gadus macrocephalus*	N & offshore from Meadow Pt, Meadow Pt, N & offshore from Smith Cove, between Alki Pt & Pt Williams	NA	30->360	0.0002[a]	7
Walleye Pollock (S. P.S.)	*Theragra chalcogramma*	S of Pt Wells, offshore between Pt Wells & Meadow Pt, Meadow Pt, offshore from mouth of Elliott Bay, W of Smith Cove, between Alki Pt & Pt Williams	NA	126->360	0.003[a]	9
Pacific Hake (C P.S.)	*Merluccius productus*	S of Pt Wells, N & offshore from Meadow Pt, offshore from mouth of Elliott Bay, between Alki Pt & Pt Williams	NA	126->360	0.003[a]	11
Lingcod	*Ophiodon elongatus*	S of Pt Wells, Meadow Pt, between West Pt & Smith Cove, N & S sides of Elliott Bay	hard, high relief structures on mud or mud/shell bottom	43-52	0.047[b]	6
Pacific Herring	*Clupea harengus pallasi*	S of Pt Wells, Meadow Pt, N of Smith Cove, S side of Elliott Bay	NA	30-360	0.0002[a]	4
Sand Lance	*Ammodytes hexapterus*	Spawning grounds (1 Nov to 15 Feb): Meadow Pt, N side of Alki Pt, between Pt Williams & Pt Brace	sand gravel beaches for spawning	upper inter-tidal	NA	probably abundant during spawning
Unidentified Baitfish	*Herring or Sand Lance*	between Pt Wells & Meadow Pt	NA	NA	NA	2

Table 4-1. Marine fish species observed in the WTD Existing Discharges Area.[1]

Common Name	Genus species	Distribution	Primary habitat	Depth range (ft)	Average density (ind/m^2)	Relative abundance[2]
Surf Smelt	*Hypomesus pretiosus*	Spawning grounds (mostly fall and winter in this area): S of Pt Wells, N side of Alki Pt, N side of Pt Williams, between Pt Williams & Brace Pt	very coarse sand to pea gravel beaches for spawning	upper inter-tidal		none observed during surveys, probably abundant during spawning
Eulachon	*Thaleichthys pacificus*	none observed	NA	NA	NA	NA
Brown Rockfish	*Sebastes auriculatus*	N of West Pt, between West Pt & Smith Cove, E & S sides of Elliott Bay, Alki Pt, S of Alki Pt	boulders on mud or mud/shell bottom	45-85	0.0986[b]	8
Copper Rockfish	*Sebastes caurinus*	S of Pt Wells, Meadow Pt, between Meadow Pt & West Pt, N of Smith Cove, Alki Pt, S of Alki Pt, N of Pt Williams, N of Pt Vashon	boulders	21-79	0.0915[b]	12
Greenstriped Rockfish	*Sebastes elongatus*	none observed	NA	NA	NA	NA
Widow Rockfish	*Sebastes entomelus*	none observed	NA	NA	NA	NA
Yellowtail Rockfish	*Sebastes flavidus*	none observed	NA	NA	NA	NA
Quillback Rockfish	*Sebastes maliger*	S of Pt Wells, Meadow Pt, N side of West Pt, between West Pt & Smith Cove, S side of Elliott Bay, S side of Alki Pt, S of Alki Pt, between Alki Pt & Pt Williams, N of Pt Vashon	boulders and artificial structures	29-79	0.416[b]	23
Black Rockfish	*Sebastes melanops*	none observed	NA	NA	NA	NA
Blue Rockfish	*Sebastes mystinus*	none observed	NA	NA	NA	NA

Table 4-1. Marine fish species observed in the WTD Existing Discharges Area.[1]

Common Name	Genus species	Distribution	Primary habitat	Depth range (ft)	Average density (ind/m^2)	Relative abundance[2]
China Rockfish	*Sebastes nebulosus*	none observed	NA	NA	NA	NA
Tiger Rockfish	*Sebastes nigrocinctus*	none observed	NA	NA	NA	NA
Bocaccio	*Sebastes paucispinus*	none observed	NA	NA	NA	NA
Canary Rockfish	*Sebastes pinniger*	none observed	NA	NA	NA	NA
Redstripe Rockfish	*Sebastes proriger*	none observed	NA	NA	NA	NA
Yelloweye Rockfish	*Sebastes ruberrimus*	none observed	NA	NA	NA	NA
Unidentified Rockfish	*Sebastes spp.*	S of Pt Wells, Meadow Pt, between Meadow Pt & West Pt, Smith Cove, N of Pt Williams	artificial structures	18-69	NA	7

NA - Not Available

[1]Based on data from Tech Report 79, Battelle, and WDFW.

[2]Relative abundance indicates the number of times a given species was observed during the surveys.

[a]Based on WDFW trawl surveys (Palsson data).

[b]Based on WDFW video surveys (Palsson data).

5.0 Vashon Island Area

The following section provides known information regarding habitat distribution and usage of the various habitats in the Vashon Island Area by the species covered in this report (listed in Section 2.0). Readily known distribution and relative abundance information for the covered species in the Vashon Island Area are also provided. Data gaps are identified in this section where appropriate; however, a detailed discussion regarding data gaps is provided in Section 6.0.

As stated in Section 3.0, a comprehensive examination of physical oceanographic characteristics in the Vashon Island Area is beyond the scope of this report but is available in a separate document (Ebbesmeyer and Cannon 2000). Water and sediment chemistry data in this area are also beyond the scope of this report but are available in the documents listed in Section 3.0.

5.1 Physical Setting

The Vashon Island Area extends from the northern tip of the Island to a point approximately midway down the Island. The eastern boundary is the upper edge of the supralittoral zone along the East Passage shoreline at Normandy Park, while the western boundary is the King/Kitsap County line running though the middle of Colvos Passage. Narrow beaches consisting of a gravel and cobble substrate characterize the eastern boundary along East Passage. The Vashon Island shoreline along both the east and west sides of the Island consists of gravel, cobble, and rocky beaches.

Along the east side of Vashon Island the shelf grades very steeply into the slope before dropping into the basin depths. Colvos Passage on the west side of the Island is fairly shallow (60 m) at its deepest depth. The substrate in Colvos Passage consist of all grades of sand mixed with gravel, cobble, and rocks. The east side of East Passage contains a variety of habitats with a fairly broad shelf consisting of sand. The slopes adjacent to points of land are primarily coarse sand and gravel, cobble, and rocks.

The deepest water depth in the Vashon Island Area is approximately 230 meters located in the main channel between Vashon Island and Three Tree Point. Figure 5-1 provides information regarding slopes and depths of the seafloor in the Vashon Island Area.

5.2 Habitat Distribution

In this section, the general distributions of the major habitats are presented. Some information is also provided on the types of fauna associated with these habitats (e.g., eelgrass). The habitats are discussed under three subheadings:

supralittoral, intertidal and shallow subtidal, and finally the deep subtidal. For more information on the types of fauna associated with these habitats, see Section 2.6.

5.2.1 Supralittoral

As compared to the Brightwater Outfall Siting Area (Figure 3-1) and WTD Existing Discharges Area (Figure 4-1), the Vashon Island Area contains much less armored shoreline, with most armoring occurring in the Seahurst Bight region (Figure 5-2). Much of the eastern shoreline of Vashon Island is unmodified, and includes of overhanging trees on low to moderately high bluffs with a likely increasing number of vascular plants, grasses, and shrubs in the supralittoral zone.

In the northern section of the Vashon Island Area the supralittoral zone is in part bulkheaded to protect the residential communities north and south of Three Tree Point. To the north of Three Tree Point along the Seahurst shoreline, steep bluffs bound the upper edge of supralittoral zone. The Vashon Island shoreline along both the east and west sides of the Island are bulkheaded in some areas to protect residential developments. A dense buffer of trees and riparian vegetation appears to extend from the supralittoral to some degree inland.

5.2.2 Intertidal through Shallow Subtidal

The intertidal and shallow subtidal zones in the Vashon Island Area contains all major habitat types normally found in central Puget Sound (e.g., eelgrass meadows, kelp forests, flats, tidal marshes, and sub-estuaries). However, this area is the only one where the 1999 WDNR Shorezone Database (WDNR 1999) indicates a native high tidal marsh, which covers a very small area on the eastern shore of Vashon Island just outside of the Vashon Island Area (Figure 5-3). The intertidal and shallow subtidal areas around Vashon Island are characterized by sandy beaches on the east side of the island and narrow sandy beaches on the west side. The distributions of some of the major vegetation taxa used to depict the nearshore habitats in the Vashon Area are shown in Figures 5-3 through 5-7, and are discussed in more detail in the following paragraphs.

Fucus sp. is common along the western shoreline, indicating a dominant coarser substrate, and is uncommon along the eastern shoreline of the Island which indicates that finer grained sediments are dominant (Figure 5-4). *Ulva* spp. is commonly found in the Vashon Island Area (Figure 5-5) where it forms continuous beds in the mid and low intertidal zone. *Laminaria* spp. is common but patchy in the upper subtidal zone throughout the area (Figure 5-6). Kelp, based on the 1999 Shorezone Database (WDNR 1999), is rare and patchy in the region (Figure 5-7).

Eelgrass is very common, with continuous meadows recorded on the west, north, and east sides of the Vashon Island Area (Figure 5-8). As in Sections 3.2.1 and 4.2.1, the presence of eelgrass indicates finer grained sediment types in the lower shallow subtidal habitats.

Similar to the Brightwater Outfall Siting Area and the WTD Existing Discharges Area, tideflats are widespread in the Vashon Island Area but their full extent has not been mapped. Flats in Tramp Harbor contain a wide array of infaunal polychaete and amphipod species as well as bivalves (Thom et al. 1984). Prey resources for juvenile chinook and chum salmon have been documented in the flats in the Vashon Island Area (Thom et al. 1984; Simenstad et al. 1991). The flats likely contain the productive microalgae that exists on flats in other regions of Puget Sound. These algae support juvenile salmon prey resources as well as other prey resources important to fish and birds in the region (Simenstad et al. 1991).

5.2.3 Deep Subtidal

The East Passage portion of the Vashon Island Area was extensively studied from 1982 through 1984 as part of the Renton Sewage Treatment Plant Seahurst Baseline Study (Word et al. 1984a). Within the Vashon area, the Seahurst Baseline Study established all or parts of ten transect lines with a total of 56 stations. Five of these stations were located in the northern end of Colvos Passage.

The shelf habitat within the study area in East Passage and along both shorelines of Vashon Island consisted primarily of medium to fine sand. The dominant mollusc in the entire study area was the bivalve *Psephedia lordi*. The dominant polychaete on both the north and south sides of Three Tree Point was *Notomastus tenuis*, while the subdominants were *Prionospio* spp. on the north side and *Mediomastus* spp. on the south side. The dominant crustacean was the ostracod *Euphilomedes carcharodonta*. The shelf area around Vashon Island is narrow and rapidly drops off to slope depths. The dominant species on the shelf surrounding Vashon Island were the polychaete *Phyllochaetopterus prolifica* and the ostracod *Euphilomedes carcharodonta*. These two species alternated being the numerical dominant around the Island, with *Phyllochaetopterus* appearing to dominate habitats with higher water current speeds.

The slope depth contained sediments consisting of a small amount of sand around points of land, but was principally silt and clay. The fine silt on the steeper slopes was held in place by the large cigar shaped tubes of polychaetes in the genus *Asychis* spp. There was no single numerically dominant polychaete, but rather a mix of the species seen in the shelf area. The same was true for the crustaceans, with *Euphilomedes carcharodonta*, *E. producta*, and the caprellid amphipod *Tritella pilimana*, vying for dominance depending on the amount of sand present.

Habitats in the deep basin consisted of fine silts and clays. The numerically dominant organism at these basin depths was the bivalve mollusc *Axinopside serricata*. In areas with a substantial amount of organic material and where the clay content of the sediment was greater than the silt content, the dominance switched to the bivalve *Macoma carlottensis*. However, this occurred in only two, small, geographically isolated areas. At these depths the dominant polychaete was in the genus *Ampharete* spp. and the dominant crustaceans were *Eudorella pacifica*, *Eudorellopsis integra*, and, in areas with more clay that silt, *Euphilomedes producta*.

5.3 Species Distribution and Occurrence

The distribution and occurrence information presented below for the proposed HCP species is based upon documented information cited in available literature and/or personal communication with biologists/experts from local, state, and federal agencies. As stated in previous sections, most of the fish distribution data are based upon video and trawl data and are dependent upon time of year, depth, and location sampled. Many pelagic fish are rarely documented in trawl surveys as the sampling method favors capturing semi-demersal or demersal fish. The absence of pelagic and other species from trawl and video data does not preclude those species from inhabiting waters in the Vashon Island Area. The majority of data for marine birds are based upon seasonal aerial and land surveys and are dependent upon favorable sighting conditions, time of year surveyed, species wariness, and location surveyed.

5.3.1 Marine Mammals and Birds

Orca -- *Orcinus orca*

Resident Orcas, including the J and K pods, have been sighted off Vashon Island in fall. The whales follow seasonal salmon runs with yearly sightings clustered from June through October (Balcomb 1982; Olesiuk et al. 1990,). In recent years, the J pod has been observed in the Vashon Island Area during the fall months (K. Koski, Whale Museum, pers. comm.). Transient whales are not known to occur in inland Puget Sound waters (Forney et al. 2000).

Harbor Porpoise -- *Phocoena phocoena*

There have been no confirmed sightings of harbor porpoises south of Admiralty Inlet (including the Vashon Island Area) during the last several years (Calambokidis et al. 1992; B. Hanson, NMML, pers. comm.). Harbor porpoises are not likely to be found in the Vashon Island Area.

Steller Sea Lion -- *Eumetopias jubatus*

Small numbers of Steller sea lions have been documented in the inland waters of Puget Sound. There are no documented occurrences of Steller sea lions in the

Vashon Island Area; however, there have been sightings south of the area and it is likely the sea lions travel through Vashon Island Area waters (Jeffries et al. 2000). In addition, Steller sea lions are known to use navigational buoys in central Puget Sound as haulout sites. There is a navigational buoy off Three Tree Point that California sea lions are known to use for a haulout site and it is possible that Steller sea lions use this buoy as well (Jeffries et al. 2000).

Common Murre -- *Uria aalge*

WDFW (2000) found that from 1992 through 1999 the number of common murres in the Vashon Island Area in the winter ranged from 0 to 5 animals/km^2 (Figure 3-8). In the summer months, the average number of common murres also ranged from 0 to 5 animals/km^2, with common murres only found in the Tramp Harbor area (Figure 3-9). During the 1999 and 2000 annual CBC surveys on Vashon Island, a total of 4 and 41 common murres were seen, respectively (S. Trevathan, Vashon Island CBC Coordinator, pers. comm.).

Marbled Murrelet -- *Brachyramphus marmoratus*

WDFW (2000) observed no marbled murrelets in the Vashon Island Area during winter and summer surveys from 1992 through 1999 (Figures 3-10 and 3-11). During the 1999 annual CBC survey on Vashon Island, one marbled murrelet was seen and none were seen in 2000 (S. Trevathan, Vashon Island CBC Coordinator, pers. comm.).

Harlequin Duck -- *Histrionicus histrionicus*

WDFW (2000) found that from 1992 through 1999, the number of harlequin ducks in the Vashon Island Area in the winter ranged from 0 to 5 animals/km^2 with sightings along the eastern shoreline of the Vashon Island Area and none around Vashon Island (Figure 3-12). In the summer months, no harlequin ducks were observed in the Vashon Island Area (Figure 3-13). A total of 8 harlequins were seen in 2000 during the Vashon Island CBC survey but none were seen in 1999 (S. Trevathan, Vashon Island CBC Coordinator, pers. comm.).

5.3.2 Salmonids

Bull Trout -- *Salvelinus confluentus*

The distribution and abundance of bull trout in Puget Sound and nearshore waters are not well known and populations of bull trout have not been documented in the Vashon Island Area. However, there have been isolated observations of bull trout in some of the rivers and streams surrounding the Vashon Island Area and it is possible bull trout travel through the waters in this area (King County 2000a). Miller and Borton (1980) documented a single occurrence of Dolly Varden in the central basin off Three Tree Point (see Figure B-12, Appendix B). As Dolly Varden are closely related to bull trout and it is difficult to distinguish the two species without genetic testing, it is possible that this fish was a bull trout.

Chinook Salmon -- *Oncorhynchus tshawytscha*

Comprehensive site-specific studies in the Vashon Island Area for juvenile chinook abundance and residence time have not been conducted. Beach seining surveys were conducted by King County in the eastern portion of the Vashon Island Area at Seahurst from June to August in 2000. Juvenile wild and hatchery chinook (less than twenty-five) were observed in all three months (Mavros and Brennan, in prep.).

Miller and Borton (1980) reported chinook salmon throughout Colvos Passage and a single occurrence near Seahurst, but abundance data were not reported (see Figure B-9, Appendix B).

WDFW (1993) did not document populations of chinook within the Vashon Island Area. However, rivers and streams surrounding the area support populations of chinook, some of which were listed as healthy with consistent returns. It is likely that the migratory pathway of these populations bring adult chinook to the waters of the Vashon Island Area (WDFW 1993b).

Chum Salmon -- *Oncorhynchus keta*

There have been no comprehensive site-specific studies in the Vashon Island Area for juvenile chum abundance and residence time. Beach seining surveys conducted by King County in the Vashon Island Area at Seahurst from June to August 2000 found small numbers of chum salmon (less than 10) only in June (Mavros and Brennan, in prep.).

Distribution data for Puget Sound fishes through 1973 showed observations of chum salmon within the Vashon Island Area (Miller and Borton 1980). Most occurrences within this area were in Colvos Passage (see Figure B-6, Appendix B). Although WDFW (1993) did not document populations of chum salmon in streams or rivers within the Vashon Island Area, the migratory pathway of chum salmon in waters to the north and south of the Vashon Island Area likely bring adult chum to the Vashon Island Area (WDFW 1993b).

Coho Salmon -- *Oncorhynchus kisutch*

There have been no comprehensive site-specific studies in the Vashon Island Area for juvenile coho abundance and residence time. Beach seining surveys conducted by King County in the Vashon Island Area at Seahurst from June to August 2000 found small numbers of coho salmon (less than five) in June and July but none in August (Mavros and Brennan, in prep.).

Although specific abundance data were not available, coho salmon were found throughout the entire Vashon Island Area in data compiled up to 1973 (Miller and Borton 1980) (see Figure B-7, Appendix B). Although WDFW (1993) did not list populations of coho within the Vashon Island Area, the presence of coho salmon in the rivers and streams surrounding the area will likely bring these fish within the waters of the Vashon Island Area (Miller and Borton 1980; WDFW 1993b).

Cutthroat trout -- *Oncorhynchus clarki*

Data on distribution of cutthroat trout compiled through 1973 (Miller and Borton 1980) revealed a cluster of cutthroat trout observations on the west side of northern Vashon Island (eastern Colvos Passage) (see Figure B-10, Appendix B). Other sections of the Vashon Island Area did not show the presence of cutthroat trout. Little information on distribution of cutthroat trout in the Vashon Island Area is available, but it is likely that cutthroat migrate through the waters in the area as there are known populations in rivers and streams in the south sound.

Sockeye salmon (*Oncorhynchus nerka*) and Steelhead Trout (*Oncorhynchus mykiss*)

There were no documented occurrences of either sockeye salmon or steelhead trout in the Vashon Island Area in data compiled through 1973 (Miller and Borton 1980) (see Figure B-8, Appendix B). No other information regarding sockeye and steelhead distribution in the Vashon Island Area was readily available.

5.3.3 Lamprey

Pacific Lamprey (*Entosphenus tridentatus*) and River Lamprey (*Lampetra ayresi*)

At this time there are no site-specific data for Pacific and River lampreys in the Vashon Island Area. However, these lampreys are known to exist in Washington waters, and therefore, may be present in the Vashon Island Area streams and marine waters (Hart 1980; Wydoski and Whitney 1979).

5.3.4 Invertebrates

Northern Abalone (*Haliotis kamtschatkana*) and Olympia Oyster (*Ostrea conchaphila*)

There were no documented occurrences of either the northern abalone or the Olympia oyster in the Vashon Island Area. As stated in Sections 3.0 and 4.0, the northern abalone is generally not found in estuaries and is primarily found on the outer coast and in the Straits (Sloan and Breen 1988). Although it is possible that isolated occurrences of Olympia oysters may be found in the Vashon Island Area, the numbers are not enough to sustain a breeding population as water temperatures in the this area are colder than spawning requirements (Couch and Hassler 1989) (see Section 3.3.4).

5.3.5 Marine Fish

Of the 24 species of marine fishes addressed in this report, seven were observed and identified in the Vashon Island Area by WDFW video and trawl surveys (Figure 5-8 and Appendix C). For both the video and trawl surveys, the coverage

in the Vashon Island Area was limited in Colvos Passage and in the northern and central portion of the area. Figure 5-9 identifies known forage fish spawning grounds in the Vashon Island Area (WDFW 1992).

Table 5-1 provides a summary of WDFW trawl and video data for the marine fish proposed for coverage in this report. Their distribution, primary habitat on which they were most often observed, the depth range at which they were observed, and their relative abundance within the Vashon Island Area are provided. As stated in Section 3.3.5, the fact that a species was not observed does not mean that it was not present. These species are mobile and many tend to hide in cracks and crevices. In addition, many have cryptic coloration making them difficult or impossible to see even when they are in the open. Seasonal variation in food resources, life history stages (e.g., spawning, juvenile recruitment), or environmental conditions can also affect the presence, distribution, and abundance of fish species.

Ground Fish

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

There were no documented records of green or white sturgeon in the Vashon Island Area, but Miller and Borton (1980) did report two records of green sturgeon occurrences somewhere within Puget Sound.

Pacific Cod -- *Gadus macrocephalus*

Miller and Borton (1980) reported Pacific cod along the west side of Vashon Island (see Figure B-15, Appendix B). WDFW trawl data indicated one occurrence in the main basin (Figure 5-9 and Appendix C).

Walleye Pollock -- *Theragra chalcogramma*

Miller and Borton (1980) reported observations of walleye pollock along the west side of Vashon Island (eastern portion of Colvos Passage) (see Figure B-17, Appendix B). WDFW found walleye pollock at three Vashon Island Area trawl stations (Figure 5-8 and Appendix C).

Pacific Hake -- *Merluccius productus*

Miller and Borton (1980) did not report observations of Pacific hake in the Vashon Island Area (see Figure B-16, Appendix B). However, WDFW found hake at all of their Vashon Island Area trawl stations (Figure 5-8 and Appendix C).

Lingcod -- *Ophiodon elongates*

No records of lingcod in the Vashon Island Area were found based on data reported in Miller and Borton (1980) and WDFW video and trawl surveys (Figure 5-8 and Appendix C).

Forage Fish

Pacific Herring -- *Clupea harengus pallasi*

Miller and Borton (1980) reported Pacific herring all along the west side of Vashon Island and in mid-channel off Three Tree Point (see Figure B-5, Appendix B). WDFW found herring off Dolphin Point (the northern portion of Vashon Island) during a trawl survey relatively close to shore (Figure 5-8 and Appendix C). Quinnell and Schmitt (1991) found Pacific herring most abundant in shallow water (9-37 m) and estimated an abundance of nearly 1.5 million individuals in the central Puget Sound area in 1987.

While there are no documented Pacific herring spawning grounds within the Vashon Island Area, spawning grounds are documented to the south (Quartermaster Harbor), west (Port Orchard/Madison), and north (Port Susan) (Lemberg et al. 1997). It is probable that Pacific herring of all ages pass through the Vashon Island Area on their way to or from the spawning grounds, especially during spawning season (late January through early June).

Sand Lance -- *Ammodytes hexapterus*

Miller and Borton (1980) reported sand lance near Three Tree Point (Figure B-18, Appendix B) (one of the documented spawning grounds in the Vashon Island Area (WDFW 1992). There are several sand lance spawning beaches in the eastern portion of the Vashon Island Area (Figure 5-10). Therefore, sand lance are seasonally abundant in the area during spawning season (November to February).

Beach seining surveys conducted by King County in the Vashon Island Area at Seahurst from June to August 2000 found sand lance (less than 100) in June and August but none in July (Mavros and Brennan, in prep.).

Surf Smelt -- *Hypomesus pretiosus*

Miller and Borton (1980) did not report surf smelt in the Vashon Island Area (see Figure B-13, Appendix B), although there are several surf smelt spawning beaches in the Vashon Island Area (Figure 5-9). Spawning grounds are located on the eastern side of Vashon Island and also along the shoreline of the eastern portion of the area (WDFW 1992). Surf smelt are abundant in the area during spawning season (mostly in the fall and winter).

Eulachon -- *Thaleichthys pacificus*

No specific records of eulachon in the Vashon Island Area were found. This is considered a rare species in Puget Sound (Emmett et al. 1991).

Rockfish

The following rockfish species proposed for coverage in the HCP are distributed along the outer Washington coasts and in the Straits surrounding the San Juan Islands but are not known to occur in inland Puget Sound waters or in the Vashon

Island Area: blue, widow, china, and tiger rockfish (W. Palsson, WDFW, pers. comm.; J. Christiansen, Seattle Aquarium, pers. comm.).

Although the following rockfish species have been documented in other parts of the Sound, there were no readily available reports of these species in the Vashon Island Area: greenstriped, yellowtail, black, bocaccio, canary, redstripe, and yelloweye rockfish.

Brown Rockfish -- *Sebastes auriculatus*

Miller and Borton (1980) reported an observation of a brown rockfish north of Three Tree Point (see Figure B-19, Appendix B). WDFW video surveys documented brown rockfish at two sampling stations in shallow waters (less than 19 m) north of Seahurst (Figure 5-8 and Appendix C).

Copper Rockfish -- *Sebastes caurinus*

Miller and Borton (1980) reported observations of copper rockfish along the mainland throughout the Vashon Island Area (see Figure B-20, Appendix B). WDFW video surveys documented copper rockfish at two sampling stations in shallow waters (less than 19 m) north of Seahurst (Figure 5-8 and Appendix C).

Quillback Rockfish -- *Sebastes maliger*

Miller and Borton (1980) reported quillback rockfish along the eastern side of Colvos Passage (see Figure B-24, Appendix B). WDFW documented quillback rockfish at most stations sampled (both video and trawl surveys) (Figure 5-8 and Appendix C).

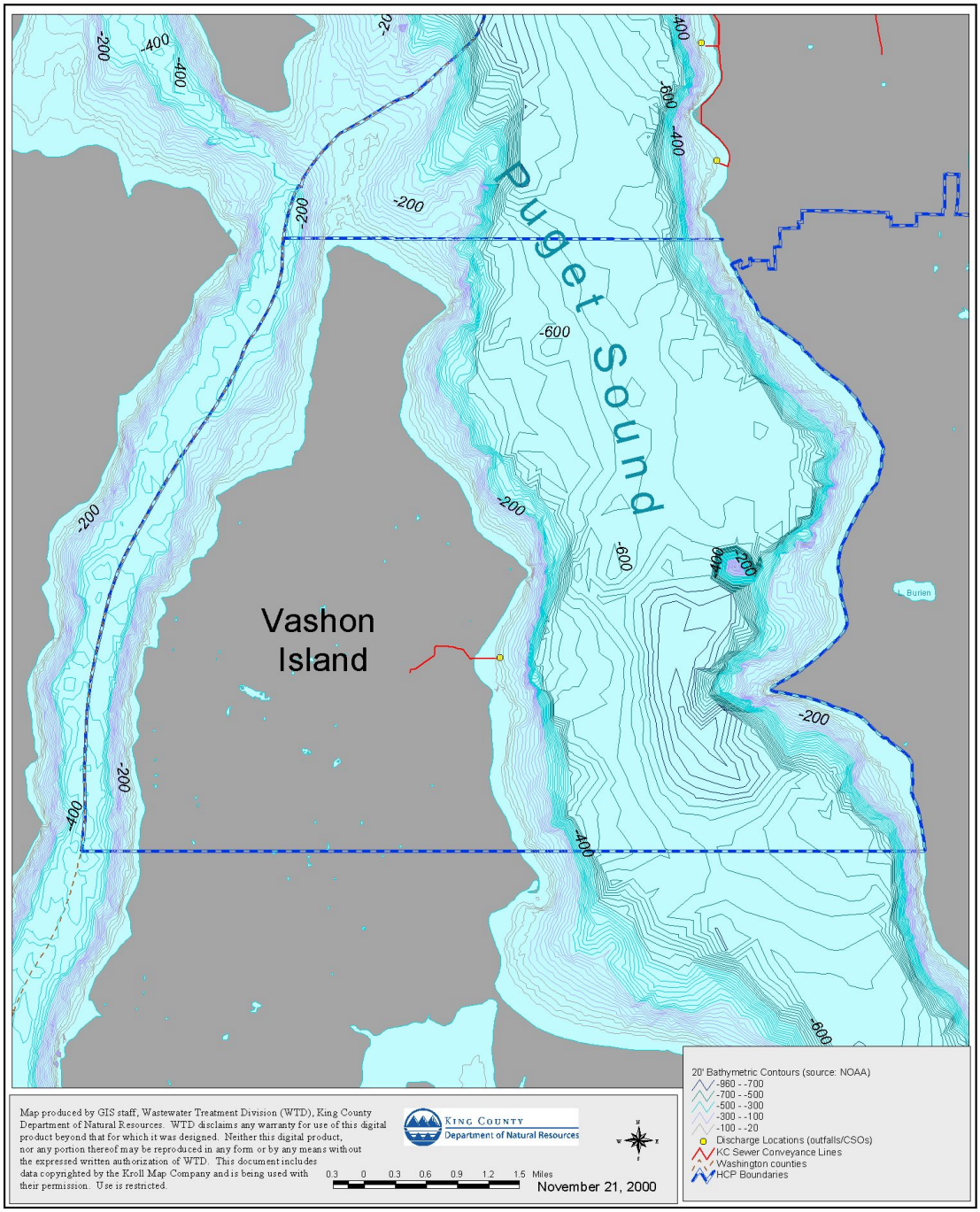

Figure 5-1. Bathymetric contours in the Vashon Island Area

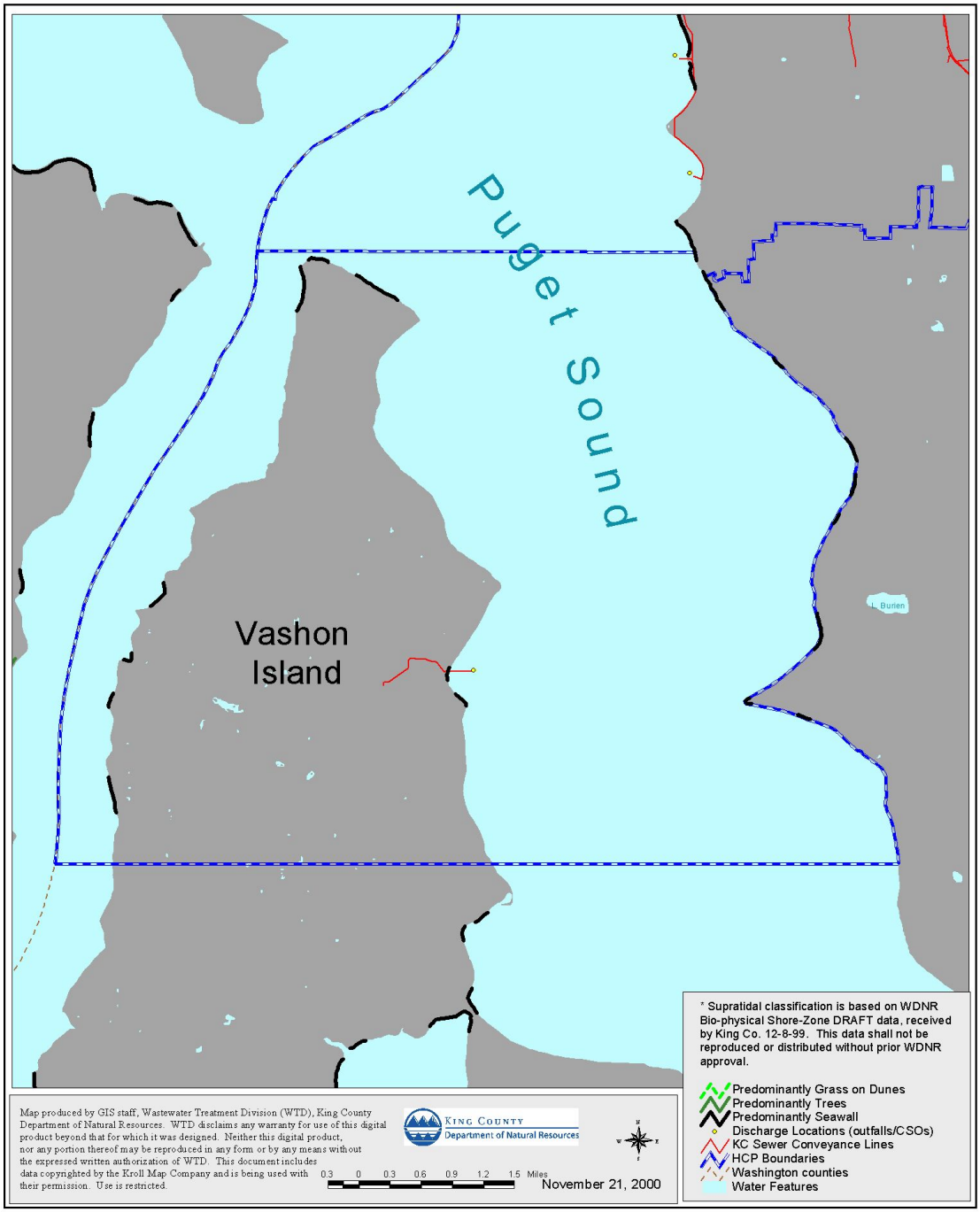

Figure 5-2. Supralittoral zone in the Vashon Island Area

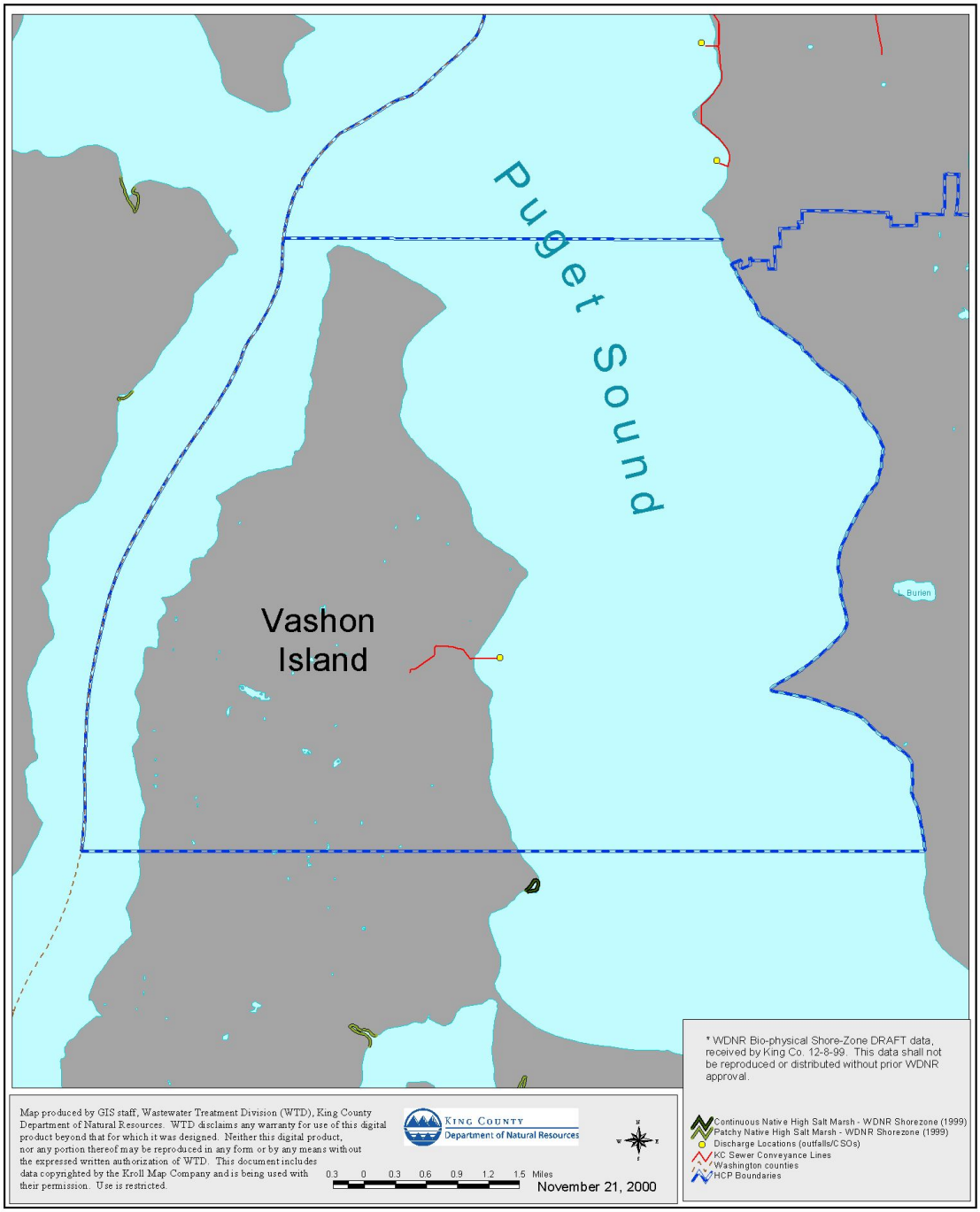

Figure 5-3. Distribution of native salt marsh in the supralittoral zone through the shallow subtidal zone of the Vashon Island Area

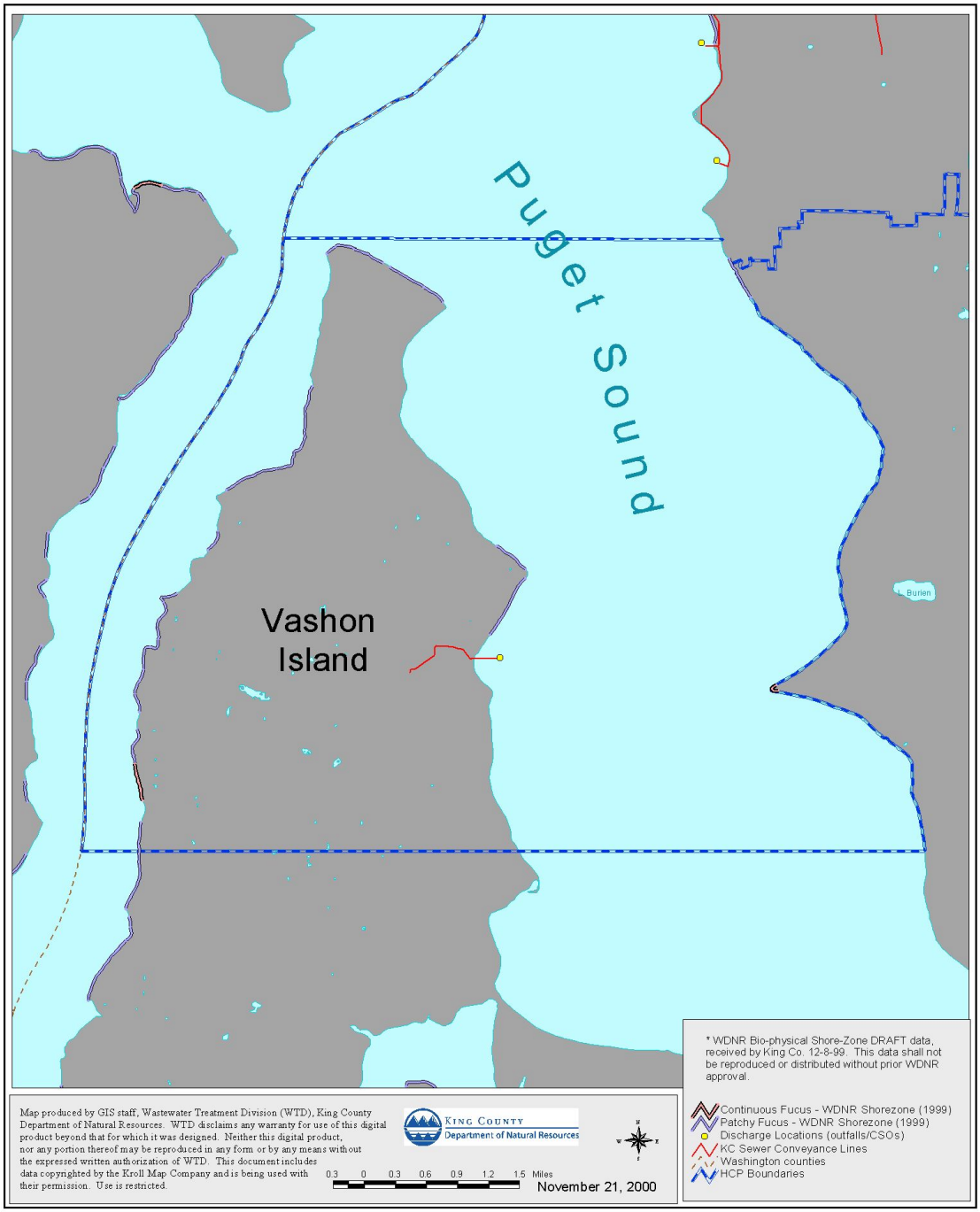

Figure 5-4. Distributions of rockweed (*Fucus*) in intertidal zone of the Vashon Island Area

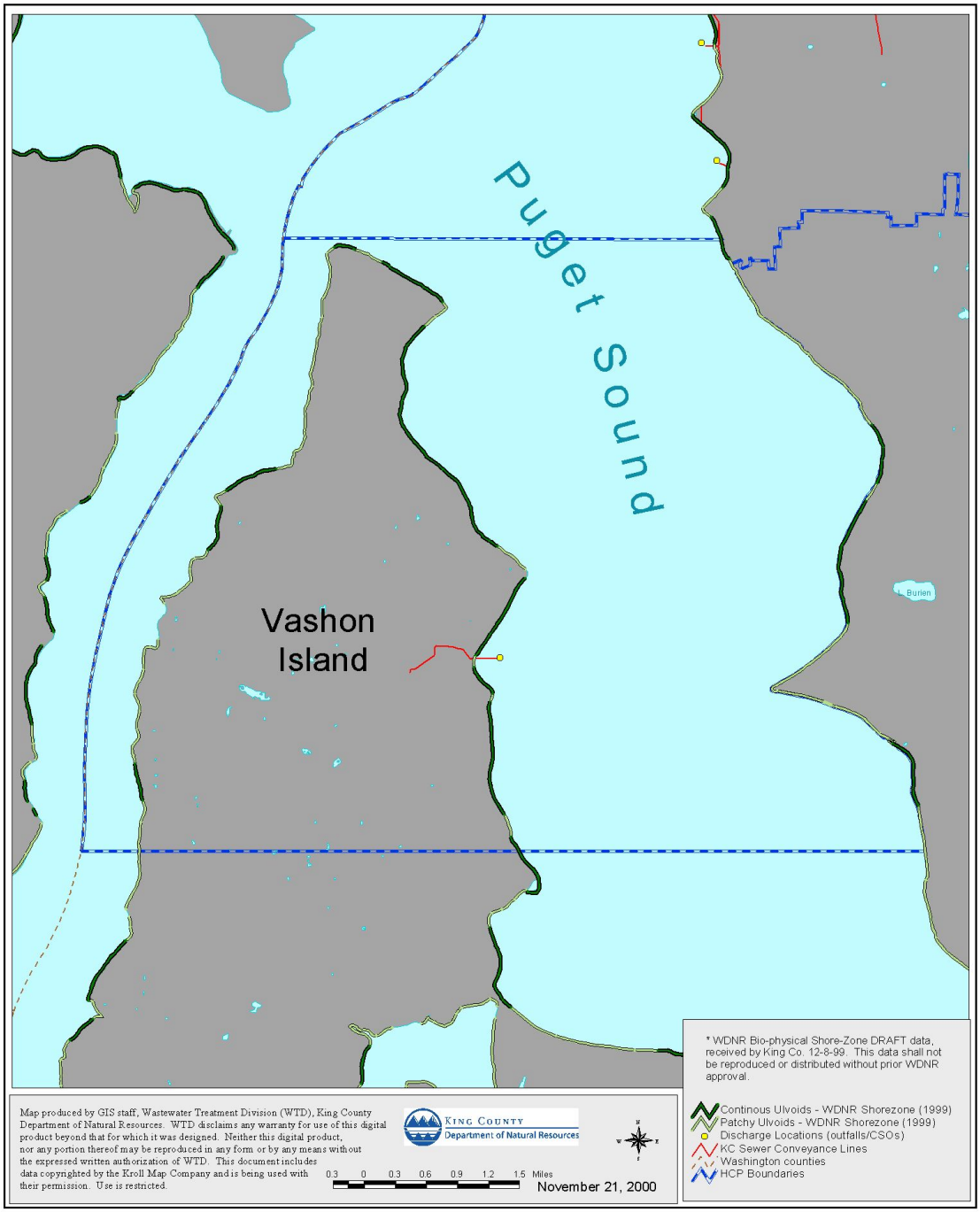

Figure 5-5. Distributions of Ulvoids in the intertidal zone through the shallow subtidal zone of the Vashon Island Area

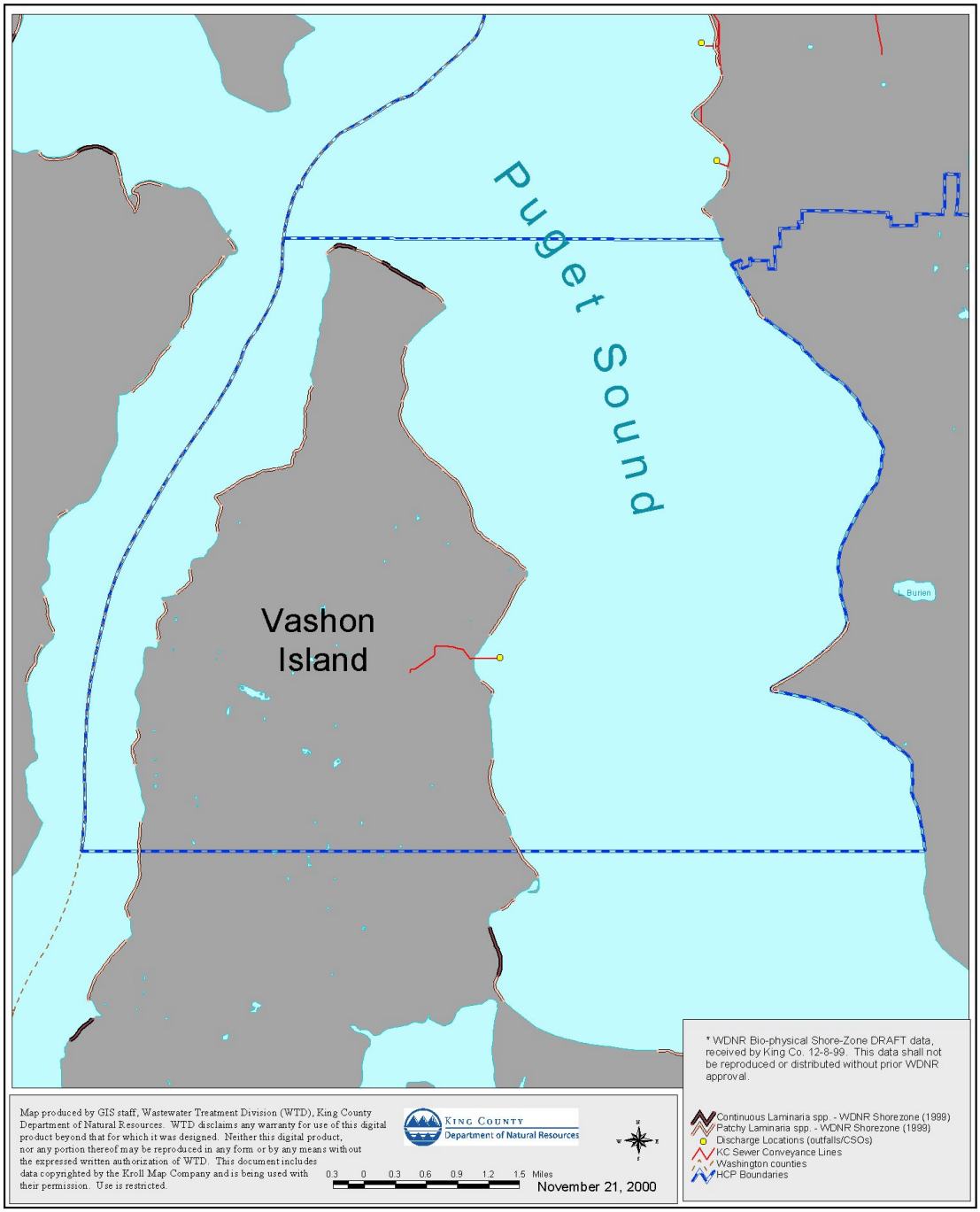

Figure 5-6. Distributions of *Laminaria* spp. in the intertidal zone through the shallow subtidal zone of the Vashon Island Area

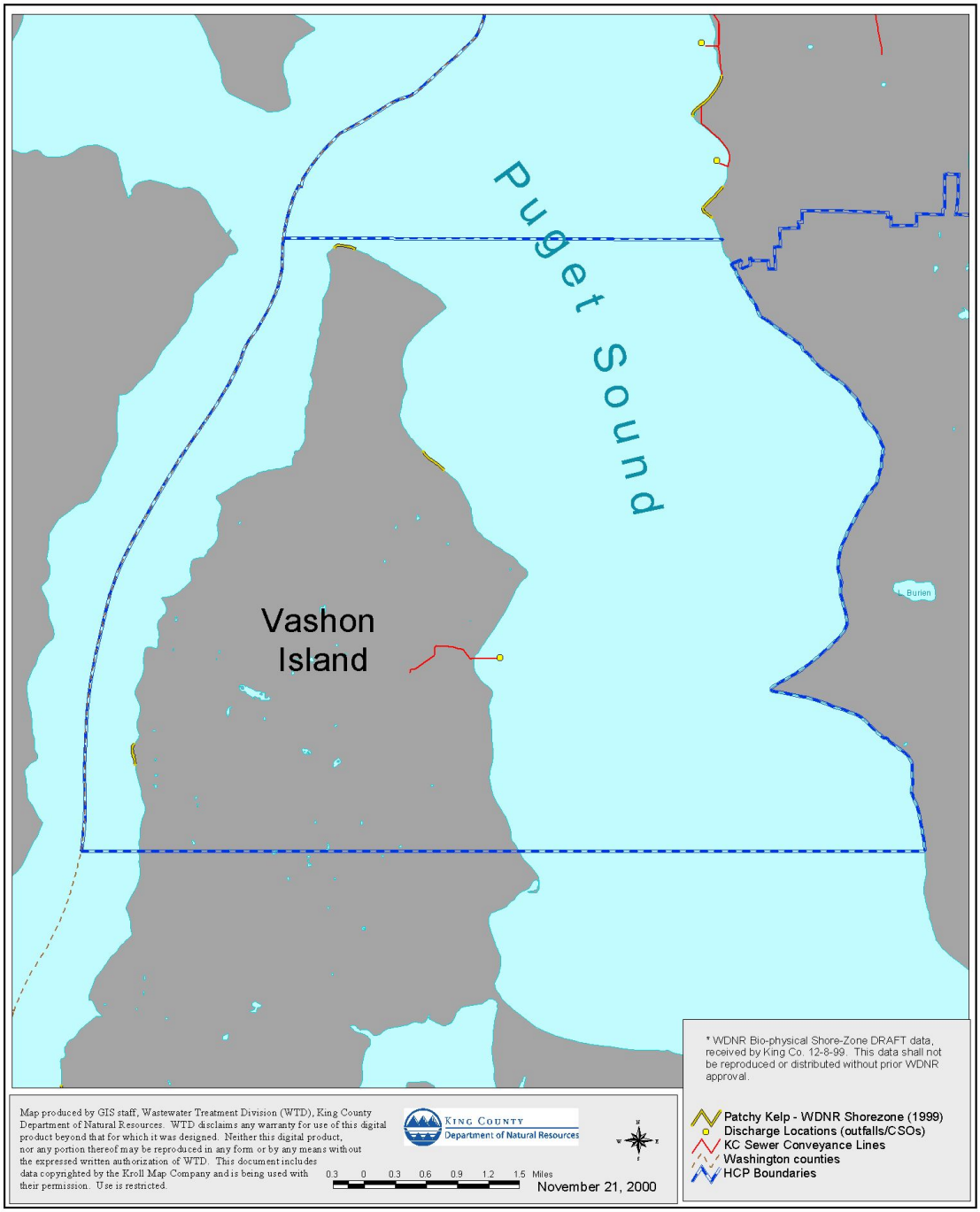

Figure 5-7. Distributions of kelp (*Nereocystis luetkeana)* in the intertidal zone through the shallow subtidal zone of the Vashon Island Area

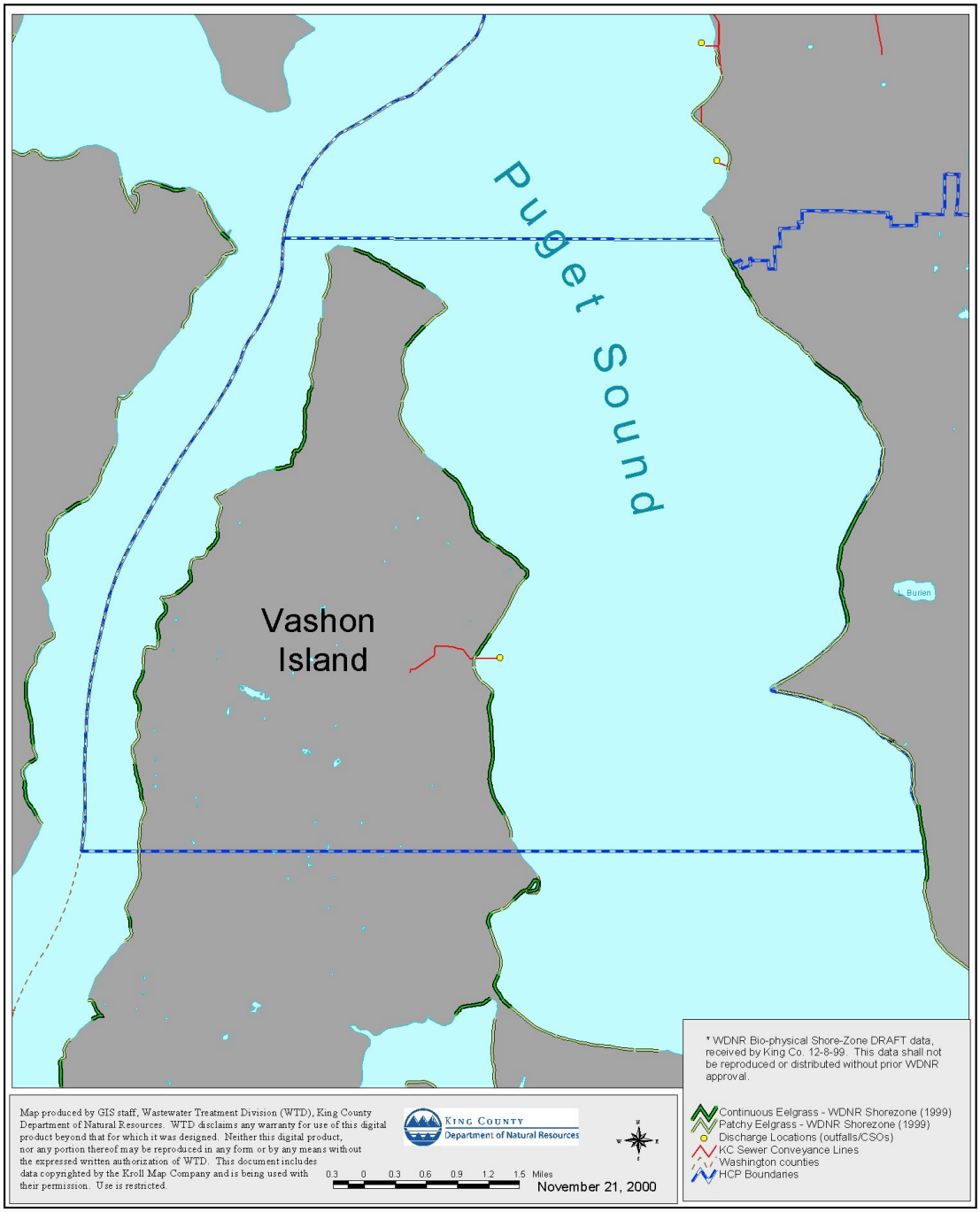

Figure 5-8. Distributions of eelgrass (*Zostera marina*) in the intertidal zone through the shallow subtidal zone of the Vashon Island Area

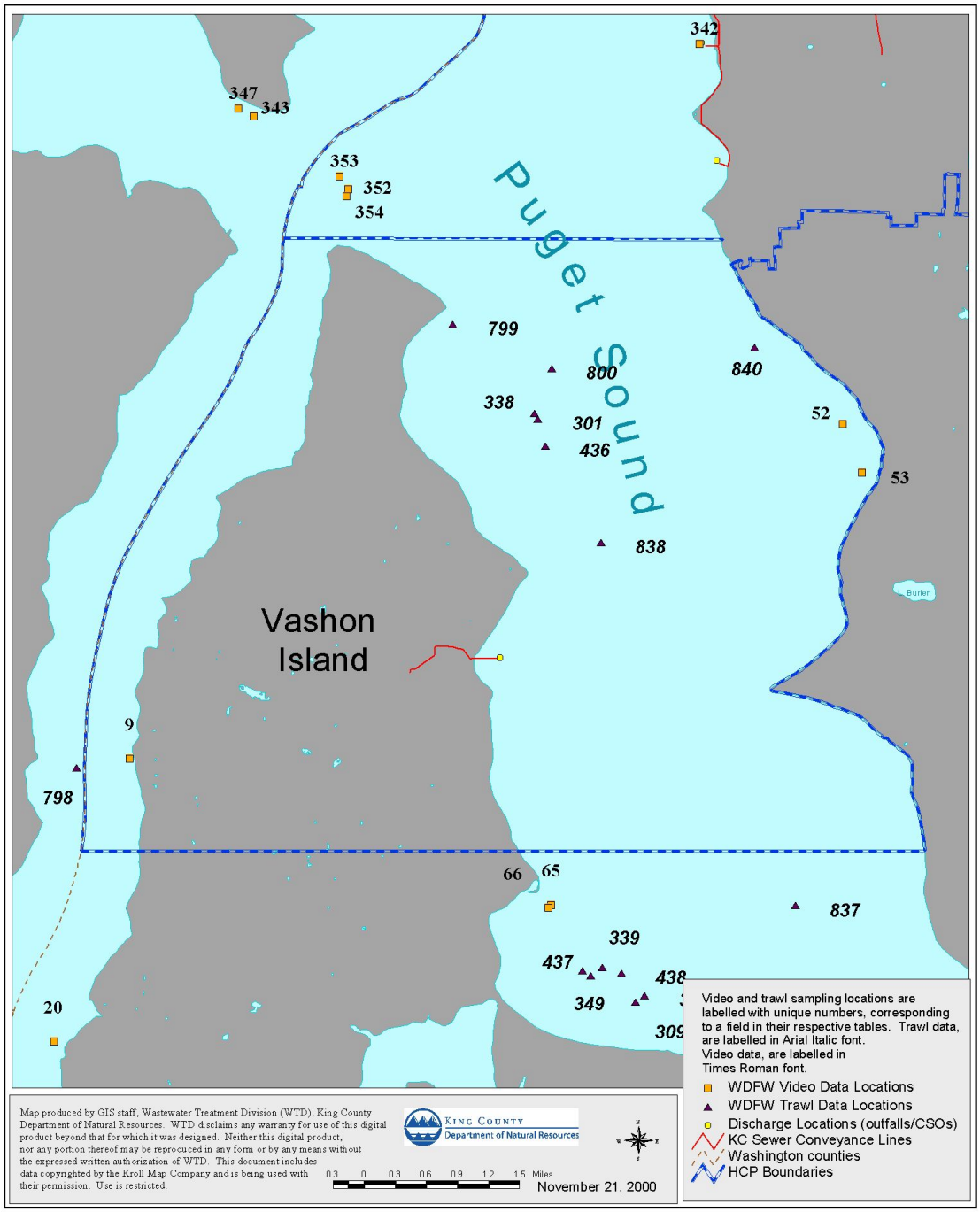

Figure 5-9. WDFW trawl and video marine fish data in the Vashon Island Area. See Appendix C for fish species noted at each location.

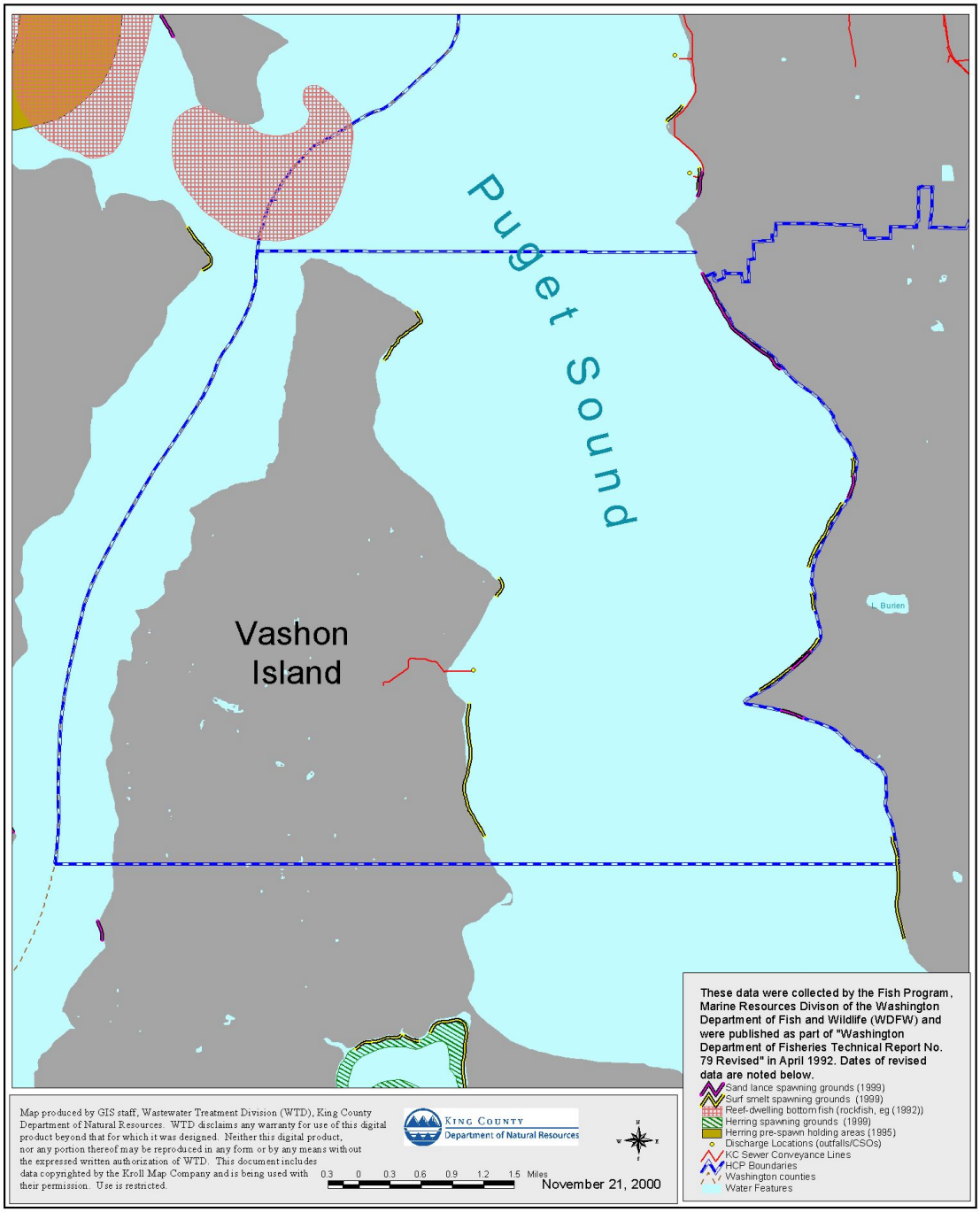

Figure 5-10. Forage fish spawning and holding areas and bottom fish/reef-dwelling habitats in the Vashon Island Area

Table 5-1. Marine fish species observed in the Vashon Island Area.[1]

Common Name	Genus species	Distribution	Primary habitat	Depth range (ft)	Average density (ind/m^2)	Relative abundance[2]
Green Sturgeon	*Acipenser medirostris*	none observed	NA	NA	NA	NA
White Sturgeon	*Acipenser transmontanus*	none observed	NA	NA	NA	NA
Pacific Cod (S & C P.S.)	*Gadus macrocephalus*	Between Dolphin Pt and Pt Beals, offshore from Sunset Beach	NA	>360	0.0008[a]	2
Walleye Pollock (S. P.S.)	*Theragra chalcogramma*	Dolphin Pt, between Dolphin Pt & Pt Beals, Pt Beals, offshore from Sunset Beach	NA	126->360	0.0003[a]	4
Pacific Hake (C P.S.)	*Merluccius productus*	Dolphin Pt, between Dolphin Pt & Pt Beals, Pt Beals, offshore from Sunset Beach, S of Brace Pt	NA	>126	0.0012[a]	8
Lingcod	*Ophiodon elongatus*	none observed	NA	NA	NA	NA
Pacific Herring	*Clupea harengus pallasi*	Dolphin Pt	NA	126-240	0.0002[a]	1
Sand Lance	*Ammodytes hexapterus*	Spawning grounds (1 Nov to 15 Feb): S of Pt Brace, between Pt Brace & Three Tree Pt, N & S sides of Three Tree Pt	sand gravel beaches for spawning	upper inter-tidal		none observed during surveys, probably abundant during spawning
Unidentified Baitfish	*Herring or Sand Lance*	none observed	NA	NA	NA	NA
Surf Smelt	*Hypomesus pretiosus*	Spawning grounds (mostly fall and winter in this area): between Brace Pt & Three Tree Pt, N side of Three Tree Pt, S of Three Tree Point, Dophin Pt, Pt Beals, S of Pt Beals	very coarse sand to pea gravel beaches for spawning	upper inter-tidal		none observed during surveys, probably abundant during spawning

Table 5-1. Marine fish species observed in the Vashon Island Area.[1]

Common Name	Genus species	Distribution	Primary habitat	Depth range (ft)	Average density (ind/m^2)	Relative abundance[2]
Eulachon	*Thaleichthys pacificus*	none observed	NA	NA	NA	NA
Brown Rockfish	*Sebastes auriculatus*	N of Three Tree Pt	sand/shell	48	0.05[b]	2
Copper Rockfish	*Sebastes caurinus*	N of Three Tree Point, near Sunset Beach	sand/shell	44	0.137[b]	3
Greenstriped Rockfish	*Sebastes elongatus*	none observed	NA	NA	NA	NA
Widow Rockfish	*Sebastes entomelus*	none observed	NA	NA	NA	NA
Yellowtail Rockfish	*Sebastes flavidus*	none observed	NA	NA	NA	NA
Quillback Rockfish	*Sebastes maliger*	Dolphin Pt, between Dolphin Pt & Pt Beals, Pt Beals, offshore from Sunset Beach, N of Three Tree Point	sand/shell	79	0.0224[a]	7
Black Rockfish	*Sebastes melanops*	none observed	NA	NA	NA	NA
Blue Rockfish	*Sebastes mystinus*	none observed	NA	NA	NA	NA
China Rockfish	*Sebastes nebulosus*	none observed	NA	NA	NA	NA
Tiger Rockfish	*Sebastes nigrocinctus*	none observed	NA	NA	NA	NA
Bocaccio	*Sebastes paucispinus*	none observed	NA	NA	NA	NA
Canary Rockfish	*Sebastes pinniger*	none observed	NA	NA	NA	NA
Redstripe Rockfish	*Sebastes proriger*	none observed	NA	NA	NA	NA
Yelloweye Rockfish	*Sebastes ruberrimus*	none observed	NA	NA	NA	NA
Unidentified Rockfish	*Sebastes spp.*	none observed	NA	NA	NA	NA

NA - Not Available

[1]Based on data from Tech Report 79, Battelle, and WDFW.

[2]Relative abundance indicates the number of times a given species was observed during the surveys.

[a]Based on WDFW trawl surveys (Palsson data).

[b]Based on WDFW video surveys (Palsson data).

6.0 Summary

The distribution of habitats and HCP species in King and southern Snohomish County that have been proposed for coverage under Section 10 of the Endangered Species Act have been documented in this report. The report artificially divides the region from Mukilteo to the middle of Vashon Island into three areas: Brightwater Outfall Siting Area, WTD Existing Discharges Area, and Vashon Island Area (see Figure 1-1). These areas are based on the potential location of the new wastewater treatment facility outfall in Puget Sound and the presence of existing wastewater treatment division outfalls and discharges.

Marine organisms, be they mammals, birds, fish, or invertebrates, make no distinction among the three areas. Most of the species proposed for coverage are mobile and some may use the three areas for feeding, resting, spawning, access to spawning grounds, or access to feeding grounds. The three habitats types discussed in this report, including the supralittoral, intertidal and shallow subtidal, and deep subtidal, provide feeding and spawning areas for many of the species under consideration for the HCP. Each of these habitats, in one way or another supports the food webs that sustain the majority of the 41 species discussed in this report. These habitats represent natural gradations in the marine environment, each containing its own dominant species and structural and functional characteristics.

The following discussion synthesizes and summarizes existing data for the habitat types found in all three MHR study areas. Habitat usage and the distribution of the HCP species in the three study areas are also summarized. Available information for several species, including the harbor porpoise, northern abalone, Olympia oyster, eulachon, widow rockfish, blue rockfish, china rockfish, tiger rockfish, and canary rockfish, indicates that these species are either not found at all in the three study areas or occur so rarely that their distribution is unknown. As a result of this lack of information, these species are not discussed in this section of the report.

6.1 Supralittoral (>+3Meters)

The supralittoral zone, often referred to as the marine “riparian” zone, includes trees, shrubs, and dune grasses which serve to protect the upland property from erosion and to provide shade to the upper intertidal zone. The presence of the vegetation moderates temperatures and provides habitat for insects that are fed upon by juvenile salmonids. Many of the shorelines in the study area have not been extensively studied; however, aerial surveys have been conducted by WDOE and WDNR (WDNR 1999). Although these surveys do not provide detailed information, they do show that vegetation along undisturbed shorelines often consists of trees such as Douglas fir and alder. WDNR data (WDNR 1999)

indicate that the supralittoral zone in the Brightwater Outfall Siting Area is predominantly bordered by seawall (mostly in the form of railroad grade and riprap) with some overhanging vegetation occurring in some of the areas. There are some beach areas in the Brightwater Outfall Siting Area, such as around stream mouths (Picnic Point Creek, Lunds Gulch, Boeing Creek and Piper's Creek). WDNR data show that the supralittoral zone in the WTD Existing Discharges Area is bordered by seawall to a far greater extent than in the Brightwater Outfall Siting Area. There is a minor amount of armoring and treed shoreline near West Point, and the supralittoral zone from West Point to Magnolia consists of very high bluffs. The armoring is far greater in inner Elliott Bay where no natural shoreline currently exists. There are areas of overhanging vegetation in some of the areas bordered by seawalls from Alki Point to the southern edge of the WTD Existing Discharges Area. As compared to the Brightwater and WTD Existing Discharges Areas, the Vashon Island Area contains much less armored shoreline, with the majority of armoring occurring in the Seahurst region. Much of the eastern shoreline of Vashon Island is unmodified, and consists of areas with overhanging trees on low to moderately high bluffs.

The supralittoral zone is important to many of the HCP species as it can provide resting habitat or be a source of food and detrital material into the nearshore environment. The supralittoral zone is seldom used by the marine mammals and birds listed in this report except as possible haul out areas by sea lions (jetties) and resting areas for harlequin ducks. Steller sea lions are known to haul out on jetties in the supralittoral zone and a Steller sea lion has been seen on the Shilshole Marina jetty in the WTD Existing Discharges Area. The importance of the supralittoral zone to juvenile salmonids is becoming more apparent as the database on their habits increase. Juveniles of all species migrate past these areas at extreme high tides, feeding on insects and their larvae (see Appendix A). Although none of the groundfish or rockfish species proposed for coverage have been documented to utilize the supralittoral zone for spawning or feeding, two species of forage fish (sand lance and surf smelt) use habitat greater than +3 MLLW as spawning grounds. There are documented sand lance and surf smelt spawning grounds in all three-study areas (WDFW 1992).

6.2 Intertidal – Shallow Subtidal (-30 to +3 Meters)

The intertidal-shallow subtidal habitats within the study area consist largely of soft substrate with some areas of rocky substrate. The zone extends from the highest reaches of the intertidal zone down to the maximum depth at which macroscopic benthic plants are found (photic zone). The upper elevations on rocky shorelines generally contains rock weed (*Fucus distichus*), which is a stable component of rocky shore habitats and is known to harbor numerous species of gammarid and caprellid amphipods, small crabs and gastropods.

Fucus sp. is common but patchy throughout the Brightwater and WTD Existing Discharges Areas, and along the eastside of East Passage in the Vashon Island Area. It is also common along the western shoreline of Vashon Island along Colvos Passage, but uncommon on the eastern shoreline where the predominant substrate type is sand.

Mid and lower intertidal areas are characterized by sea lettuce (*Ulva* spp.), and the brown algae *Laminaria* spp. The shallow subtidal zone in rocky areas also contains *Laminaria* spp. as well as kelp forests (*Nereocystis luetkeana*). Kelp forests are often sites of congregation of adult and juvenile fishes, especially rockfish. *Ulva* spp. is found almost continuously from the north end of the Brightwater Outfall Siting Area to the south end of the Vashon Island Area. It is found in rocky habitats as well as in areas with sand or a combination of sand, gravel and cobble. *Laminaria* spp., on the other hand, is present but rare in the Brightwater Outfall Siting Area but common with a patchy distribution in the low intertidal-shallow subtidal zones in the WTD Existing Discharges and Vashon Island Areas (see Laminaria Figures 3-5, 4-5, 5-6). Eelgrass (*Zostera marina*), which forms meadows in the low intertidal and shallow subtidal zone in the region, is common but patchy in the intertidal zone of the Brightwater Outfall Siting Area and moderate to dense in the shallow subtidal zone. In the WTD Existing Discharges Area the intertidal eelgrass is common but patchy. Eelgrass is common in the Vashon Island Area with patchy meadows on the west, north and east sides of the area. Together, the eelgrass meadows and tidal flats form an extremely important feeding and rearing habitat for juvenile salmon. Eelgrass meadows harbor large number of fish species and often contain juvenile Dungeness crab and salmonids in very high numbers (Simenstad et al. 1991).

While whales and porpoises do not use the intertidal zone, seals and sea lions are known to use haul out areas in the intertidal zone. However, there were no documented occurrences of Steller sea lions using the intertidal zone in any of the three areas. Orcas may use the shallow subtidal zone for feeding and as a pathway to other feeding areas. Orcas have been sighted in all three study areas, particularly in the fall months when salmon are returning to their natal streams (K. Koski, Whale Museum, pers. comm.). Steller sea lions may use the shallow subtidal zone in all three areas for feeding on small schooling fishes and Pacific hake and as a migratory pathway (Gearin et al. 1999). In addition, Steller sea lions have been known to use a navigational buoy anchored in the shallow subtidal zone in the WTD Existing Discharges Area as a haul out site (M. Lance, WDFW, pers. comm.).

All three marine birds proposed for coverage in this report have been seen in low and varying numbers all along the shoreline in the study area. While all three species may be found feeding in intertidal and shallow subtidal habitats, harlequin ducks are the most likely to be seen in intertidal areas (Robertson and Goudie 1999). All three species of birds feed to some extent on small fishes, molluscs, crabs, and other crustaceans, which can be found in kelp beds and eelgrass meadows.

The importance of the intertidal-shallow subtidal zone to juvenile and adult salmonids cannot be overstated. Juveniles of all species migrate through, feed in, and use these areas for shelter. At high tide, gammarid amphipods, harpacticoid copepods, and some epibenthic zooplankton emerge from the shelter of rockweed, *Fucus* sp., and *Laminaria* spp. beds to be fed upon by juvenile chinook and chum salmon and cutthroat trout (see Appendix A). Coho salmon are less reliant than other salmonid species on benthic and epibenthic organisms for food because they tend to feed upon planktonic crustaceans and larger coho feed upon bait and forage fish (see Appendix A). Juvenile bull trout, sockeye salmon, and steelhead trout may also feed in these areas as well as using eelgrass meadows, *Laminaria* spp., and kelp beds as refuges. Juvenile chinook, chum, and coho salmon have been noted in the intertidal-shallow subtidal zone for all three areas. Juvenile steelhead trout have been found in the intertidal-shallow subtidal zone in the Brightwater Outfall Siting Area and the WTD Existing Discharges Area and juvenile cutthroat trout and sockeye salmon have been found in the WTD Existing Discharges Area (Mavros and Brennan, in prep.). However, the lack of juvenile salmonids in certain portions of the study area does not preclude these species from inhabiting these areas, but is a reflection of limited surveys and information. Adults of all salmonid species may feed in the kelp beds and eelgrass meadows due to the wide variety of prey items found in these areas. Adults are opportunistic feeders and prey on similar food items, such as small schooling fishes, Pacific hake, and scorpaenids (Emmett et al. 1991). Adults of all salmonid species, with the exception of bull trout and sockeye salmon, are known or are likely to use this zone in all three study areas. Sockeye salmon are known to use waters in the Brightwater Outfall Siting Area and the WTD Existing Discharges Area, but have not been documented in the Vashon Island Area. Bull trout have been documented in the WTD Existing Discharges Area but information in the other two areas is lacking.

The two lamprey species (Pacific and river) are known to inhabit the waters of Puget Sound but little information is known about their abundance and distribution. The river and stream habitats in the region contain suitable areas for both species, and it is likely that they pass through the intertidal-shallow subtidal zone as they migrate to Puget Sound. Their distribution within the study area is unknown.

There has been no confirmed sighting of either green or white sturgeon in Puget Sound since the 1970s. Miller and Borton (1980) reported two green and two white sturgeons in Puget Sound, however the locations of these sightings were not reported. Their life history indicates that they spawn and breed in the large rivers of the Oregon and Washington coast (mainly the Columbia River and tributaries) where they are commercially fished. Both juveniles and adults are benthic feeders, preying on worms, crustaceans, molluscs, and small fish (Emmett et al. 1991). Records indicate that these species typically feed in shallow subtidal waters at the mouths of large rivers. The absence of information on their distribution in Puget Sound does not indicate their absence, but a lack of concerted surveys to confirm or deny their presence.

Pacific cod have declined severely in the Puget Sound region since the 1980s. The northern Puget Sound population is considered to be depressed and the southern Puget Sound population is considered critical. Declining populations may be the result of fishing pressures and long-term cycles in Puget Sound water temperatures (Palsson et al. 1997). This species is found throughout the MHR study area, and uses the shallow subtidal zone for spawning, rearing, and feeding. Juveniles can be often found in eelgrass meadows where they feed on crabs, shrimp, snails, and small fish. Adults are demersal and usually found in the deep subtidal; however, they will migrate to shallow areas to feed. Adults feed on euphausids, shrimp, and both demersal and pelagic fish such as juvenile flatfish, sand lance, and Pacific herring (West 1997).

Walleye pollock were once the most common species caught recreationally in Puget Sound. In the 1980's, walleye pollock abundance declined sharply largely due to natural mortalities and fishing pressures (Schmitt et al. 1994). Pollock are present throughout Puget Sound (although they are more abundant in north and central Sound) and are found in all three study areas. Juveniles are semi-demersal and occupy inshore, shallow habitats in their first year of life. They settle in areas with eelgrass, gravel and cobble substrate. In their second year of life, juvenile pollock move to deeper subtidal waters, occupying mid-water and near-bottom habitat near sandy or muddy substrates (Schmitt et al. 1994).

The Pacific hake population in Puget Sound is considered to be at a critical level as its abundance has declined since the 1980s, likely due to over harvesting (Palsson et al. 1997). Pacific hake are a mid-water schooling species that undergoes northward feeding migrations to Washington and British Columbia in the summer, before return to southerly waters for winter spawning (West 1997). Juveniles may use nearshore and shallow subtidal areas for rearing before moving into deeper subtidal waters, although information on their distribution in nearshore areas is lacking. Adult hake are found in all three of the study areas but mainly in subtidal areas.

Lingcod populations have declined in recent years due mainly to over-harvesting by commercial and sport fisheries (Schmitt et al. 1994). Larvae and juveniles use nearshore intertidal and shallow subtidal habitats. Juveniles settle out in shallow water vegetated habitats, such as eelgrass and kelp beds (West 1997). Adults are demersal and are found in both shallow subtidal to deep subtidal rocky habitats. Adults feed on juvenile rockfish, cephalopods, gastropods, and crustaceans. Lingcod occur throughout Puget Sound and have been found in the Brightwater Outfall Siting Area and the WTD Existing Discharges Area (WDFW 2000). They have not been documented in the Vashon Island area although it is likely they also occur in this region.

Three of the four forage fish species proposed for coverage in the HCP have been documented in all three MHR areas: Pacific herring, sand lance and surf smelt. Pacific herring use the lower intertidal to shallow subtidal areas for spawning and rearing. Adults move from offshore waters to inshore holding areas prior to moving to spawning grounds (Lemberg et al. 1997). There are no documented

Pacific herring spawning grounds in any of the MHR study areas (spawning grounds have been documented in nearby Quartermaster Harbor, Port Orchard, and Port Susan); however, adult herring have been reported in all MHR areas at water depths ranging from 9 to 37 m (Quinnell and Schmitt 1991). Sand lance and surf smelt spawn in the intertidal zone at depths greater than +1.5 meters MLLW. Juveniles of both species rear in nearshore waters and adult surf smelt are pelagic and tend to stay in shallow subtidal habitats (Lemberg et al. 1997). There are documented sand lance and surf smelt spawning grounds in all three MHR areas (Bargmann 1998).

Fourteen species of rockfish have been proposed for coverage in the HCP. Very little is known about the early life history of most of these species because they are difficult to identify. Studies of the more common species (copper, quillback, and brown rockfish) indicate that shallow areas with eelgrass, kelp beds, and other vegetation on cobbles and boulders are utilized as nursery habitats. Upon reaching adult size, species such as brown, copper, yellowtail, quillback, black, redstripe, and yelloweye rockfish can be found in shallow subtidal as well as deep subtidal habitats. Adult greenstriped, black, and bocaccio rockfish are only found in deep subtidal habitats (Lamb and Edgell 1986). Brown, copper, and quillback rockfish have been documented in all three MHR areas (WDFW 2000). Yellowtail, black, redstripe, and yelloweye rockfish have been documented in the Brightwater Outfall Siting Area and the WTD Existing Discharges Area, but not in the Vashon Island Area. However, it is likely that these species occur in this area but have not been documented due to survey methods.

6.3 Deep Subtidal

The deep subtidal zone is the area in Puget Sound that lies below the level of light penetration and is characterized by narrow shelves and relatively steep slopes that flatten out into the deep central portions of the sound.

The shelf areas below the photic zone are in water depths ranging from 30 to 60 m. The narrow shelves consist primarily of medium to fine sand, intermixed with a small amount of gravel in shallow water, grading to silty sand with increasing water depth (EHI 1987, Tetra Tech 1990, Striplin et al. 1990, 1991,1993). Areas with rocky outcroppings can be found in the vicinity of points and headlands.

The slope depths (~60-150 m) are difficult to characterize because in many areas their steepness precludes the use of standard sampling equipment. This includes many locations in the MHR study area. In areas where surveys can be easily conducted (i.e., outer Elliott Bay), the sediments consist of sand with various amounts of silt, depending on the slope. In areas with fairly steep slopes, the sediments consist of silt, often overlying hard clay (Word et al. 1984a).

The slope of Puget Sound generally flattens out at water depths of 150 m. In these water depths the sediments consist of silt with clay. The exceptions to this general observation can be found at the bases of points (i.e., West, Alki, Three

Tree Points) where bottom currents are swift enough that fine silts do not settle (Word et al. 1984a, 1984b).

All three of these areas contain wide and varied communities of epifaunal and infaunal invertebrates as described in Sections 3.0 , 4.0 and 5.0. Many of these invertebrates, primarily polychaete worms and epifaunal ostracods, are prey items that may be used by the HCP species that feed on or near the sediment surface (cods, pollocks, and sturgeons). In other cases, these and other invertebrate species are two or three tiers lower in the food web than the HCP species and so do not have a direct connection. Some of the data necessary to make these connections can be found in Appendix A in the compilation of existing fish food web data (Cordell 2000). However, more information is needed before we can adequately answer how or if the species in deep subtidal benthic communities affect the food webs leading to the HCP proposed species of concern.

Marine mammals, Orcas and Steller sea lions utilize the deep subtidal in their search for prey and as a pathway to other feeding and/or resting areas. Orcas have been sighted in deep subtidal areas in all three study areas, particularly in the fall months (K. Koski, Whale Museum, pers. comm.). Steller sea lions may use the deep subtidal zone in all three areas for feeding or as a migratory pathway (Gearin et al. 1999).

Of the three marine birds proposed for coverage in the HCP, only the common murre dives regularly to deep subtidal depths in search of food (Ehrlich et al. 1998). There have been documented sightings of common murres at the water surface over deep subtidal depths in all three study areas (WDFW 2000). Murres are presumably feeding in these areas.

Juvenile salmonids do not utilize deep subtidal areas to forage for food. As adults, chinook salmon commonly forage in deep subtidal areas. Chinook salmon have been observed by anglers to feed along the moving tide lines where the sediment is stirred up, disturbing demersal fish and epibenthic invertebrates (J. Word, MEC Environmental, pers. comm.). Although there is no documentation, it is likely that adult chinook salmon feed along the tide lines in all three MHR study areas. The other salmonid species generally feed in the upper layers of the water column (less than 50 m) and may forage at deep subtidal depths only on occasion (Healey 1980). Salmonids returning to inside waters do not appear to use deep subtidal depths (Quinn et al. 1989).

Very little is known about the life history or distribution of Pacific and river lampreys in the deep subtidal. Since they act as scavengers as well as parasites, it is likely they inhabit the deep subtidal where they may feed on the remains of fish. Numerous salmonid species have lamprey scars and it is possible those fish encountered the lampreys at depth. However, there was no information confirming lamprey presence in the deep subtidal in any of the three study areas.

As stated previously, there is little information on distribution of either green or white sturgeons in inland Puget Sound waters. However, there is no indication that either of these species feed or occur in deep subtidal waters.

Pacific cod and walleye pollock were found in all three MHR study areas in deep subtidal areas (WDFW 2000). Pacific cod adults are demersal and generally found in the deep subtidal; however, as stated in the previous section, they will also feed in shallow areas (West 1997). Walleye pollock adults are also demersal and use the deep subtidal region to feed and spawn. Juvenile Pacific hake use nearshore and shallow subtidal areas for rearing before moving into deeper subtidal waters. Adult hake were found in deep subtidal areas in all three MHR study areas (WDFW 2000). Adult lingcod are demersal and are found in shallow subtidal to deep subtidal rocky habitats throughout Puget Sound. Although lingcod were not found in deep subtidal areas in any of the three study areas, it is probable they do occur in these areas. Their absence in these areas is likely a reflection of sampling methods, as lingcod hide in rocks and crevices which are difficult to sample.

Three of the four forage fish species proposed for coverage in the HCP (Pacific herring, sand lance, and surf smelt) utilize nearshore habitats and there is no indication that they utilize deep subtidal areas (Lemberg et al. 1997). As stated previously, there is little information on habitat usage for eulachon.

Of the 14 rockfish species proposed for coverage in the HCP, adult brown, copper, yellowtail, quillback, black, redstripe, and yelloweye rockfish can be found in both shallow subtidal as well as deep subtidal habitats. Adult greenstriped, black, and bocaccio rockfish are only found in deep subtidal habitats (Lamb and Edgell 1986). The quillback rockfish was the only species found in deep subtidal waters during WDFW (2000) trawl and video surveys in any of the three MHR areas. Quillback were found in deep subtidal areas for all three study areas. However, the lack of other rockfish species in deep subtidal areas is likely a reflection of sampling methods and does not preclude their presence in these areas.

6.4 Major Data Gaps

Key data gaps for several of the species proposed for coverage in this report are listed below. Unless otherwise noted, the information applies to all three areas covered in this report.

Most of the abundance and distribution data for marine birds (common murre, marbled murrelet, and harlequin duck) are based upon seasonal aerial and land surveys and are dependent upon favorable sighting conditions, time of year surveyed, species wariness, and location surveyed. As a result, abundance of these birds may be underestimated. There are no major data gaps for the three marine mammals discussed in this report: Orcas, harbor porpoises, and Steller sea lions.

While there are no major data gaps for the northern abalone, information on isolated occurrences of Olympia oysters in all three areas is lacking. Olympia oyster spawning populations are not expected in the study area.

There are many data gaps for the salmonid species proposed for coverage. There is little or no information regarding residence times within the areas covered in this report for all salmonid populations known to spawn in rivers and streams with outlets into central Puget Sound. There is limited information for chinook, chum, and coho salmon residence times in the WTD Existing Discharges Area and information on preferred habitat for feeding and rearing is limited. Depth distribution and habitat usage data for adult and juvenile salmonids in nearshore waters in all three areas are limited or nonexistent. There is very little information regarding abundance and distribution for bull trout in estuarine waters. The movement of cutthroat trout in estuarine waters and its distribution in all three areas covered in this report are not well known.

Little information is known regarding abundance and distribution of both species of lampreys (Pacific and river) and both species of sturgeon (green and white) in the HCP study area.

Possible spawning grounds for forage fish (Pacific herring, sand lance, and surf smelt) in most of the WTD Existing Discharges Area and the southern portion of the Brightwater Outfall Siting Area have not been extensively surveyed. Information regarding sand lance movements and distribution, other than during the spawning season, is also lacking as is basic ecological information for this species. Little information is known regarding eulachon in inland Puget Sound waters, including time of occurrence, distribution, and water depth requirements.

Most distribution data for fishes are based on trawl and video data and are dependent upon time of year, depth, and location sampled. Many pelagic fish are rarely documented in trawl surveys as this sampling method favors capturing semi-demersal or demersal fish. As a result, abundance and distribution data for fishes such as yellowtail, black, and bocaccio rockfish and forage fish may be underestimated. In addition, many rockfish species and lingcod hide in crevices and rocks and are difficult to sample with both video and trawl surveys. Rockfish species such as the greenstriped, black, and bocaccio rockfish are found in deep waters and are difficult to sample. As a result, the abundance and distribution information for these species may be underestimated. The absence of pelagic and other species difficult to sample with trawl and video data does not preclude those species from inhabiting waters in the study areas.

For the WTD Existing Discharges Area, Vashon Island Area, and the northernmost portion of the Brightwater Outfall Siting Area, there are data gaps regarding vegetation abundance and distribution in the low intertidal-shallow subtidal zone. The vegetation data for these areas were based upon aerial surveys, which were limited to the supralittoral and high to mid intertidal zones. Consequently, the full extent of eelgrass and kelp distribution in these areas is not known. In addition, the survey technique does not allow for the vegetation to be

analyzed on a small scale. Only generalizations can be made using the WDNR Shorezone Database.

Benthic fauna in intertidal and shallow subtidal nearshore areas of the Brightwater Outfall Siting Area and the Vashon Island Area have not been extensively surveyed, and little information is available regarding potential prey items in nearshore areas for the species proposed for coverage in the HCP. There have been several benthic fauna and salmonid prey studies in the WTD Existing Discharges Area, but general food web information in all study areas is lacking.

Limited habitat usage information is available for Colvos Passage in the Vashon Island Area. Forage fish spawning surveys and one video survey for fish distribution have been conducted within this area, but nearshore vegetation distribution and habitat usage by marine fish have not been studied.

Table 6-1. General summary of distribution, habitats, and relative abundance of proposed HCP marine species

Common Name	Scientific Name	Distribution in Puget Sound [a]	Primary Habitat in Puget Sound	Relative Abundance in Puget Sound [b]	Timing of Primary Occurrence (season)	Diet
Killer Whale (orca)	*Orcinus orca*	Areas 1,2,3**:** All of Puget Sound including the Central Basin; Vashon Island, Alki Point, Point Jefferson [1-6]	open water, active at water surface, they do not make prolonged deep dives [7]	common [1,3,4]	Summer, Fall [1,3,4]	Resident pods feed predominantly on fish including salmon, lingcod, rockfishes, flatfishes, and squid.[8]
Pacific Harbor Porpoise	*Phocoena phocoena*	No MHR Areas: From Cape Flattery through the Stait of Juan de Fuca and San Juan Islands. No sightings south of Admiralty inlet for several years [9,10]	coastal waters, including bays, estuaries and nearshore areas in waters less than 200 m [5,11]	rare [9,10,12]	Follow prey inshore to offshore with most moving seaward in Winter [13]	main prey includes schooling fishes (herring, smelt, pollock, whiting), squid, and crustaceans[11,12]
Steller Sea Lion	*Eumetopias jubatus*	Areas 1,2,3: Mainly coastal, San Juan Islands, and Stait of Juan de Fuca. Occasionally seen in both northern and southern Puget Sound[14]	Open water; prefer shallow waters and are often found foraging close to shore at night. Haul out sites include jetties and buoys. [14,15]	uncommon [14]	early fall to early spring [15]	Pacific whiting, herring, smelt, rockfish, skates, salmon, and squid [16]
Common Murre	*Uria aalge*	Areas 1,2,3: Common on islands off the coast. Frequent in San Juan Islands, Strait of Juan de Fuca and all of Puget Sound. [17]	Open water and rocky shores. Typically dive to 20-30 m when feeding [18]	common [17]	late summer and fall [17]	Small fish including sandlance, herring, smelt and bottomfish. Worms and other invertebrates [17,18]
Harlequin Duck	*Histrionicus histrionicus*	Areas 1,2,3: Common in Strait of Juan de Fuca and north; few south of Admiralty Inlet. Found in north and south Puget Sound when occur [17,19]	rivers and streams for breeding, coastlines and shallow intertidal areas [20]	common [19,20]	October to May [17]	intertidal and subtidal marine invertebrates, particularly crabs, amphipods, and snails. Occasionally small fish and fish roe [20]
Marbled Murrelet	*Brachyramphus marmoratus*	Areas 1,2,3: Common winter visitor in the Strait of Juan de Fuca, San Juan Islands but a rarer visitor to Puget Sound. [17,19]	nearshore waters and areas within 5 km of shore in waters less than 60 m deep [21]	uncommon [19]	fall and winter [17]	opportunistic, small schooling fish (sandlance, herring, smelt), sea perch, crustaceans, mollusks, and squid [21]

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Common Name	Scientific Name	Distribution in Puget Sound [a]	Primary Habitat in Puget Sound	Relative Abundance in Puget Sound [b]	Timing of Primary Occurrence (season)	Diet
Bull Trout	*Salvelinus confluentus*	Areas 1,2, possibly 3: Marine distribution not known, Green River, Cedar River, Skagit River, Skykomish River, Hood Canal [22]	streams, lakes, mouth of rivers, marine habitat includes estuarine and nearshore areas [22,23]	not readily available [24]	estuarine waters in spring to mid summer [22]	adults opportunistic, feed on fish (salmonids and bait fish); juveniles feed on insects, zooplankton, amphipods, mysids, small fish [23,25,26]
Chinook Salmon	*Oncorhynchus tschawytscha*	Areas 1,2,3: most major rivers in north and south Puget Sound, including Duwamish/Green River [27]	intertidal and subtidal habitats including, nearshore areas [27,28]	stock dependent [27]	spring, summer,and fall [27]	adults opportunistic, feed on fish (salmonids and bait fish), squid; juveniles feed on insects, zooplankton, amphipods, small fish [29,30]
Chum Salmon	*Oncorhynchus keta*	Areas 1,2,3: most major rivers in north and south Puget Sound, including Duwamish/Green River [31]	shallow waters near tidal marshes, eelgrass meadows, and tideflats [31]	stock dependent [31]	fall, winter, spring [31]	adults opportunistic, feed on fish (salmonids and bait fish); juveniles feed on insects, zooplankton, amphipods, small fish [29,30]
Coho Salmon	*Oncorhynchus kisutch*	Areas 1,2,3: most major rivers in north and south Puget Sound, including Duwamish/Green River [32]	not well known, juveniles both subtidal and nearshore habitats including eelgrass meadows and tideflats, adults epipelagic [29, 32]	stock dependent [32]	fall and peak outmigration in May [32]	adults opportunistic, feed on fish (salmonids and bait fish), scorpaenids; juveniles feed on insects, zooplankton, amphipods, small fish [29,30,33]
Cutthroat Trout	*Oncorhynchus clarki*	Areas 1,2,3: most major rivers emptying into Puget Sound, including Lake Washington system [34]	juveniles and adults can be found over a variety of substrates in both nearshore and offshore waters [29,35]	not well known [34]	fall, winter [29]	northern anchovy, kelp greenling, scorpaenids, salmonids, euphausiids, mysids and crab megalopae [29]

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Common Name	Scientific Name	Distribution in Puget Sound [a]	Primary Habitat in Puget Sound	Relative Abundance in Puget Sound [b]	Timing of Primary Occurrence (season)	Diet
Sockeye Salmon	*Oncorhynchus nerka*	Areas 1,2,3: northern and central Puget Sound, including Lake Washington and Cedar River [36]	in marine waters, juveniles and adults found near gravel substrate, juveniles use nearshore areas [36]	not readily available	summer, fall [29]	juveniles feed on fish larvae, juvenile shrimp, insects, amphipods, mysids and euphausiids, adults feed on fishes [29, 36]
Steelhead	*Oncorhynchus mykiss*	Areas 1,2,3: most major rivers in Puget Sound [37]	Adults are epipelagic and found in coastal waters, usually in upper 12.5 m of the water column to a depth of 25m [37]	not readily available	winter, spring [29]	in marine waters juveniles and adults eat fish, crustaceans, squid, herring and amphipods [29,37]
Pacific Lamprey	*Entosphenus tridentatus*	detailed ditribution not available for Washington, however may spawn and rear in major Puget Sound rivers and streams [38]	juveniles in streams, estuarine channels; adults in open marine waters [38]	not known	spring, summer [38]	juveniles feed on diatoms, protozoa and invertebrates; adults parasitic on fish and marine mammals [35,38,39]
River Lamprey	*Lampetra ayresi*	detailed ditribution not available for Washington, however may spawn and rear in major Puget Sound rivers and streams [38]	juveniles in streams, estuarine channels; adults in open marine waters [38]	not known	spring, summer [38]	juveniles feed on diatoms, protozoa and invertebrates; adults parasitic on fish and marine mammals [35,38,39]
Northern Abalone	*Haliotis kamtschatkana*	No MHR Areas: Straits, San Juan Islands, and northern Puget Sound [40,41]	Typically nearshore rocky substrate at subtidal depths from 10 to 15 m [42]	uncommon [40]	all	juveniles feed on coralline algae, diatoms, and bacterial films;adults brown algae [41,43]
Olympia Oyster	*Ostrea conchaphila*	Areas 1,2,3 possibly: primarily southern Puget Sound[44]	intertidal and subtidal habitats including, mud flats, bays, and estuaries; rocks and gravel [42,45]	not available	all	filter feeder, detritus and planktonic algae [46]
Green Sturgeon	*Acipenser medirostris*	MHR Areas not known: Strait of Juan de Fuca [47]	juveniles in shallow water of high-flow rivers and estuaries; adults reside in subtidal marine areas [29]	rare [29]	not known	adults and larger juveniles feed on benthic and epibenthic invertebrates, small fish[29]

Table 6-1. General summary of distribution, habitats, and relative abundance of proposed HCP marine species

Common Name	Scientific Name	Distribution in Puget Sound [a]	Primary Habitat in Puget Sound	Relative Abundance in Puget Sound [b]	Timing of Primary Occurrence (season)	Diet
White Sturgeon	*Acipenser transmontanus*	Areas 1,2: Strait of Juan de Fuca, Port Orchard, Seattle area, South Puget Sound, Hood Canal [47,48]	young juveniles are riverine; older juveniles and adults reside in rivers, estuaries, and ocean waters; mostly subtidal in estuarine habitat [29]	rare [29]	not known	juveniles and adults feed on benthic invertebrates (including shrimp and bivalves); adults feed on benthic invertebrates, eulachon and anchovy [29]
Pacific Cod	*Gadus macrocephalus*	Areas 1,2,3: most areas in Puget Sound but most abundant in northern areas [49]	variety of habitats, juveniles use eelgrass and adults demersal; water depths 50 to 200 m [49]	seasonally abundant [49]	most abundant during fall through early spring [49]	juveniels feed on crabs, shrimp, snails; adults feed on shrimp, benthic and pelagic fishes [50,51]
Walleye Pollock	*Theragra chalcogramma*	Areas 1,2,3: throughout Puget Sound [47,49, 51]	juveniles shallow, nearshore area; adults depper waters near sandy or muddy bottoms [49, 51]	seasonally abundant [51]	spawning aggregations in late winter/ spring [49,51]	juveniles feed mostly on crustaceans; adults small fishes [49]
Pacific Hake	*Merluccius productus*	Areas 1,2,3: throughout Puget Sound but more common in central and south Puget Sound [47]	predominantly in mid-water column, deep water to 980m [49, 51]	common [47]	all year [49]	juveniles feed on planktonic crustaceans; adults shrimp, sand lance, herring, and other small fish [49]
Lingcod	*Ophiodon elongatus*	Areas 1,2,3: throughout most of Puget Sound [50]	juveniles nearshore areas near kelp, eelgrass; adults rocky locations usually less than 100 m [52]	common [53]	all year [48]	juveniels feed on pelagic crustaceans, fish larvae; adults feed on fish (mainly juvenile rockfish), cephalopods, and crustaceans [52]
Pacific Herring	*Clupea harengus pallasi*	Areas 1,2,3: throughout Puget Sound [54]	large schools in shallow bays and nearshore areas and also throughout water column [55]	common [47,53]	all year [54]	juveniles feed on zooplankton and phytoplankton; adult diet not well known [56]
Sand Lance	*Ammodytes hexapterus*	Areas 1,2,3: throughout Puget Sound [54]	rear in bays and nearshore waters; open nearshore waters during day and burrow in bottom at night [55]	common [54]	all year [54]	juveniles feed on diatoms, copepods, copepod nauplii; adult diet not well known [29]

Table 6-1. General summary of distribution, habitats, and relative abundance of proposed HCP marine species

Common Name	Scientific Name	Distribution in Puget Sound [a]	Primary Habitat in Puget Sound	Relative Abundance in Puget Sound [b]	Timing of Primary Occurrence (season)	Diet
Surf Smelt	*Hypomesus pretiosus*	Areas 1,2,3: throughout Puget Sound [54]	rear in nearshore areas; adults tend to inhabit nearshore areas and remain close to bottom at all times [54]	abundant [55]	all year [48]	juveniles feed on planktonic organisms; adults feed on planktonic crustaceans, fish larvae, combjellies [57]
Eulachon	*Thaleichthys pacificus*	MHR Areas not known: mainly northern Puget Sound (the Straits and San Juan Islands) but not well known [54]	close to bottom in ocean waters most of life, spawn in rivers [29,54]	uncommon [47]	spawn from winter to spring [54]	larvae eat phytoplankton and small zooplankton; juveniles and adults eat planktonic crustaceans (euphausiids, copepods) [29,35]
Brown Rockfish	*Sebastes auriculatus*	Areas 1,2,3: throughout most of Puget Sound [47]	shallow rocky nearshore areas and offshore areas over rocks; remains on or close to bottom at depths to 128 m [58]	common [53,59]	all year [58]	crab, shrimp, small fish, isopods, and polychaetes [58]
Copper Rockfish	*Sebastes caurinus*	Areas 1,2,3: throughout Puget Sound [58,59]	adults demersal in rocky areas; juveniles found in nearshore areas in kelp beds [50,58]	common [59]	all year [58]	juveniles eat copepods, other zooplankton and amphipods;adults benthic feeders on crustaceans, fish, and molluscs [58]
Greenstriped Rockfish	*Sebastes elongatus*	Areas 1,2,3: throughout Puget Sound [47]	deep, level, mostly sandy bottoms[51]	uncommon [47,59]	not known	not known, probably opportunistic
Widow Rockfish	*Sebastes entomelus*	No MHR Areas: not found in inland Puget Sound, only found along outer coasts and Straits [59, 60]	midwater above rocky reef or steep shoreline [35,50]	rare, if at all [59,60]	not applicable	plankton, small fish [35]
Yellowtail Rockfish	*Sebastes flavidus*	Areas 1,2,3: throughout Puget Sound [47]	shallow open water along steeply sloping shores or above rocky reefs [50]	common [53,59]	adults all year [59]	small fish, crustaceans, squid [35]

Table 6-1. General summary of distribution, habitats, and relative abundance of proposed HCP marine species

Common Name	Scientific Name	Distribution in Puget Sound [a]	Primary Habitat in Puget Sound	Relative Abundance in Puget Sound [b]	Timing of Primary Occurrence (season)	Diet
Quillback Rockfish	*Sebastes maliger*	Areas 1,2,3: throughout Puget Sound [59,61]	rocky reefs and hard, even bottoms between 15m and 275m, found at or near bottom [35,50,59]	common [53,59]	all year [59]	amphipods, crabs, shrimp, snails, fish (herring, sand lance) [57]
Black Rockfish	*Sebastes melanops*	Areas 1,2,3: mainly north and central Puget Sound [61,62]	water column over rocky reefs and shores to 360m but most abundant in waters less than 54 m [50,58]	fairly common [62]	not known	adults feed on herring and other fish (smelt, anchovies), and squid; juveniles feed on zooplankton [58]
Blue Rockfish	*Sebastes mystinus*	No MHR Areas: not found in inland Puget Sound, only found along outer coasts and Straits [59, 60]	water column over rocky reefs and shores to 360m [35]	rare, if at all [59,60]	not applicable	tunicates, jellies, fish [35]
China Rockfish	*Sebastes nebulosus*	No MHR Areas: not found in inland Puget Sound, only found along outer coasts and Straits [59, 60]	exposed rocky shores or reefs less than 126m [50]	rare, if at all [59,60]	not applicable	not known, probably opportunistic
Tiger Rockfish	*Sebastes nigrocinctus*	No MHR Areas: not found in inland Puget Sound, only found along outer coasts and Straits [59, 60]	rocky reefs between 10 and 275m [50]	rare, if at all [59,60]	not applicable	not known, probably opportunistic
Bocaccio	*Sebastes paucispinus*	MHR Areas not known: mianly outer coasts and Straits, occassionally north and central Puget Sound [59,63]	open water adjacent to deep reefs to 300m [50]	uncommon [47,53,59]	not known	small fish [35]
Canary Rockfish	*Sebastes pinniger*	No MHR Areas: mainly outer coasts and Straits, occassionally north Puget Sound and Hood Canal [59]	rocky areas at various depths at least 360m; juveniels inhabit shallow waters [50,59]	uncommon [59]	not known	not known, probably opportunistic

Table 6-1. General summary of distribution, habitats, and relative abundance of proposed HCP marine species

Common Name	Scientific Name	Distribution in Puget Sound [a]	Primary Habitat in Puget Sound	Relative Abundance in Puget Sound [b]	Timing of Primary Occurrence (season)	Diet
Redstripe Rockfish	*Sebastes proriger*	Areas 1,2,3: north and central Puget Sound, probably south Puget Sound [47,59,61]	rocky reefs and steep silt-covered cliff faces meet gently sloping sandy or muddy bottoms deeper than 25m [50]	fairly common [59]	not known	not known, probably opportunistic
Yelloweye Rockfish	*Sebastes ruberrimus*	Areas 1,2,3: throughout Puget Sound [47,59]	steep-faced rocky reefs' offshore pinnacles and boulder fields, adults usually deeper than 30 m [50,57,59]	fairly common [59]	not known	shrimp, fish (gadids, sand lance, herring, juvenile rockfishes),crabs, and snails [57,59]

Table notes and references

[a] Area 1: NTF Outfall Siting Area
Area 2: WTD Existing Discharge Area
Area 3: Vashon Island Area

[b] Abundant-often seen or caught in groups
Common-often seen or caught
Uncommon-occasionally seen or caught
Rare-few reported observations

1 Balcomb 1982
2 Balcomb,K. & C. Goebal 1976
3 Balcomb et al. 1980
4 Olesiuket al. 1990
5 Forney et al. 1999
6 Forney et al. 2000
7 Baird et al. 1998
8 Ford et al. 1994
9 B. Hanson, NMML, pers. comm.
10 Calambokidis et al. 1992
11 Leatherwood and Reeves 1983
12 Osmek et al. 1997
13 Osborne et al. 1988
14 Jeffries et al. 2000
15 Reeves et al. 1992
16 Gearin et al. 1999
17 Angell and Balcomb 1982
18 Ehrlich et al. 1988
19 WDFW 2000
20 Robertson and Goudie 1999
21 Nelson 1997
22 WDFW 1998
23 Kraemer 1994
24 King County 2000
25 Rieman and McIntyre 1993
26 McPhail and Baxter 1996
27 Myers et al. 1998
28 Shreffler et al. 1990
29 Emmett et al. 1991
30 Simenstad and Cordell 2000
31 Johnson et al. 1997
32 Weitkamp et al. 1995
33 Simenstad et al. 1991
34 Johnson et al. 1999
35 Hart 1980
36 Gustafson et al. 1997
37 Pauley et al. 1986
38 Wydoski and Whitney 1979
39 Potter 1980
40 R. Anderson, Seattle Aquarium, pers. comm.
41 Sloan and Breen 1988
42 Kozloff 1983
43 Fallu 1991
44 Cook et al. 1998
45 McConnaughey and McConnaughey 1985
46 Conte et al. 1994
47 DeLacy et al. 1972
48 Monaco et al. 1990
49 Wilson et al. 1994
50 Lamb and Edgell 1986
51 West 1997
52 Shaw and Hassler 1989
53 Sommerton and Murray 1976
54 Bargmann 1998
55 WDFW 1997
56 Lassuy 1989
57 Williams 1989
58 Stein and Hassler 1989
59 J. Christiansen, Seattle Aquarium, pers. comm.
60 W. Palsson, WDFW, pers. comm.
61 Miller and Borton 1980
62 Pacunski and Palsson 1998
63 Stober and Pierson 1984

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FINAL

King County Marine Habitat Report
Prepared in support of the Wastewater Treatment Division Habitat Conservation Plan and the Brightwater Marine Outfall Siting Study

Appendix A
Compilation of Existing Fish Food Web Data

January 2001

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Appendix A
Compilation of Existing Fish Food Web Data

The accompanying tables (Tables 1 through 11) contain synopsized data from archived, unpublished, or "gray" literature sources. Data are included from the main basins of Puget Sound (from the south tip of Whidbey Island south) and Hood Canal. Three large studies that supplied much of the data bear mentioning. First, Kurt Fresh (Washington Department of Fish and Wildlife) and others conducted extensive sampling in north and south Puget Sound in 1978 and 1979 using a variety of gear types—this data is denoted as "Fresh unpublished" in the tables. A brief summary of this data was presented in Fresh et al. 1981. Second, a number of fish species were trapped in and around piers and docks in Commencement Bay from 1984-86. Some of this data appeared in a University of Washington Master's thesis and an unpublished document (Ratte and Salo1985), but it remains largely unpublished. This is denoted as "Cordell and Simenstad unpublished. Third, Stephen Bollens (San Francisco State University) and J. Cordell analyzed a large number of salmon, herring, hake, and other species from Dabob Bay, Hood Canal from 1985-87. Salmon diet data from this study has been analyzed for a paper to be submitted to the Canadian Journal of Fisheries and Aquatic Sciences and is referenced as such in the tables, but information for other fish species has not been formally worked up. This data set is referred to as "Bollens and Cordell unpublished".

For each group of fish entered, in the accompanying tables, all prey categories that comprised over 5% of prey biomass are listed in order of abundance. Brief notes on food web connotations for each prey category are also included, as is the source of the data. The findings for each species are summarized as follows:

Chinook Salmon (Oncorhyncus tschawytcha)

There are datasets for chinook salmon (mainly juveniles) that spanned a period from 1978 through 1999. The data indicates two broad categories of chinook feeding: (1) nearshore feeding fish that consumed mainly gammarid amphipods and other epibenthic crustaceans, and terrestrial (neustonic) insects; and (2) pelagic feeding fish that fed as small juveniles on planktonic crustaceans (primarily euphausiids) and as larger juveniles and adults on herring and other fish. Thus, the important habitats and food web connections for chinook salmon in Puget Sound are:

1. Intertidal and shallow subtidal areas that produce amphipods and other epibenthic crustaceans. As has been established for juvenile chum salmon, these probably include intertidal flats as well as vegetation and areas of high detritus buildup.
2. Nearshore vegetated terrestrial habitats that are the source of terrestrial insects in the diets.
3. Feeding on planktonic grazers such as euphausiids, shrimp and crab larvae, planktonic amphipods, and copepods.
4. Feeding on other secondary pelagic consumers such as herring and other fish.

Coho Salmon (*Oncorhyncus nerka*)

There was much less diet data for Coho than for Chinook salmon. It appears that food web linkages for Puget Sound Coho salmon are similar to those for Chinook, with larger fish feeding on herring and other "baitfish" and smaller fish feeding on planktonic crustaceans. Coho differ from Chinook in being less dependent on benthic/epibenthic habitats, evidenced by fewer cases of diet dominated by taxa such as gammarid amphipods. Although the resolution of the data presented here does not show it, even when amphipods occurred as important prey for Coho, they were often pelagic types, particularly such taxa as the gammarid *Cyphocaris challengeri* and the hyperiid *Parathemisto pacifica*.

Chum Salmon (Oncorhyncus keta)

Similarly to Chinook, Chum salmon depended on two major habitats for feeding. In the spring when they were small, they fed primarily on the epibenthic harpacticoid copepods *Harpacticus* and *Tisbe*. Food web linkages at this stage have been presumed to be detritus based, but may also include some epibenthic primary production (e.g., diatoms). At this time they also fed on epibenthic aquatic insect larvae such as chironomids. In late spring to early summer, Chum salmon switched to feeding on planktonic primary consumers such as larvaceans and planktonic copepods. In the summer, they fed on larger zooplankton such as euphausiids, hyperiid amphipods, and fish larvae.

Pacific Herring (*Clupea harengus*)

The herring sampled from Puget Sound and Hood Canal fed almost exclusively on plankton. This consisted mainly of planktonic copepods in smaller juvenile fish and euphausiids and amphipods in larger juveniles and

adults. It is interesting to note that in the diet from herring sampled from Padilla Bay (this small data set is included as a reference), which has extensive eelgrass beds, the diet had a significant amount of epibenthic harpacticoid copepods. Therefore, this habitat should not be ruled out as providing food web linkages for this species.

Surf Smelt (Hypomesus pretiosus)

There were only a few data sets for surf smelt. One fairly large group of 32 individuals from the Kurt Fresh data fed mainly on zooplankton. As for herring, a group of surf smelt captured at Padilla Bay fed on harpacticoid copepods and other epibenthic taxa.

Pacific Sand Lance (*Ammodytes hexapterus*)

The only data set with appreciable numbers of sand lance was that from Hood Canal (Bollens and Cordell data). In these fish, planktonic copepods were the dominant prey. Like surf smelt, sand lance from Padilla Bay fed on harpacticoid copepods.

Pacific Hake (Merluccius productus)

Virtually all of the data for Pacific Hake in the table came from the Dabob Bay data set of Bollens and Cordell. In this deep fjord, hake appear to be euphausiid specialists, with minor contributions by other zooplankton species.

Other Species

Very little data was found for other listed/candidate fish species. There is some extant data on feeding by juvenile rockfish analyzed by Ray Buckley (Washington Department of Fish and Wildlife). This data is in raw numerical form and must be further analyzed by the University of Washington's GUTBUGS diet analysis program in order to make sense of it. This should be done before a final draft of the food web document is completed.

Summary

Perhaps the most striking result of this review of diet data for ESA listed and candidate fish species in Puget sound is the preponderance of zooplankton species used by the fish. This points directly to a large gap in our understanding of the biology of these fish. Salmon ecology and the effects of

habitat degradation on juvenile salmon in estuaries and nearshore marine habitats in Puget Sound and other waters in the Pacific Northwest are relatively well studied (Simenstad et al. 1991, Aitken 1998, Simenstad and Cordell in press). In contrast, the ecology of juvenile salmon and other listed and candidate fish in water column habitats of Puget Sound is poorly known. Elsewhere in the region the role of the nearshore pelagic environment, and particularly the importance of zooplankton feeding, has been established for juvenile salmon. For example, juvenile pink and chum salmon off northern Vancouver Island had more material in their stomachs, were in better condition, and had higher potential growth rates than pink and chum salmon off southern Vancouver Island; these variations were consistent with spatial differences in zooplankton biomass, there being more plankton in the northern region (Perry et al. 1996). Brodeur et al. (1992) suggested that juvenile coho and chinook salmon off of Oregon and Washington experienced planktonic food limitation during years of unusually low productivity (e.g., El Niño). The few relevant studies (e.g., Fresh et al. 1981, Bollens et al. submitted) and the data summarized here indicate that the pelagic habitat is important for Puget Sound salmon and several of their important forage fish. Especially notable is the importance of euhpausiids in the diet of a variety of fish species, in both Puget Sound and Hood Canal. The dominant euphausiid, *Euphausia pacifica*, requires deep basins for reproduction, and apparently breeding populations of this species occur only in Carr Inlet, Port Susan, and Dabob Bay, within the area examined (Cooney 1971, Ross et al. 1982). Thus, euphausiid populations may be a limiting factor for many of their predators in Puget Sound, and this subject bears investigation. Unfortunately, virtually nothing is known about how Puget Sound zooplankton species vary in time and space and how this relates to the fish that feed on them.

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Table 1. Chinook Salmon (*Onchoryncus tsawytcha*)

Location	Date	Habitat, Gear	#, LH Stage	Principal Prey Taxa	Food Web Comments	Source
Carr Inlet, Wollechet Bay, Gibson Pt., Anderson Is., Johnson Pt., Hale Pass, Fox Pt., Pt. Defiance	Feb-July78	Townet	11 Juvenile, 14 Adu	Clupea harengus	Unidentified Fish	Fresh, unpublished data
				Teleostei	Herring	
Wollochet Bay	Jul-78		8 Juvenile	Polychaeta	Benthic Worms (but may have pelagic phase)	
				Insecta	Terrestrial Insects	
Anderson Is. -Lyle Point	Aug-78		12 Juvenile	Teleostei	Unidentified Fish	
				Theragra chalcogramma	Walleye Pollock	
				Cymatogaster aggregata	Shiner Perch	
Johnson Point	Aug-78		14 Juvenile	Teleostei	Unidentified Fish	
				Clupea harengus	Herring	
Wollochet Bay	Aug-78		12 Juvenile	Decapoda Brachyura	Crab Larvae	
				Insecta	Terrestrial Insects	
				Teuthidida	Squid	
12009	Aug-78		13 Juvenile	Insecta	Terrestrial Insects	
				Polychaeta	Benthic Worms (but may have pelagic phase)	
				Ostracoda	Epibenthic Crustaceans	
				Gammaridea	Epibenthic Crustaceans	
				Decapoda Brachyura	Crab Larvae	
Anderson Is. -Lyle Point	Sep-78		15 Juvenile	Clupea harengus	Herring	
				Gadidae	Cod Family	
				Teleostei	Unidentified Fish	
Henderson Inlet	Sep-78	Townet	5 Juvenile	Polychaeta	Benthic Worms (but may have pelagic stage)	
Fox Island	Sep-78		4 Juvenile	Gammaridea	Can't tell from level of identification	
				Insecta	Terrestrial (neuston)	
				Ampipoda	Can't tell from level of identification	
Wollochet Bay	Sep-78		6 Juvenile	Euphausiacea	Planktonic Crustaceans	
				Teleostei	Unidentified Fish	
				Decapoda-Bracyura	Crab Larvae	
Wollochet Bay	Sep-78		5 Juvenile	Euphausiacea	Planktonic Crustaceans	
Anderson Is. -Lyle Point	Oct-78		10 Juvenile	Teleostei	Unidentified Fish	
				Gadidae	Cod Family	
				Theragra chalcogramma	Walleye Pollock	
				Clupea harengus	Herring	

Table 1. Chinook Salmon (*Onchoryncus tsawytcha*)

Location	Date	Habitat, Gear	#, LH Stage	Principal Prey Taxa	Food Web Comments	Source
Gibson Pt., Fox Is., Wollochet Bay, Hale Pass, Green Pt., Anderson Is. -Lyle Pt.	Nov-78		32 Juvenile, 1 Adult	Teleostei	Unidentified Fish	
				Clupea harengus	Herring	
Fox Is., Gibson Pt. Nisqually Reach, Wollochet Bay, Anderson Is., Johnson Pt.	Dec-78		16 Juvenile	Clupea harengus	Unidentified Fish	
				Teleostei	Herring	
Gibson Pt., Fox Pt., Wollochet Bay, Johnson Pt., Day Is.	Jan-79		10 Juvenile, 1 Adult	Clupea harengus	Herring	
				Loligo sp.	Squid	
Hale Pass	Feb-79		11 Juvenile	Euphausiacea	Planktonic Crustaceans	
				Clupea harengus	Herring	
Hale Pass	Feb-79		7 Juvenile	Clupea harengus	Herring	
Hale Pass	Feb-79		5 Juvenile	Euphausiacea	Planktonic Crustaceans	
				Teleostei	Unidentified Fish	
Hale Pass	Feb-79		15 Juvenile	Euphausiacea	Planktonic Crustaceans	
Hale Pass	Feb-79		17 Juvenile	Euphausiacea	Planktonic Crustaceans	
				Clupea harengus	Herring	
Hale Pass	Feb-79		10 Juvenile	Clupea harengus	Herring	
				Euphausiacea	Planktonic Crustaceans	
				Teleostei	Unidentified Fish	
Hale Pass	Feb-79		15 Juvenile	Clupea harengus	Herring	
				Teleostei	Unidentified Fish	
Port Madison	Feb-79	Purse Seine	14 Adult	Gammaridea	Can't tell from level of identification	
				Mysidacea	Can't tell from level of identification	
				Teleostei	Unidentified Fish	
Port Madison	Feb-79	Purse Seine	10 Adult	Teleostei	Unidentified Fish	
				Clupea harengus	Herring	
W. Blake Island	Feb-79	Purse Seine	15 Juvenile	Hyperiidea	Planktonic Amphipods	
				Teleostei	Unidentified Fish	
				Polychaeta	Benthic Worms (but may have pelagic phase)	
W. Blake Island	Feb-79	Purse Seine	7 Juvenile	Clupea harengus	Herring	
Port Madison, Hale Pass, Solo Point	Feb-79		19 Juvenile, 62 Adu	Euphausiacea	Planktonic Crustaceans	

Table 1. Chinook Salmon (*Onchoryncus tsawytcha*)

Location	Date	Habitat, Gear	#, LH Stage	Principal Prey Taxa	Food Web Comments	Source
Pt. Defiance, Gibson Pt.,	Mar-79		14 Adult	Clupeidae	Herring	
Glen Cove, Anderson Is.,				Teleostei	Unidentified Fish	
Green Pt., Johnson Pt.				Gadidae	Cod Family	
Commencement Bay	Apr-June 1983		152 Juvenile	Teleostei	Unidentified Fish	Cordell and Simenstad unpublished
				Euphausiacea	Planktonic Crustaceans	
				Clupeidae	Herring	
				Harpacticoida	Epibenthic Copepods	
				Crangonidae	Shrimp Larvae	
				Cancridae	Cancer Crab Larvae	
Commencement Bay	April-June 1984		9 Juvenile	Insecta	Terrestrial Insects	
				Harpacticoida	Epibenthic Copepods	
Commencement Bay	Apr-June 1985		82 Juvenile	Insecta	Terrestrial Insects	
				Teleostei	Unidentified Fish	
Duwamish Head	Jul-84	Eelgrass	5 Juvenile	Ischyrocerus sp.	Epibenthic gammarid amphipods	Simenstad and Cordell unpublished
				Eogammarus confervicolu	Epibenthic gammarid amphipods	
				Calliopius sp.	Epibenthic gammarid amphipods	
				Crangon sp.	Benthic shrimp	
Dabob Bay (Hood Canal)	June-July 1985-8'	Offshore Statior	12 Juvenile	Euphausiacea	Planktonic Crustaceans	Bollens et al. submitted
				Teleostei	Unidentified Fish	
				Calanoida	Planktonic Copepods	
				Hyperiidea	Planktonic Amphipods	
Dabob Bay (Hood Canal)	August 1985-87	Offshore Statior	18 Juvenile	Euphausiacea	Planktonic Crustaceans	
				Hyperiidea	Planktonic Amphipods	
				Insecta	Terrestrial Insects	
Dabob Bay (Hood Canal)	October 1985-87	Offshore Statior	35 Juvenile	Euphausiacea	Planktonic Crustaceans	
				Gammaridea	Can't tell from level of identification	
				Insecta	Terrestrial Insects	
Dabob Bay (Hood Canal)	June-July 1985-8'	Inshore Station	18 Juvenile	Decapoda	Crab and Shrimp Larvae	
				Teleostei	Unidentified Fish	
Dabob Bay (Hood Canal)	August 1985-87	Inshore Station	15 Juvenile	Insecta	Terrestrial Insects	
				Decapoda	Crab and Shrimp Larvae	
Dabob Bay (Hood Canal)	October 1985-87	Inshore Station	19 Juvenile	Insecta	Terrestrial Insects	
				Hyperiidea	Planktonic Amphipods	
				Pteropoda	Planktonic Molluscs	
Shilshole Bay	June-Aug 1999	Beach Seine	45 Juvenile	Gammaridea	Epibenthic/benthic Amphipods	Cordell unpublished
				Clupea harengus	Herring	
				Daphnia	Freshwater Cladocera (from below locks)	

FINAL

King County Marine Habitat Report
Prepared in support of the Wastewater Treatment Division Habitat Conservation Plan and the Brightwater Marine Outfall Siting Study

Appendix B
Geographical Distribution of Puget Sound Fishes: Maps and Data Source Sheets (from Miller and Borton, 1980)

January 2001

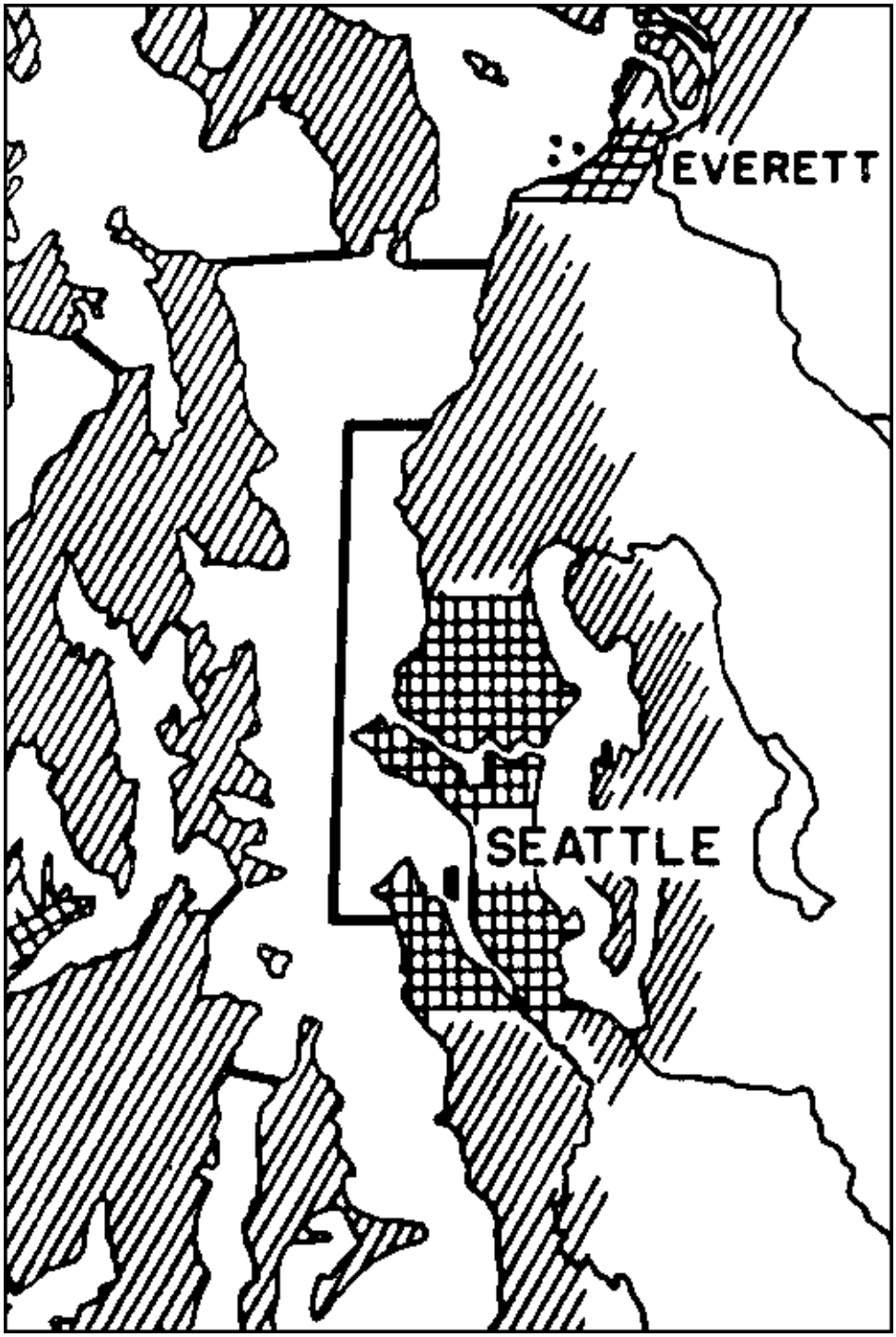

Figure B-1. Geographic distribution (represented by black dots) of *Lampetra tridentata* (Pacific Lamprey) in the Puget Sound. From: Miller, B.S. and S.F. Borton. 1980. Geographical distribution of Puget Sound fishes: Maps and data source sheets. Volumes 1 and 2. Fisheries Research Institute, College of Fisheries, University of Washington.

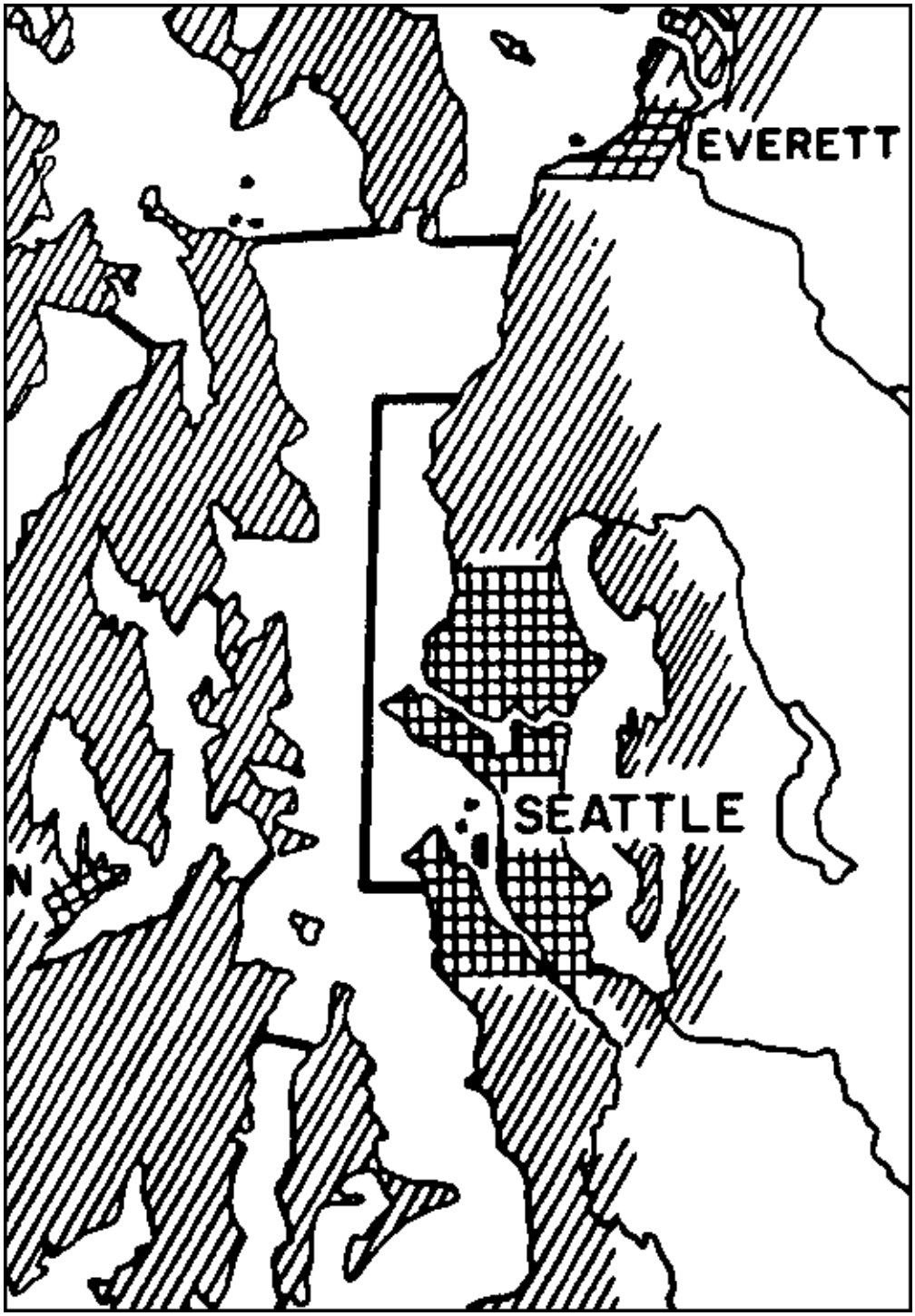

Figure B-2. Geographic distribution (represented by black dots) of *Lampetra ayresii* (River Lamprey) in the Puget Sound. From: Miller, B.S. and S.F. Borton. 1980. Geographical distribution of Puget Sound fishes: Maps and data source sheets. Volumes 1 and 2. Fisheries Research Institute, College of Fisheries, University of Washington.

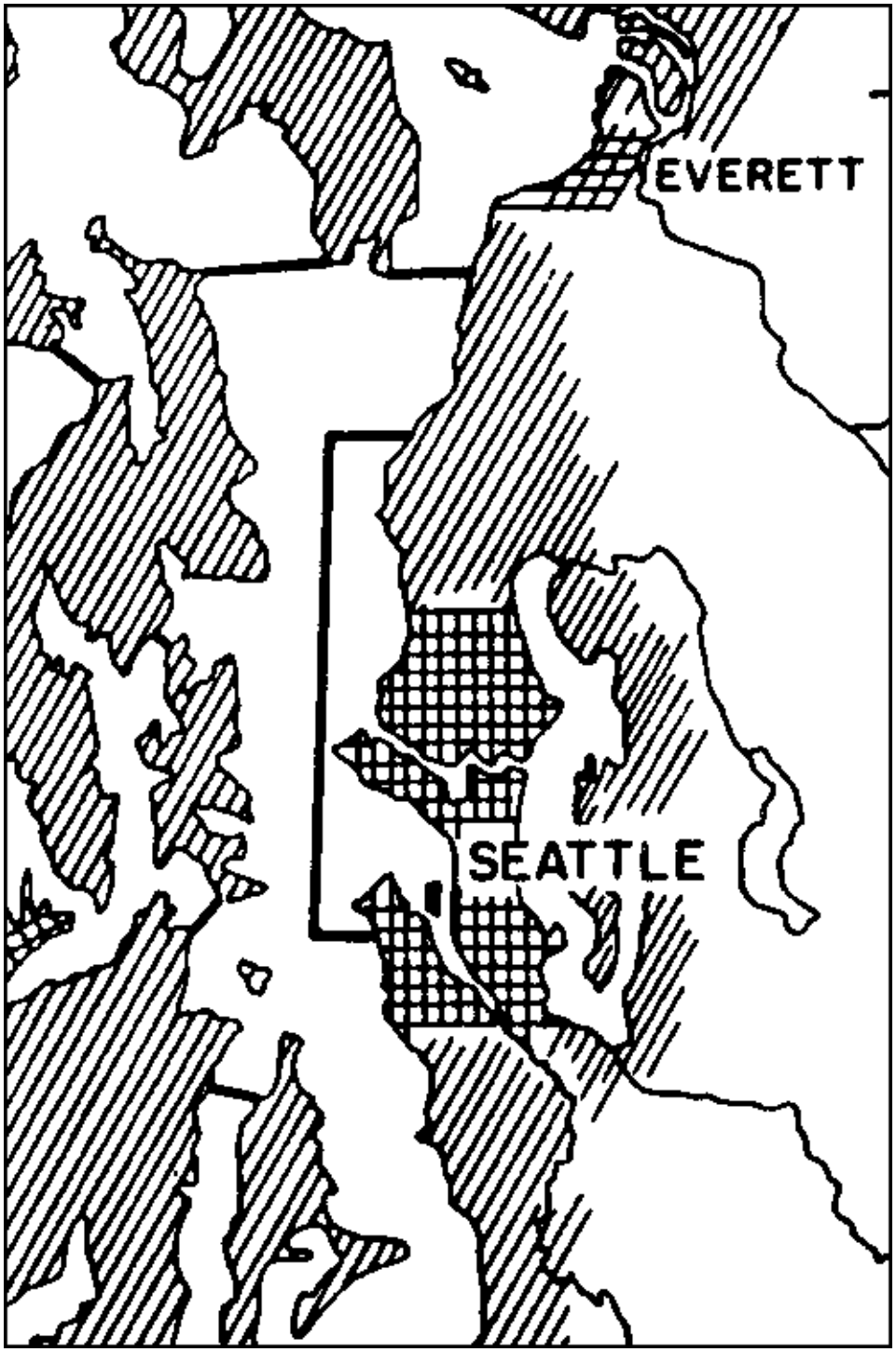

Figure B-3. Geographic distribution (represented by black dots) of *Acipenser medirostris* (Green Sturgeon) in the Puget Sound. From: Miller, B.S. and S.F. Borton. 1980. Geographical distribution of Puget Sound fishes: Maps and data source sheets. Volumes 1 and 2. Fisheries Research Institute, College of Fisheries, University of Washington.

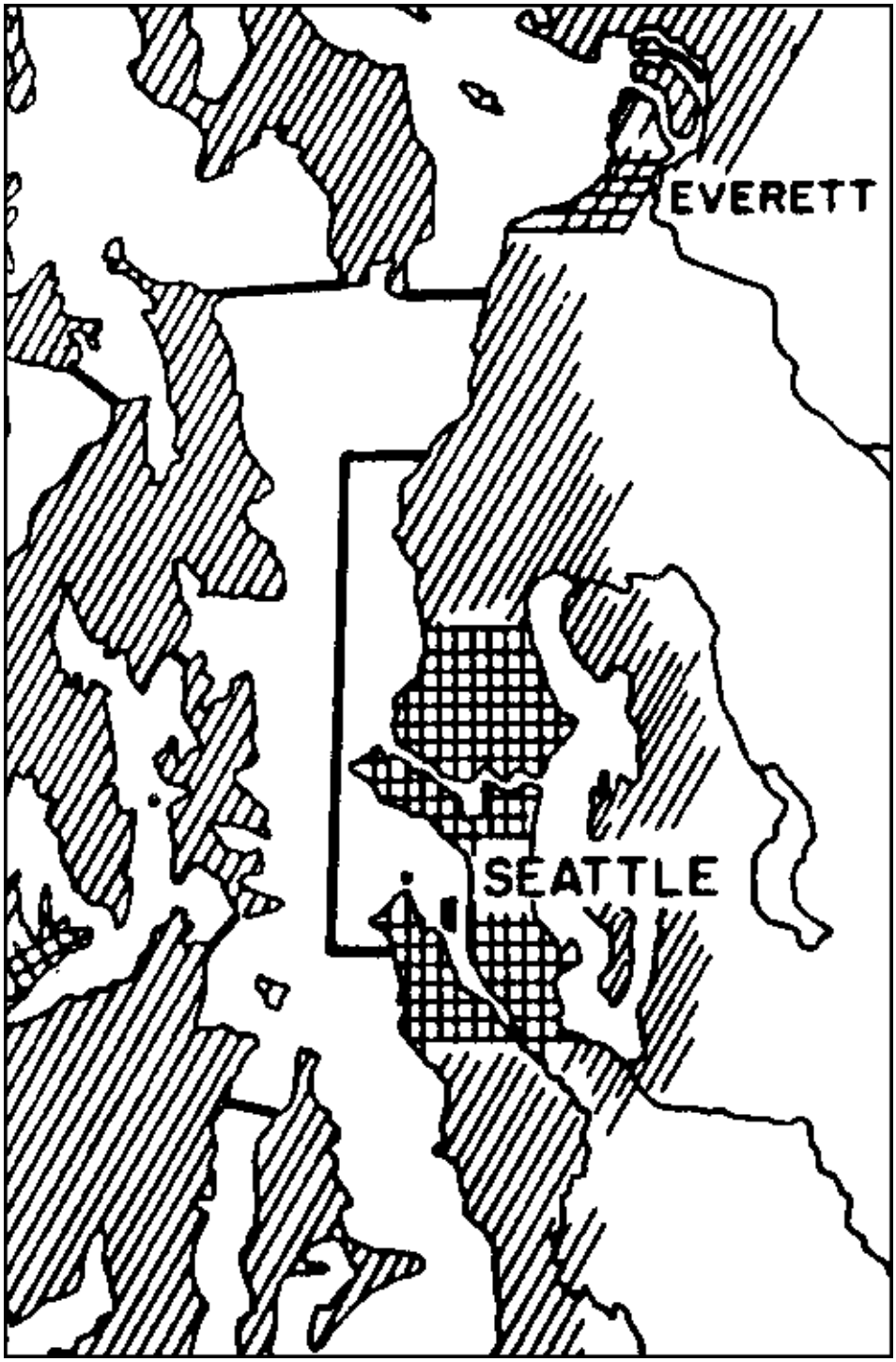

Figure B-4. Geographic distribution (represented by black dots) of *Acipenser transmontanus* (White Sturgeon) in the Puget Sound. From: Miller, B.S. and S.F. Borton. 1980. Geographical distribution of Puget Sound fishes: Maps and data source sheets. Volumes 1 and 2. Fisheries Research Institute, College of Fisheries, University of Washington.

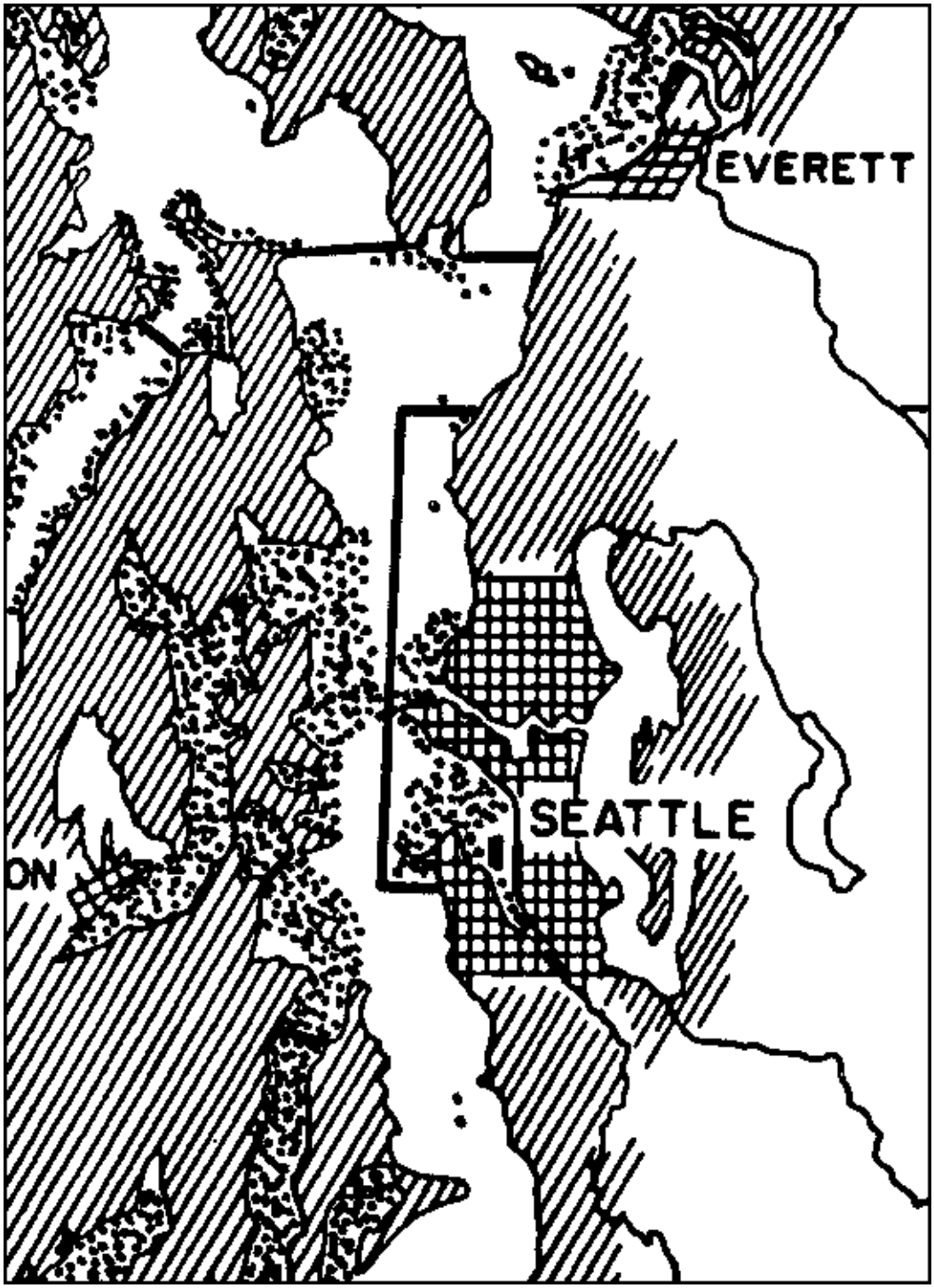

Figure B-5. Geographic distribution (represented by black dots) of *Clupea harangus pallasi* (Pacific Herring) in the Puget Sound. From: Miller, B.S. and S.F. Borton. 1980. Geographical distribution of Puget Sound fishes: Maps and data source sheets. Volumes 1 and 2. Fisheries Research Institute, College of Fisheries, University of Washington.

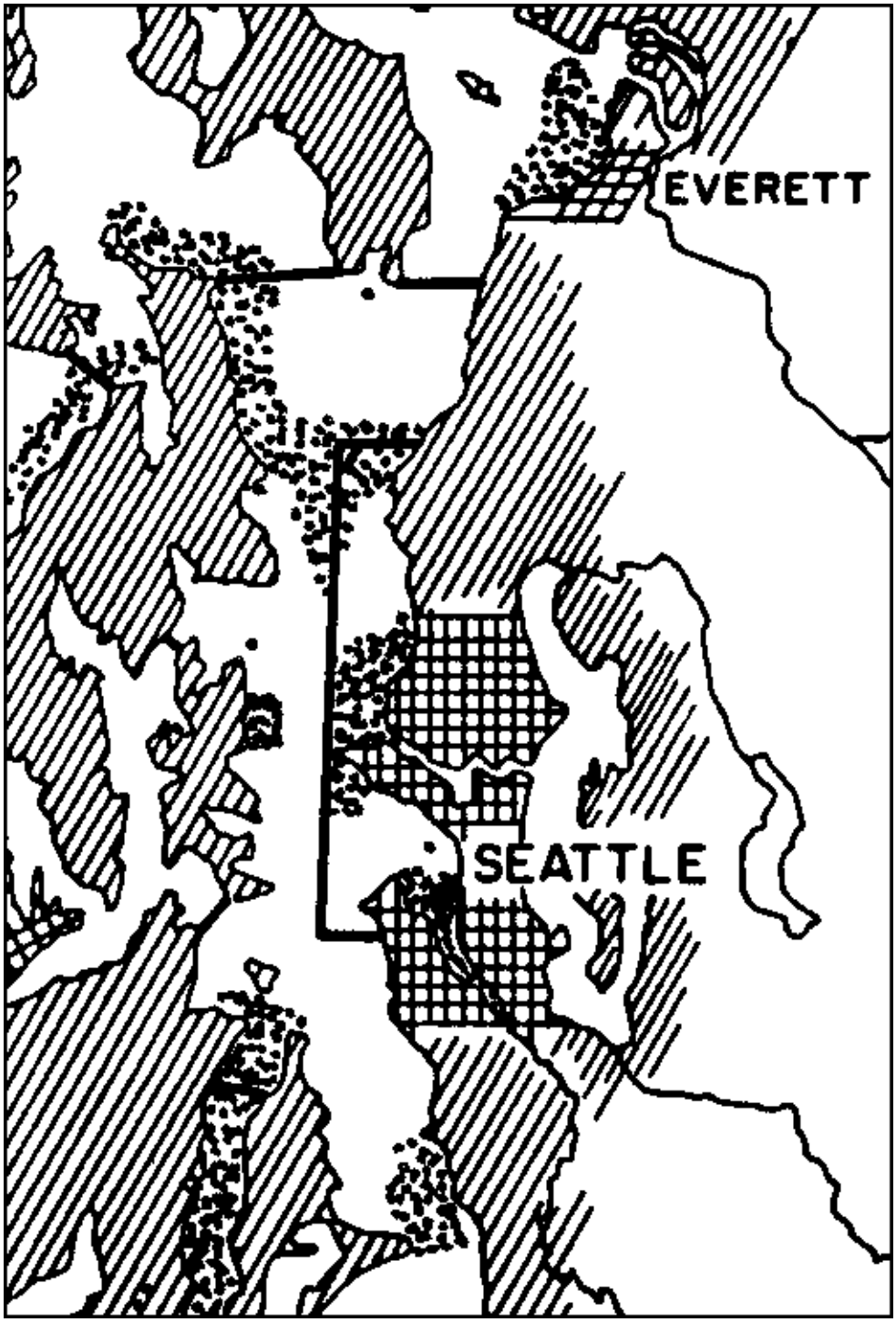

Figure B-6. Geographic distribution (represented by black dots) of *Oncorhynchus keta* (Chum Salmon) in the Puget Sound. From: Miller, B.S. and S.F. Borton. 1980. Geographical distribution of Puget Sound fishes: Maps and data source sheets. Volumes 1 and 2. Fisheries Research Institute, College of Fisheries, University of Washington.

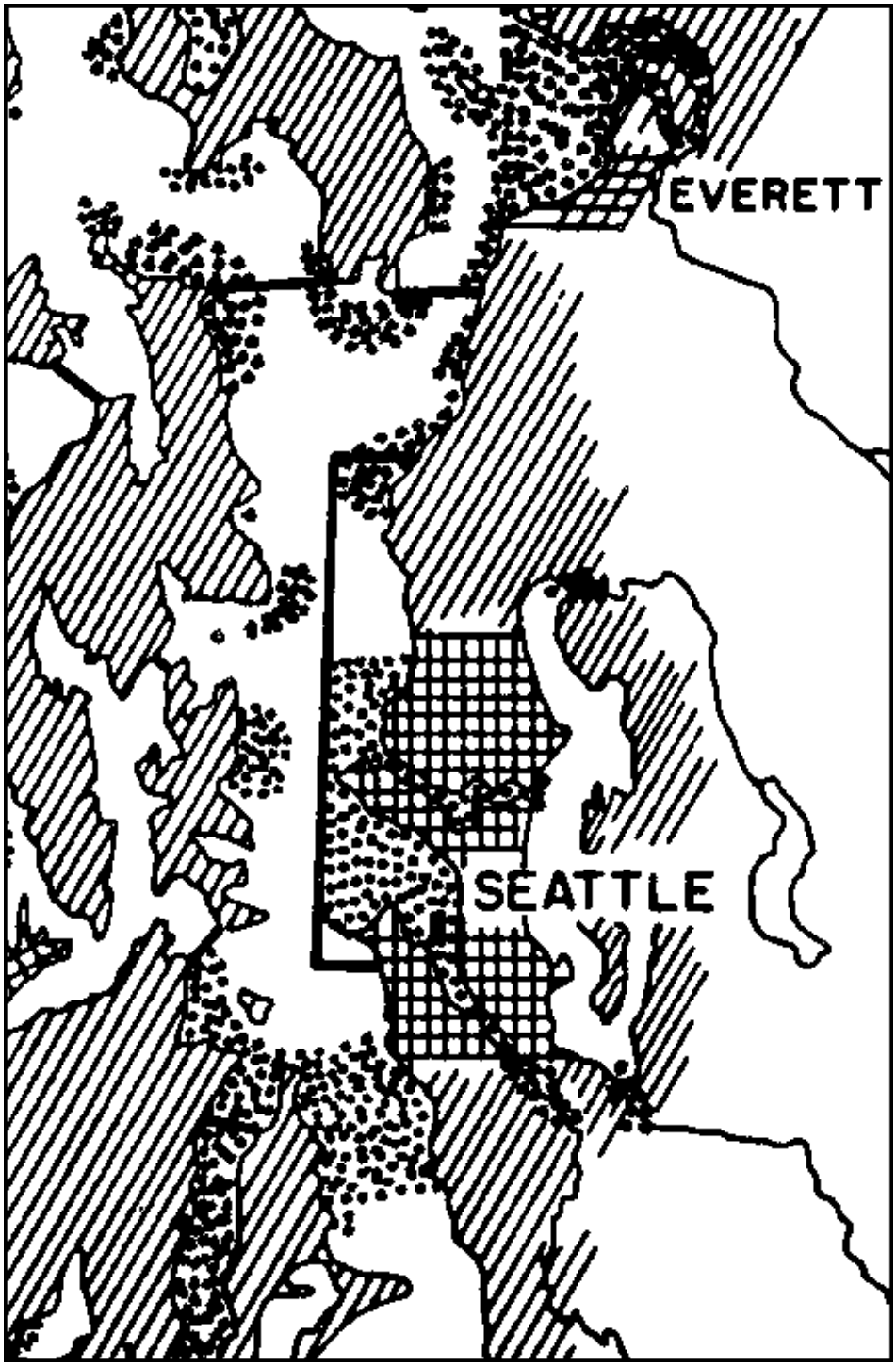

Figure B-7. Geographic distribution (represented by black dots) of *Oncorhynchus kisutch* (Coho Salmon) in the Puget Sound. From: Miller, B.S. and S.F. Borton. 1980. Geographical distribution of Puget Sound fishes: Maps and data source sheets. Volumes 1 and 2. Fisheries Research Institute, College of Fisheries, University of Washington.

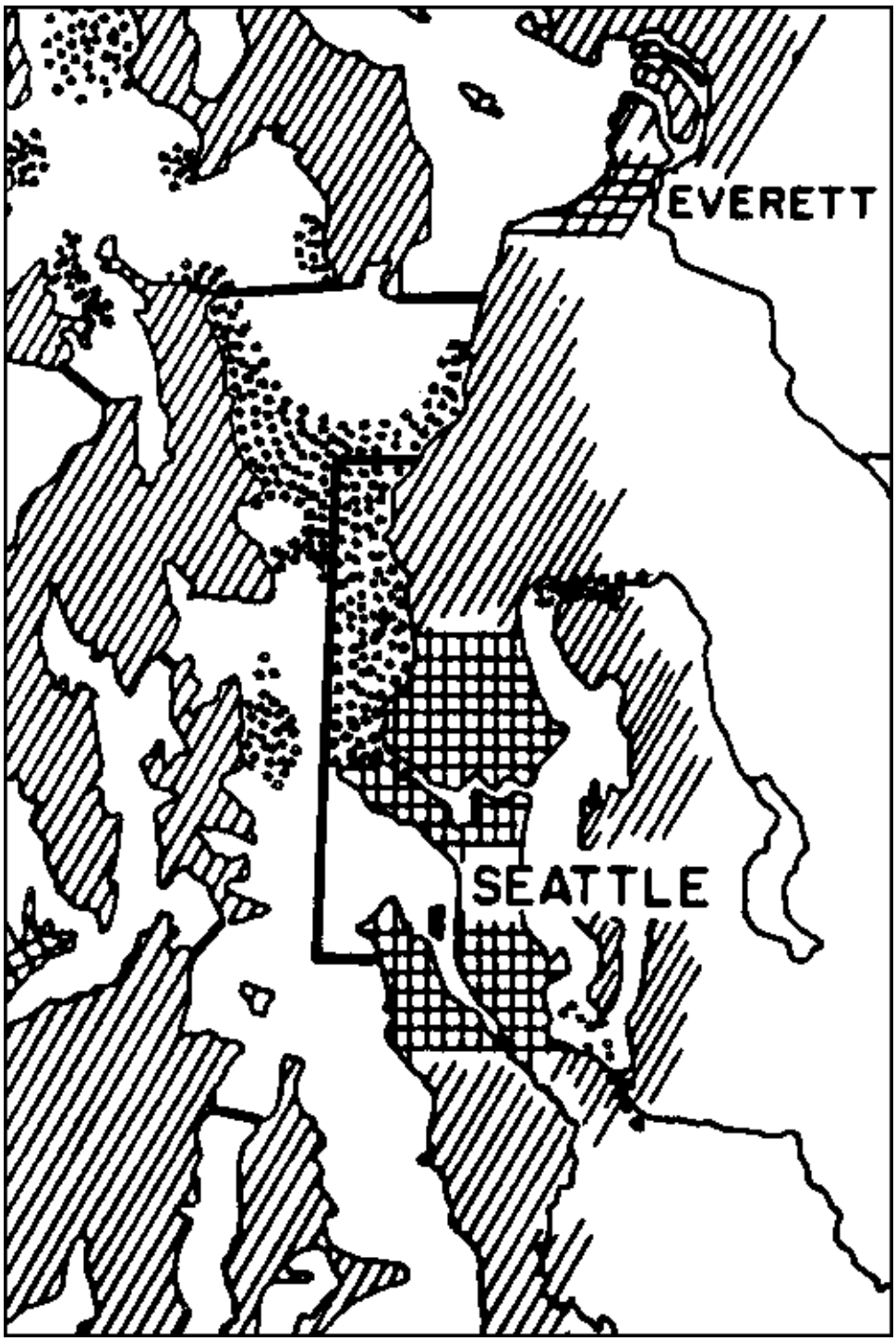

Figure B-8. Geographic distribution (represented by black dots) of *Oncorhynchus nerka* (Sockeye Salmon) in the Puget Sound. From: Miller, B.S. and S.F. Borton. 1980. Geographical distribution of Puget Sound fishes: Maps and data source sheets. Volumes 1 and 2. Fisheries Research Institute, College of Fisheries, University of Washington.

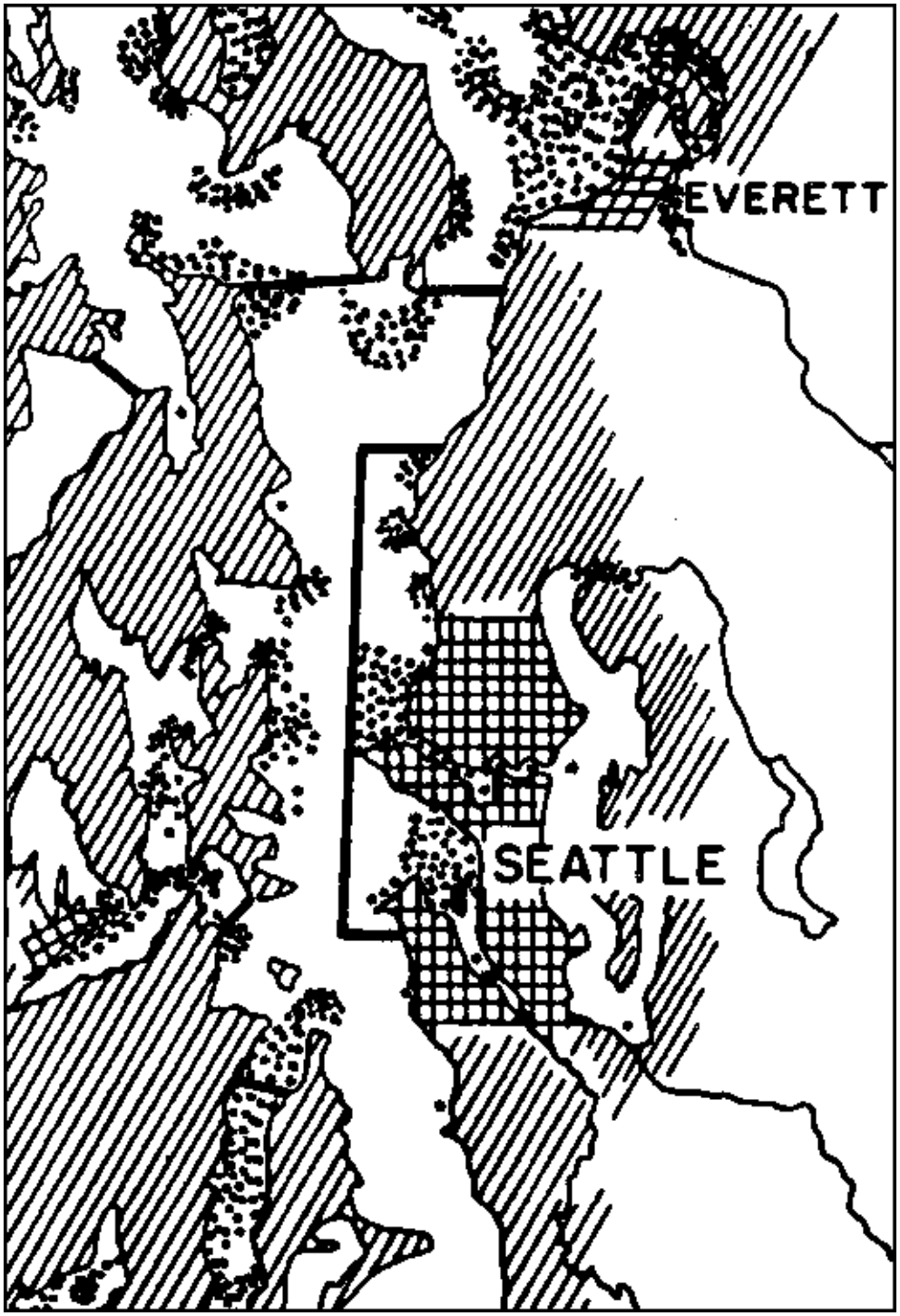

Figure B-9. Geographic distribution (represented by black dots) of *Oncorhynchus tshawytscha* (Chinook Salmon) in the Puget Sound. From: Miller, B.S. and S.F. Borton. 1980. Geographical distribution of Puget Sound fishes: Maps and data source sheets. Volumes 1 and 2. Fisheries Research Institute, College of Fisheries, University of Washington.

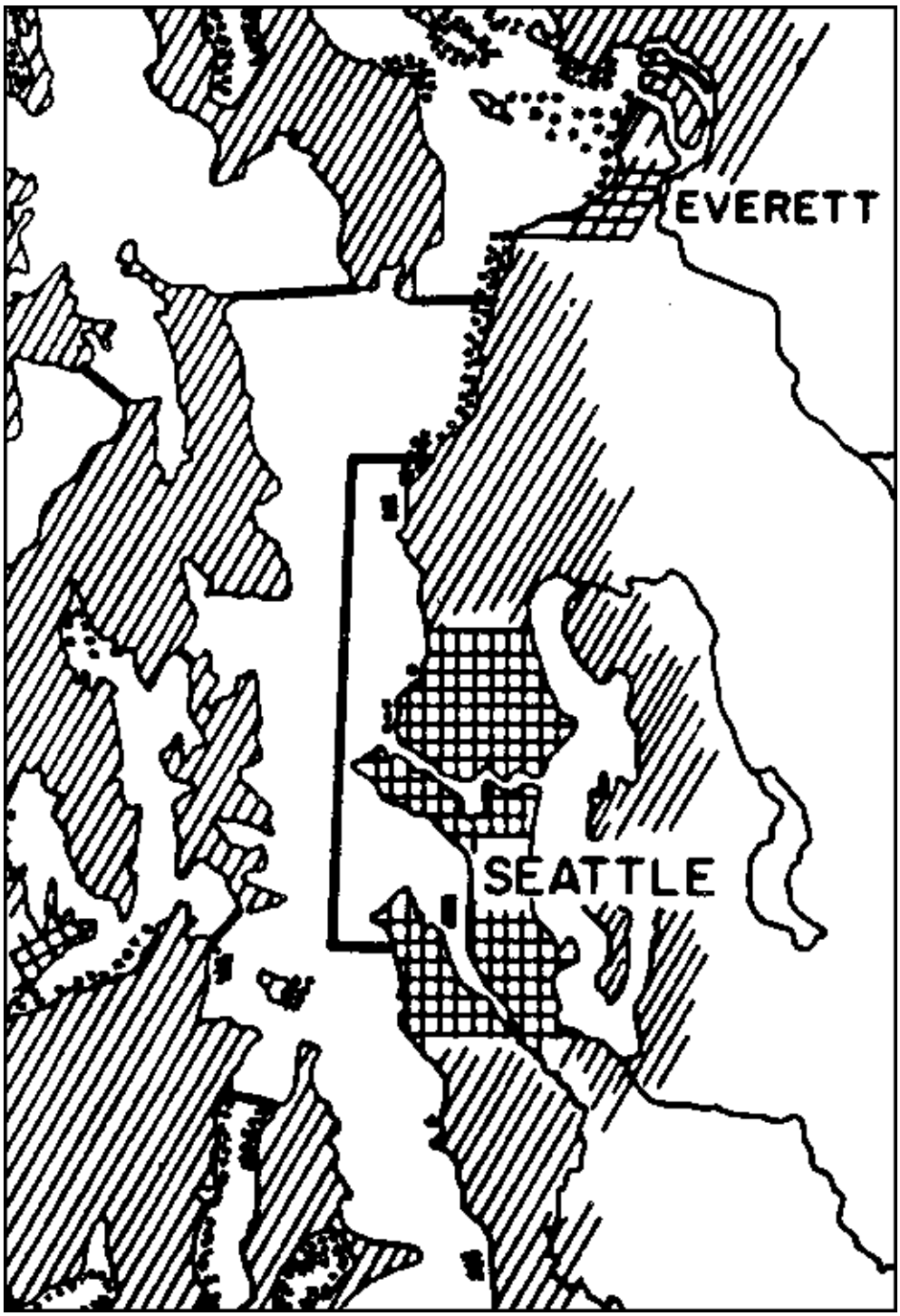

Figure B-10. Geographic distribution (represented by black dots) of *Oncorhynchus clarkii* (Cutthroat Trout) in the Puget Sound. From: Miller, B.S. and S.F. Borton. 1980. Geographical distribution of Puget Sound fishes: Maps and data source sheets. Volumes 1 and 2. Fisheries Research Institute, College of Fisheries, University of Washington.

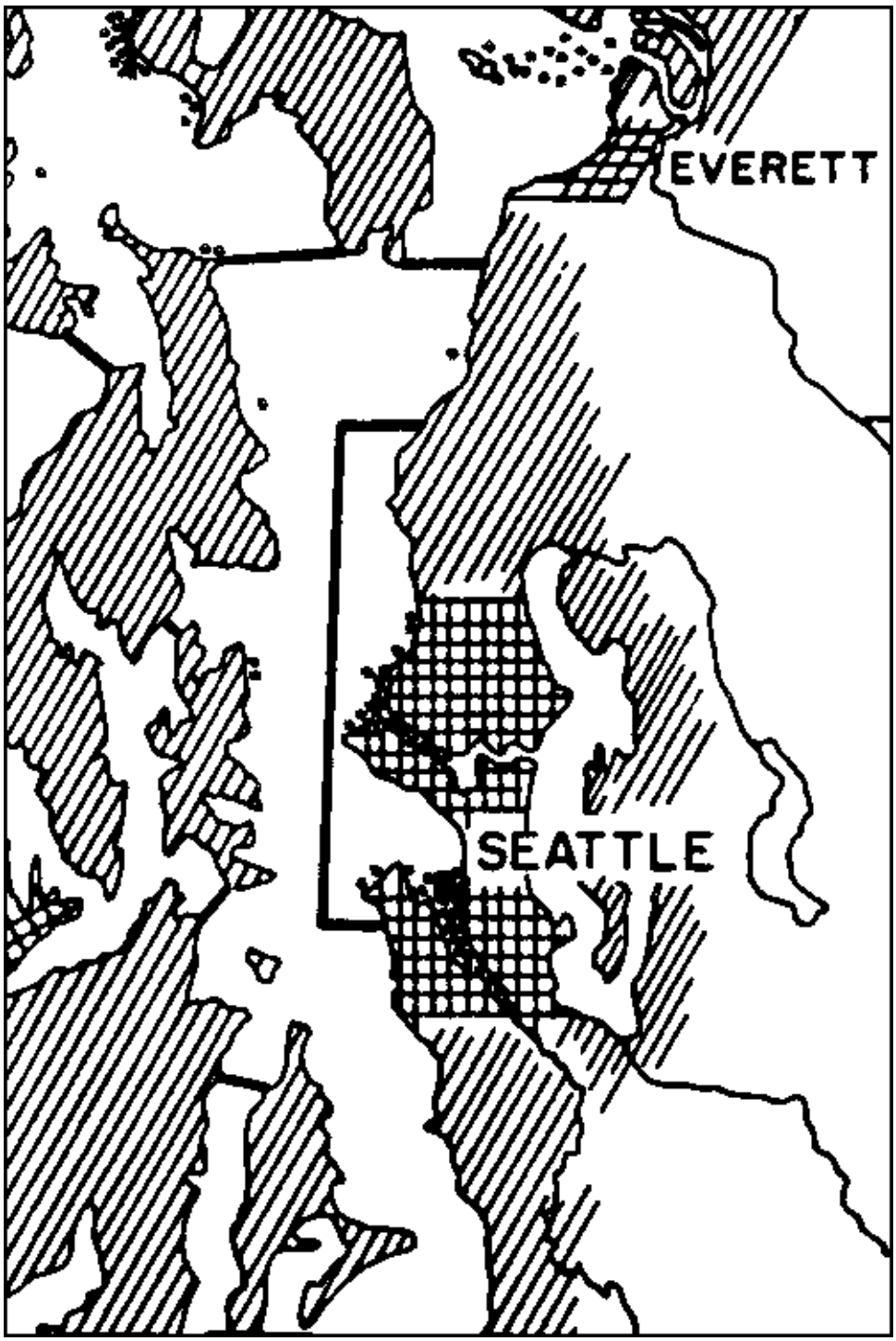

Figure B-11. Geographic distribution (represented by black dots) of *Oncorhynchus mykiss* (Steelhead) in the Puget Sound. From: Miller, B.S. and S.F. Borton. 1980. Geographical distribution of Puget Sound fishes: Maps and data source sheets. Volumes 1 and 2. Fisheries Research Institute, College of Fisheries, University of Washington.

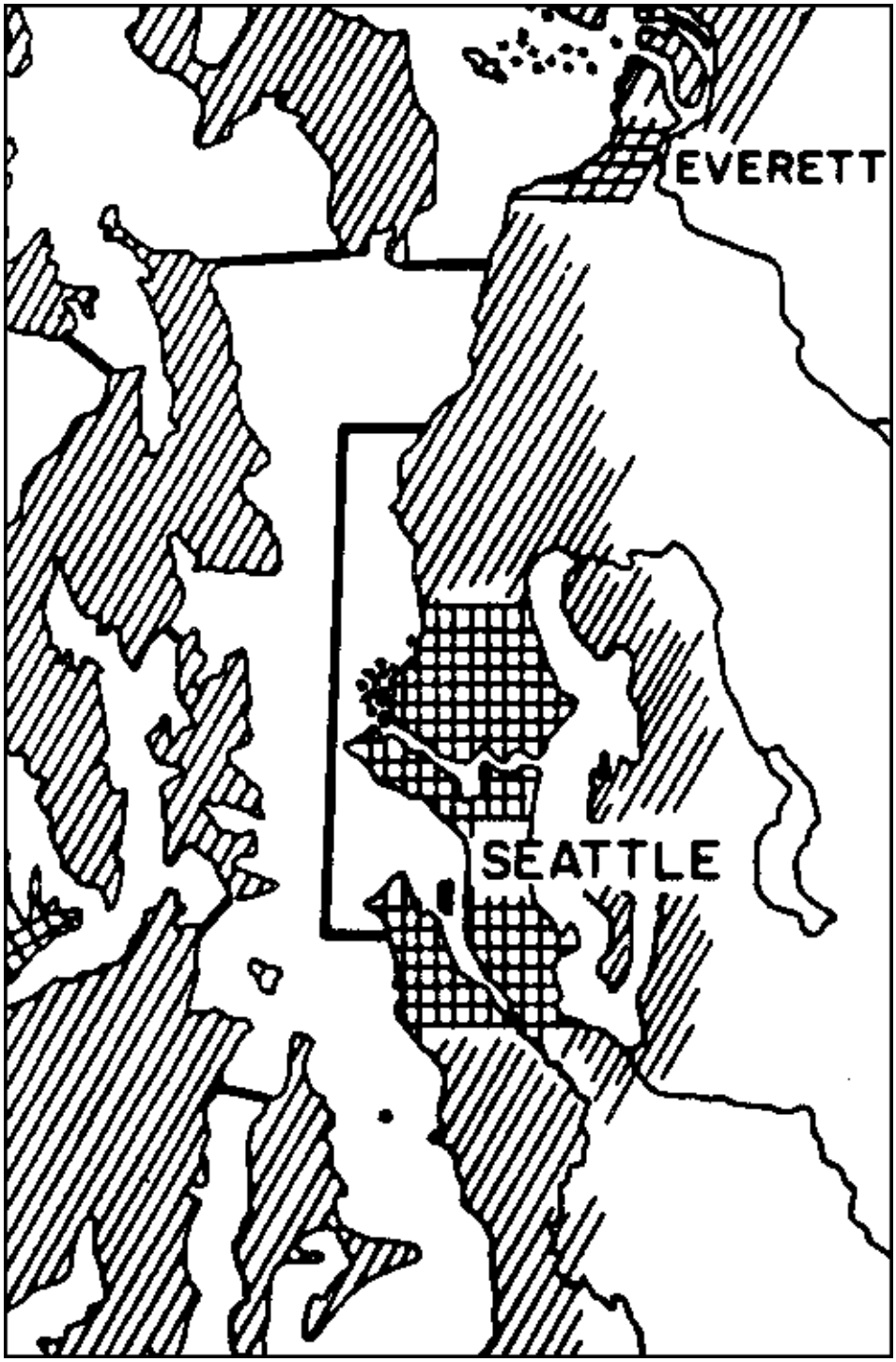

Figure B-12. Geographic distribution (represented by black dots) of *Salvelinus malma* (Dolly Varden) in the Puget Sound. From: Miller, B.S. and S.F. Borton. 1980. Geographical distribution of Puget Sound fishes: Maps and data source sheets. Volumes 1 and 2. Fisheries Research Institute, College of Fisheries, University of Washington.

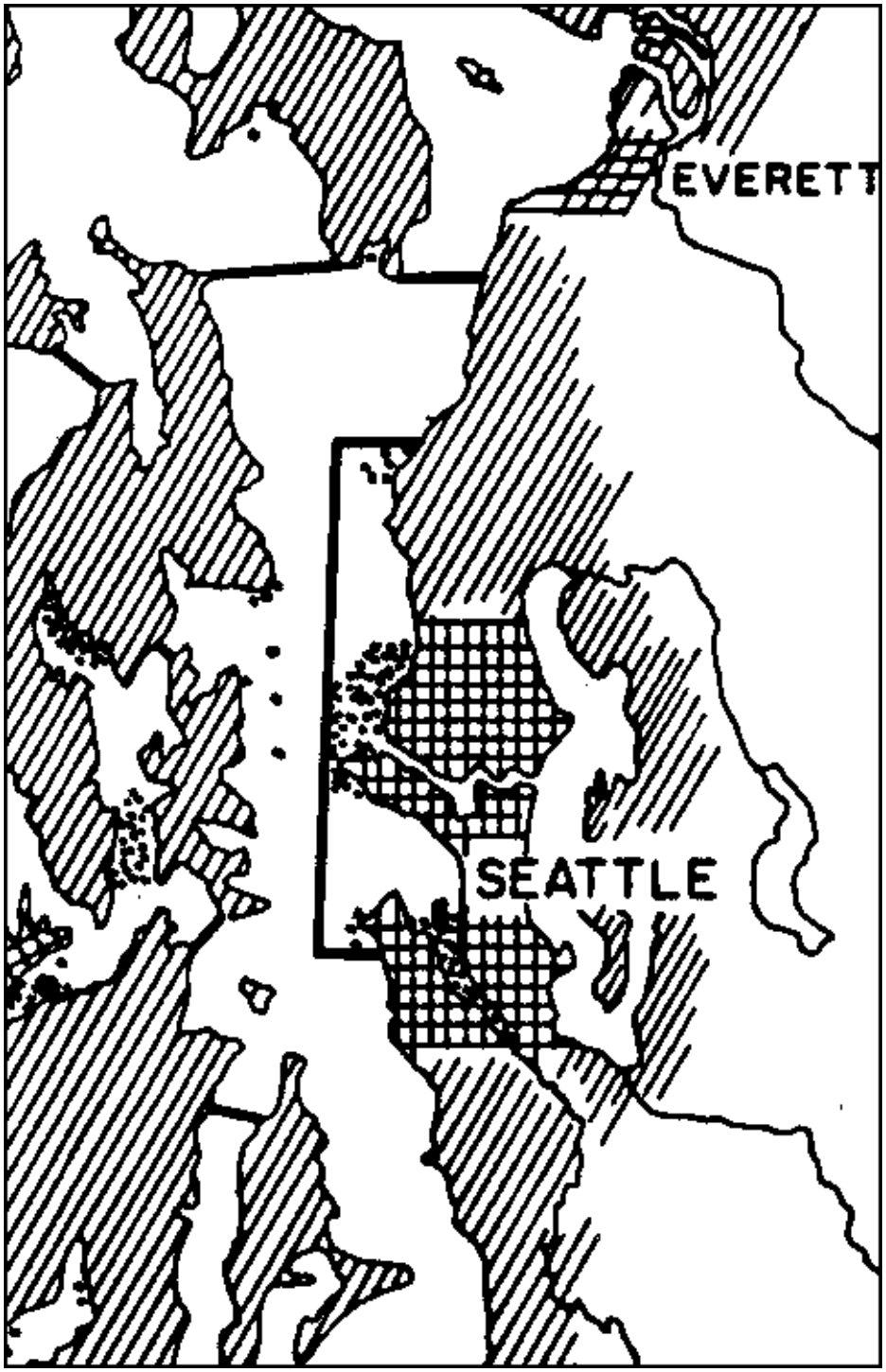

Figure B-13. Geographic distribution (represented by black dots) of *Hypomesus pretiosus* (Surf Smelt) in the Puget Sound. From: Miller, B.S. and S.F. Borton. 1980. Geographical distribution of Puget Sound fishes: Maps and data source sheets. Volumes 1 and 2. Fisheries Research Institute, College of Fisheries, University of Washington.

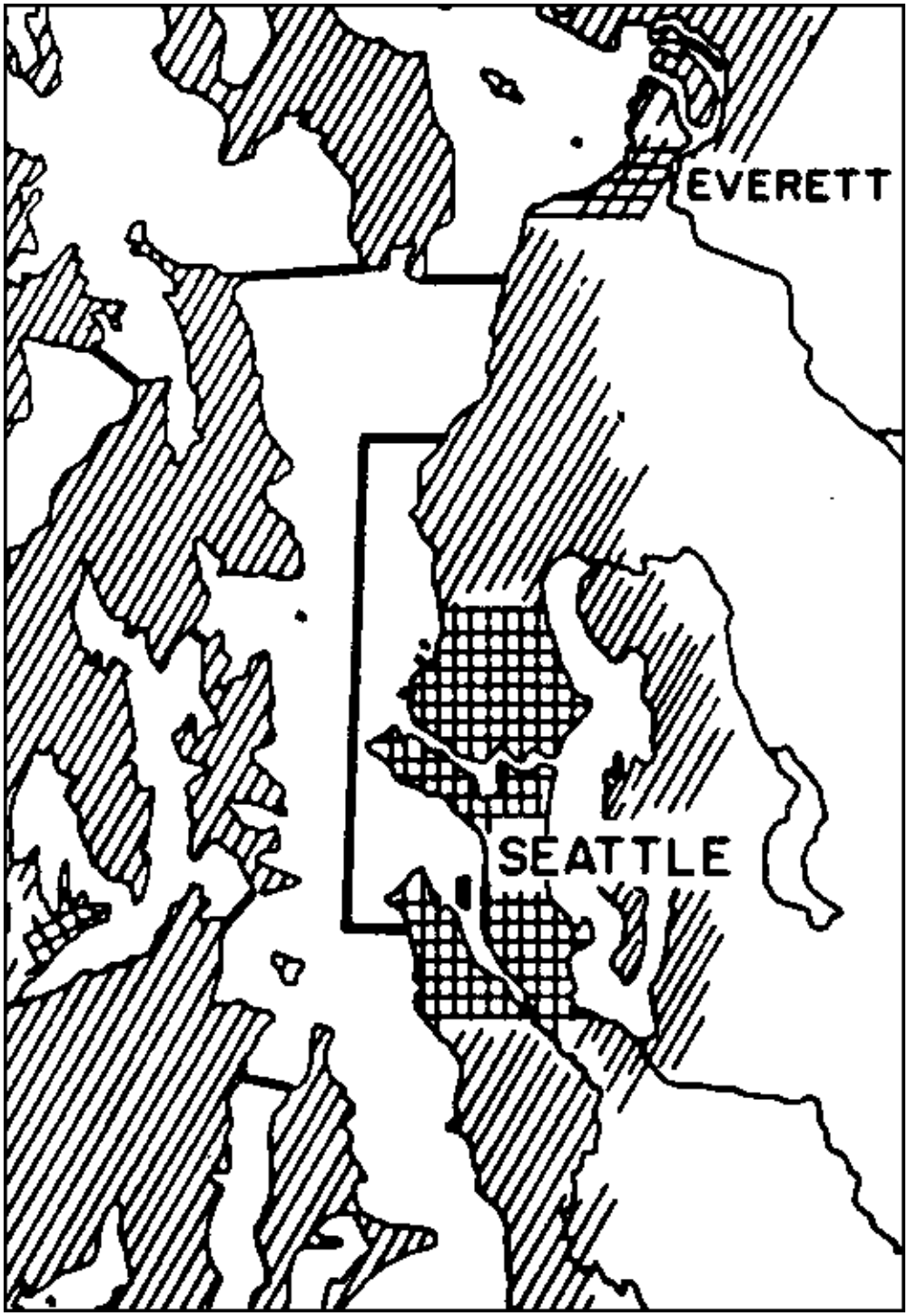

Figure B-14. Geographic distribution (represented by black dots) of *Thaleichthys pacificus* (Eulachon) in the Puget Sound. From: Miller, B.S. and S.F. Borton. 1980. Geographical distribution of Puget Sound fishes: Maps and data source sheets. Volumes 1 and 2. Fisheries Research Institute, College of Fisheries, University of Washington.

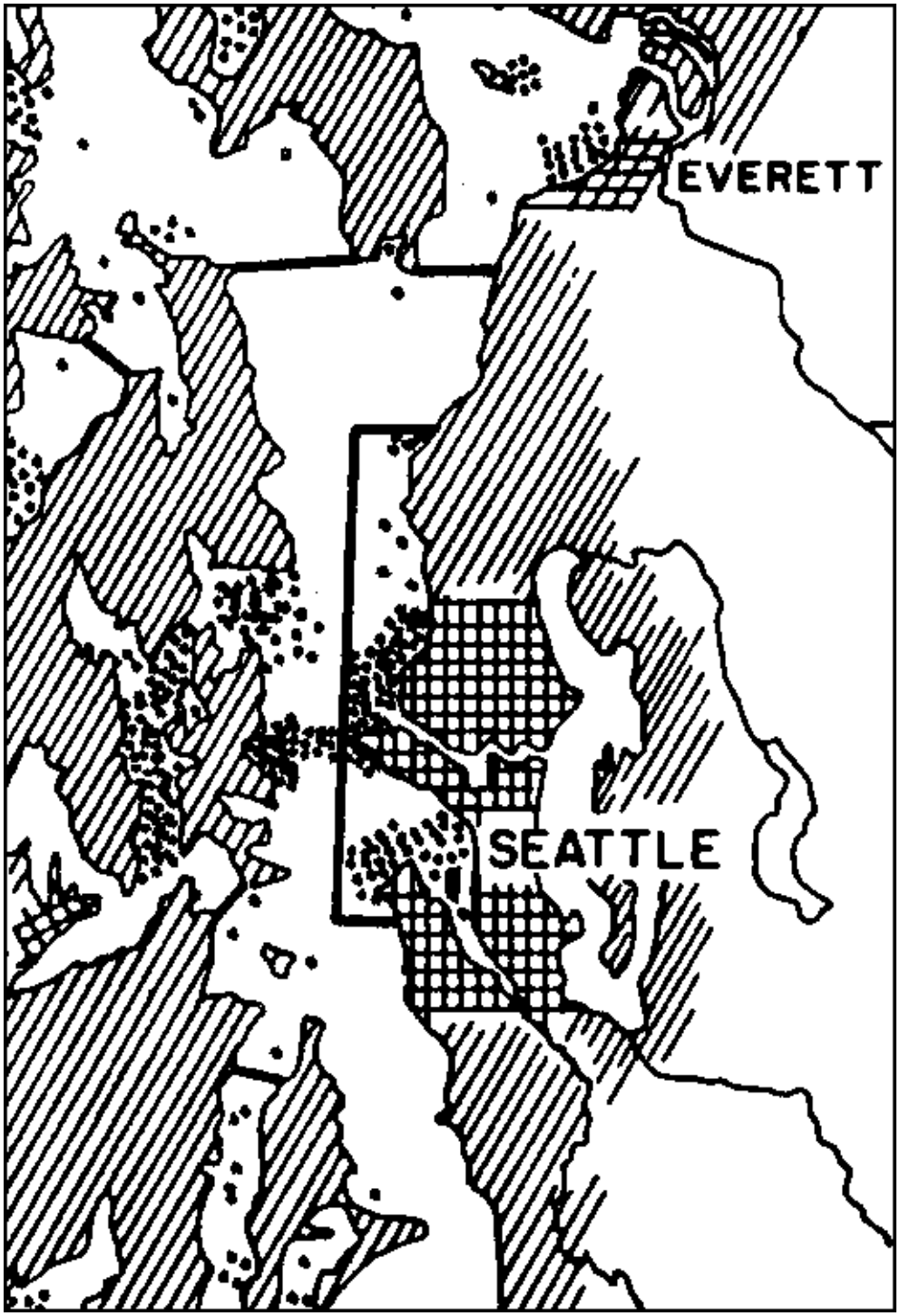

Figure B-15. Geographic distribution (represented by black dots) of *Gadus macrocephalus* (Pacific Cod) in the Puget Sound. From: Miller, B.S. and S.F. Borton. 1980. Geographical distribution of Puget Sound fishes: Maps and data source sheets. Volumes 1 and 2. Fisheries Research Institute, College of Fisheries, University of Washington.

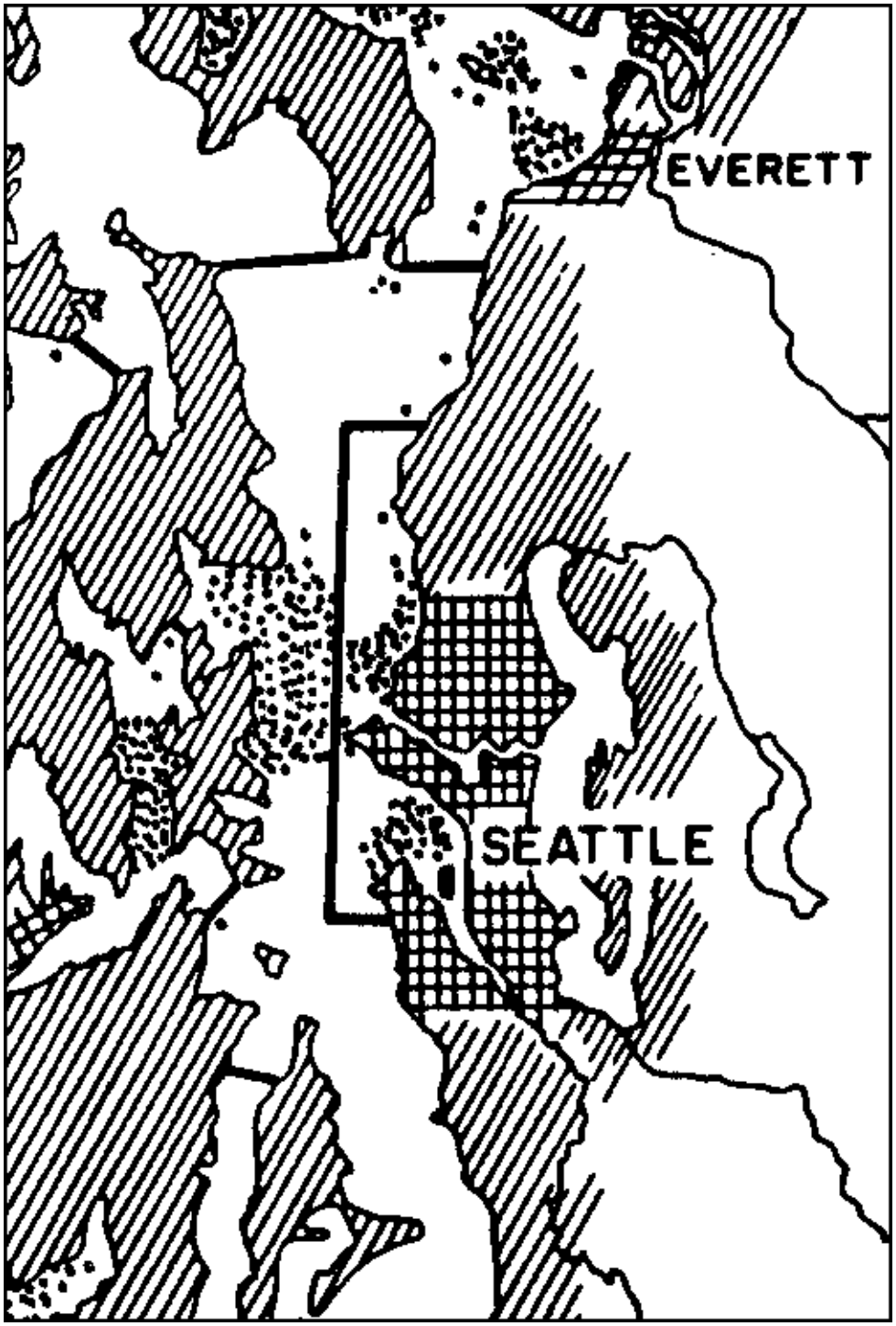

Figure B-16. Geographic distribution (represented by black dots) of *Merluccius productus* (Pacific Hake) in the Puget Sound. From: Miller, B.S. and S.F. Borton. 1980. Geographical distribution of Puget Sound fishes: Maps and data source sheets. Volumes 1 and 2. Fisheries Research Institute, College of Fisheries, University of Washington.

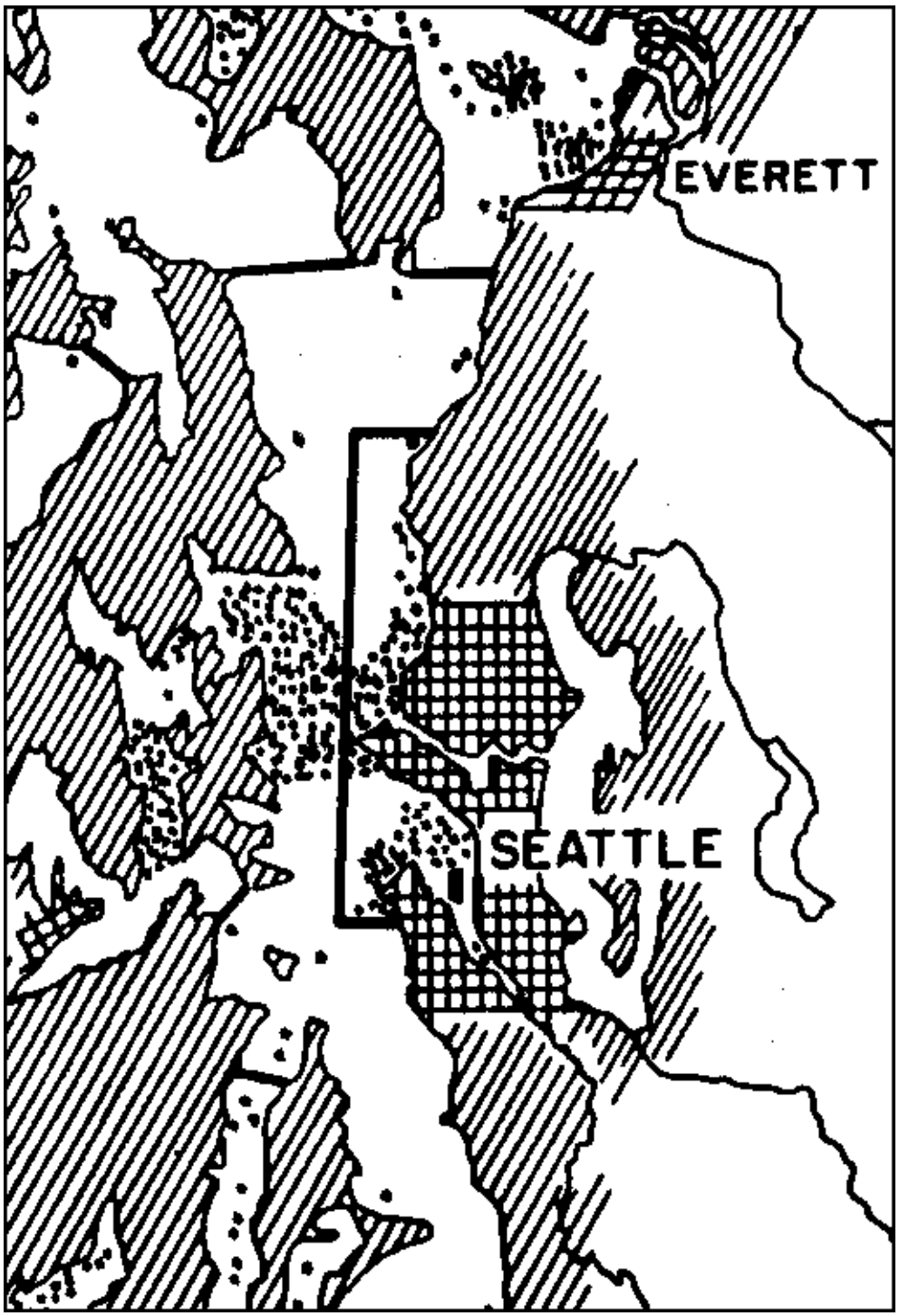

Figure B-17. Geographic distribution (represented by black dots) of *Theragra chalcogramma* (Walleye Pollock) in the Puget Sound. From: Miller, B.S. and S.F. Borton. 1980. Geographical distribution of Puget Sound fishes: Maps and data source sheets. Volumes 1 and 2. Fisheries Research Institute, College of Fisheries, University of Washington.

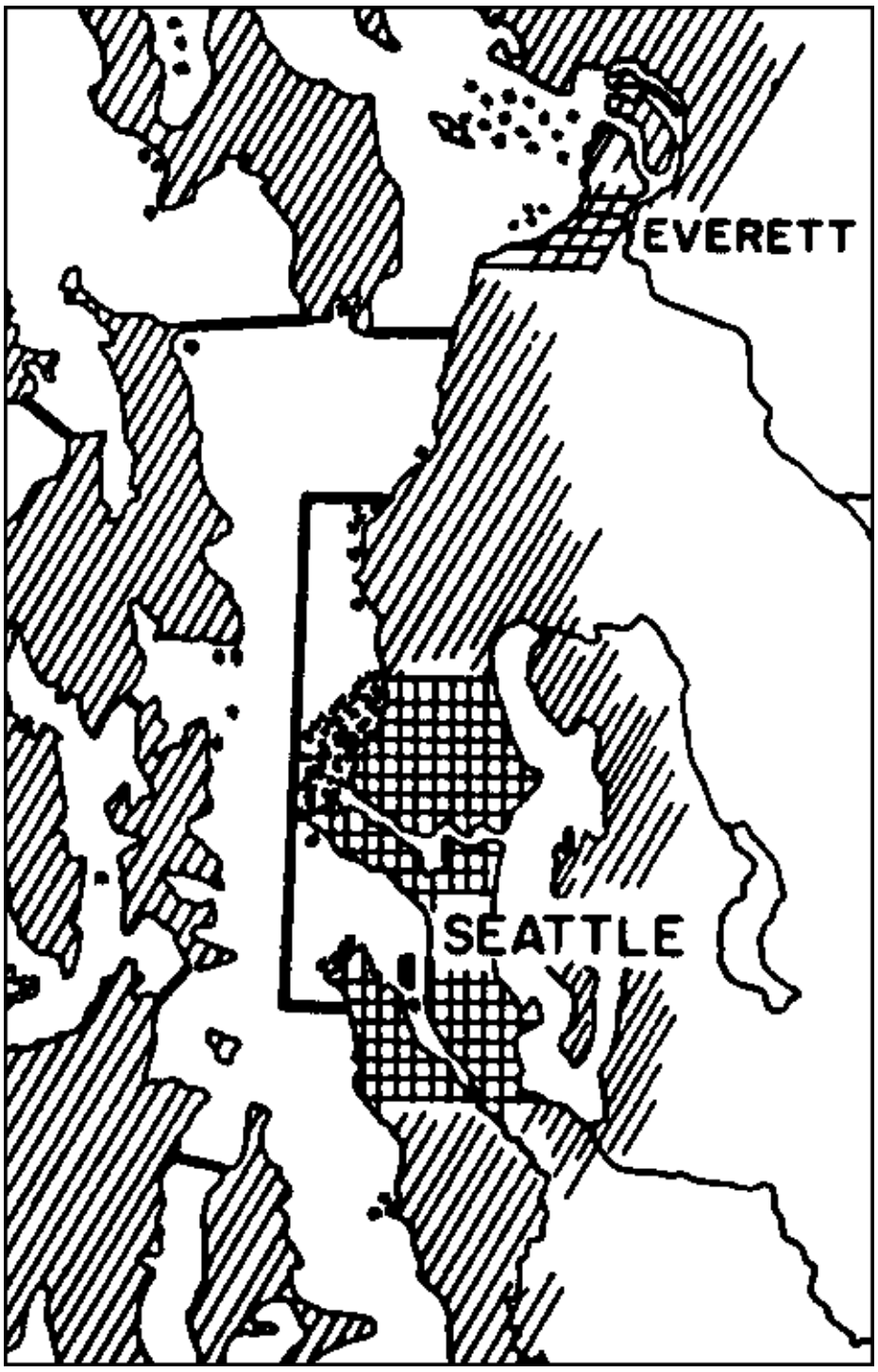

Figure B-18. Geographic distribution (represented by black dots) of *Ammodytes hexapterus* (Sand Lance) in the Puget Sound. From: Miller, B.S. and S.F. Borton. 1980. Geographical distribution of Puget Sound fishes: Maps and data source sheets. Volumes 1 and 2. Fisheries Research Institute, College of Fisheries, University of Washington.

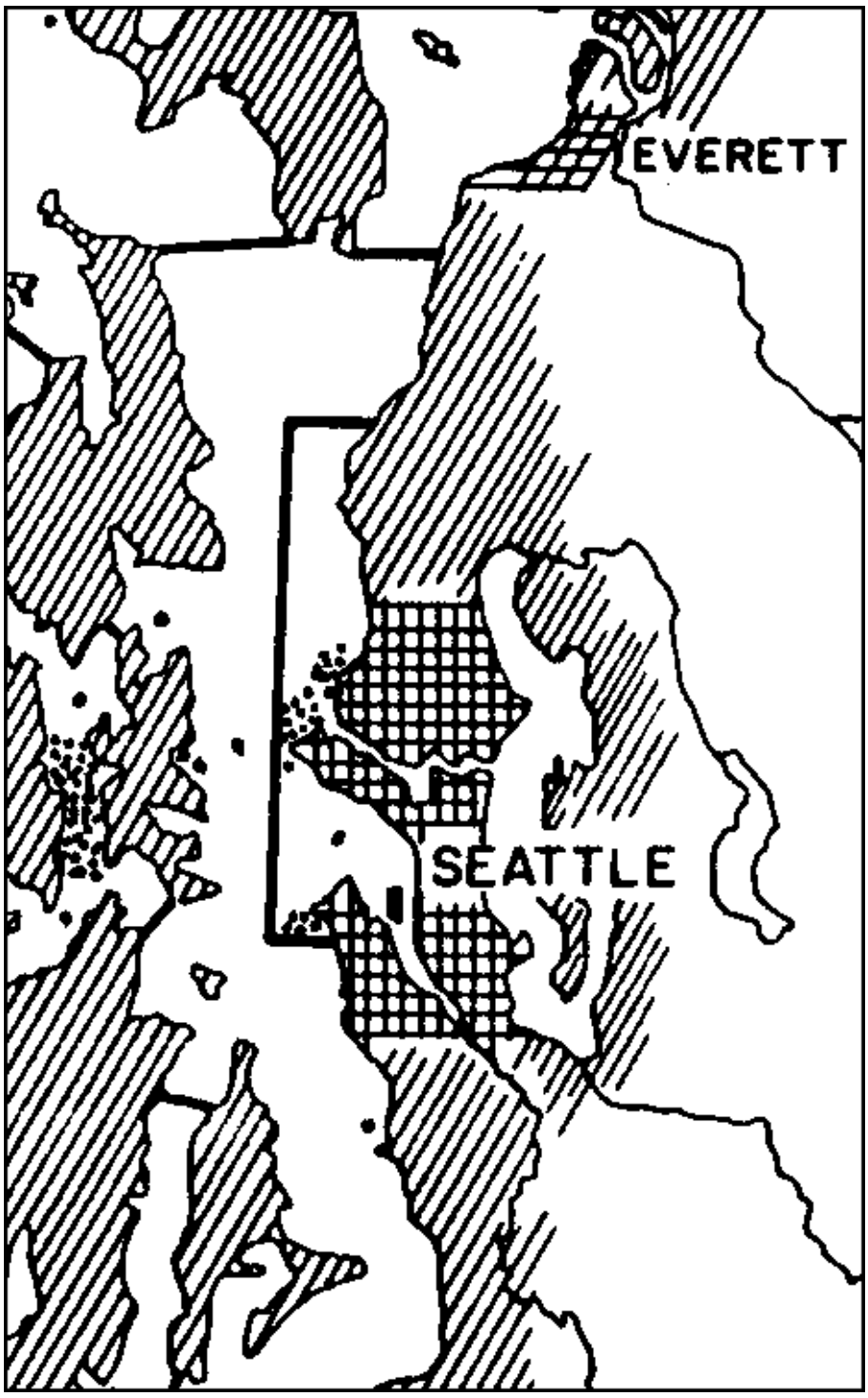

Figure B-19. Geographic distribution (represented by black dots) of *Sebastes auriculatus* (Brown Rockfish) in the Puget Sound. From: Miller, B.S. and S.F. Borton. 1980. Geographical distribution of Puget Sound fishes: Maps and data source sheets. Volumes 1 and 2. Fisheries Research Institute, College of Fisheries, University of Washington.

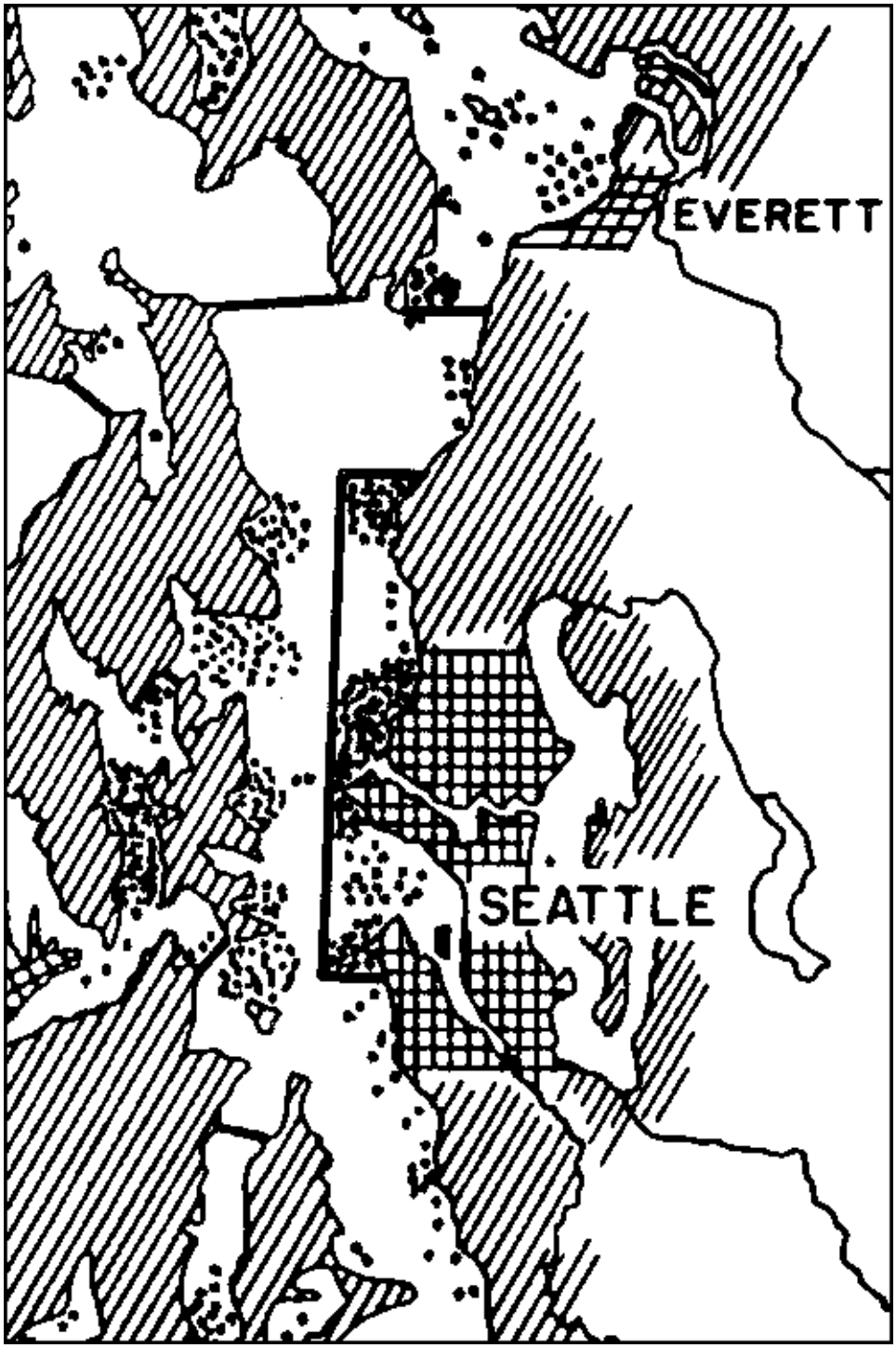

Figure B-20. Geographic distribution (represented by black dots) of *Sebastes caurinus* (Copper Rockfish) in the Puget Sound. From: Miller, B.S. and S.F. Borton. 1980. Geographical distribution of Puget Sound fishes: Maps and data source sheets. Volumes 1 and 2. Fisheries Research Institute, College of Fisheries, University of Washington.

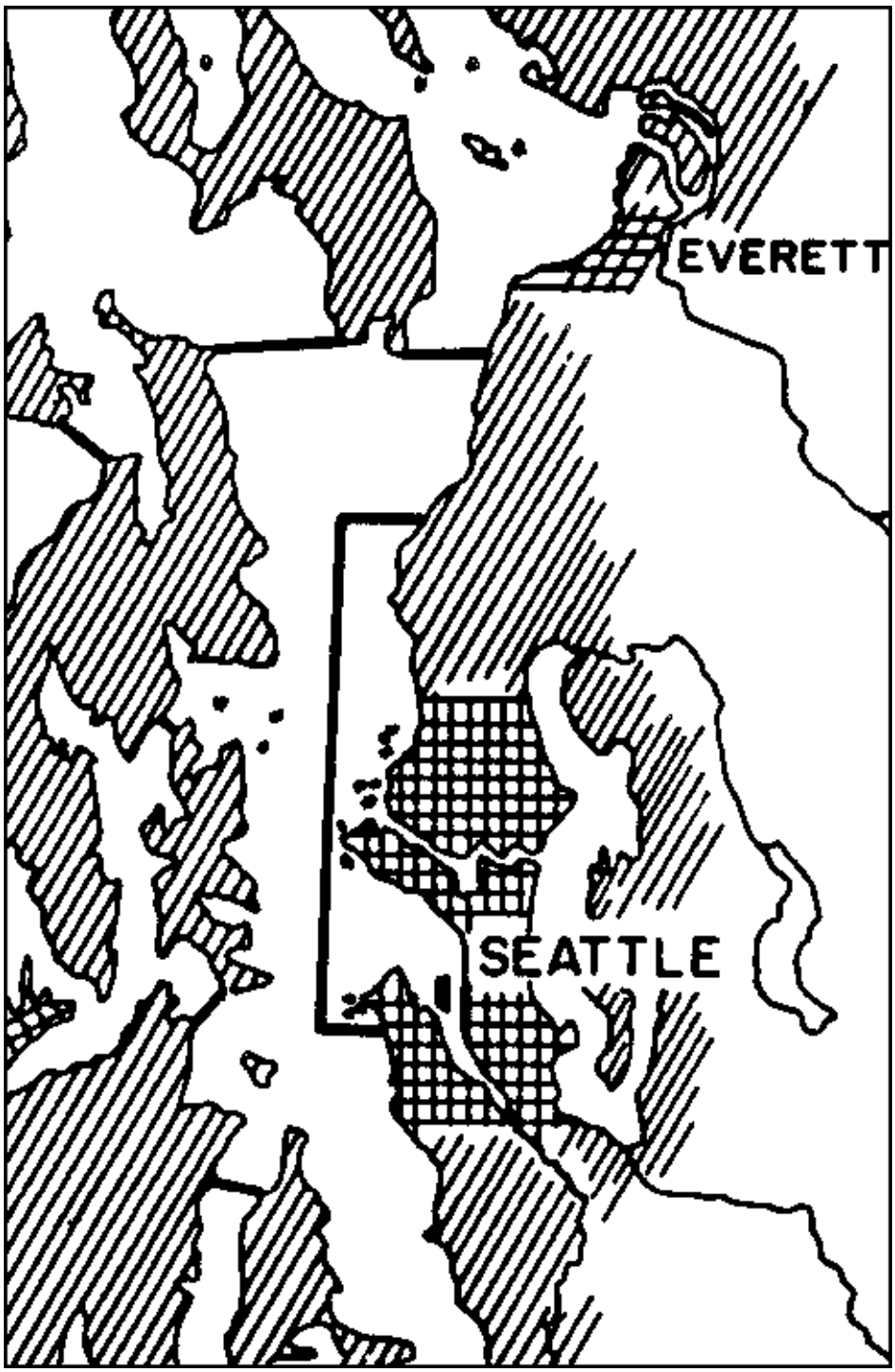

Figure B-21. Geographic distribution (represented by black dots) of *Sebastes elongates* (Greenstripe Rockfish) in the Puget Sound. From: Miller, B.S. and S.F. Borton. 1980. Geographical distribution of Puget Sound fishes: Maps and data source sheets. Volumes 1 and 2. Fisheries Research Institute, College of Fisheries, University of Washington.

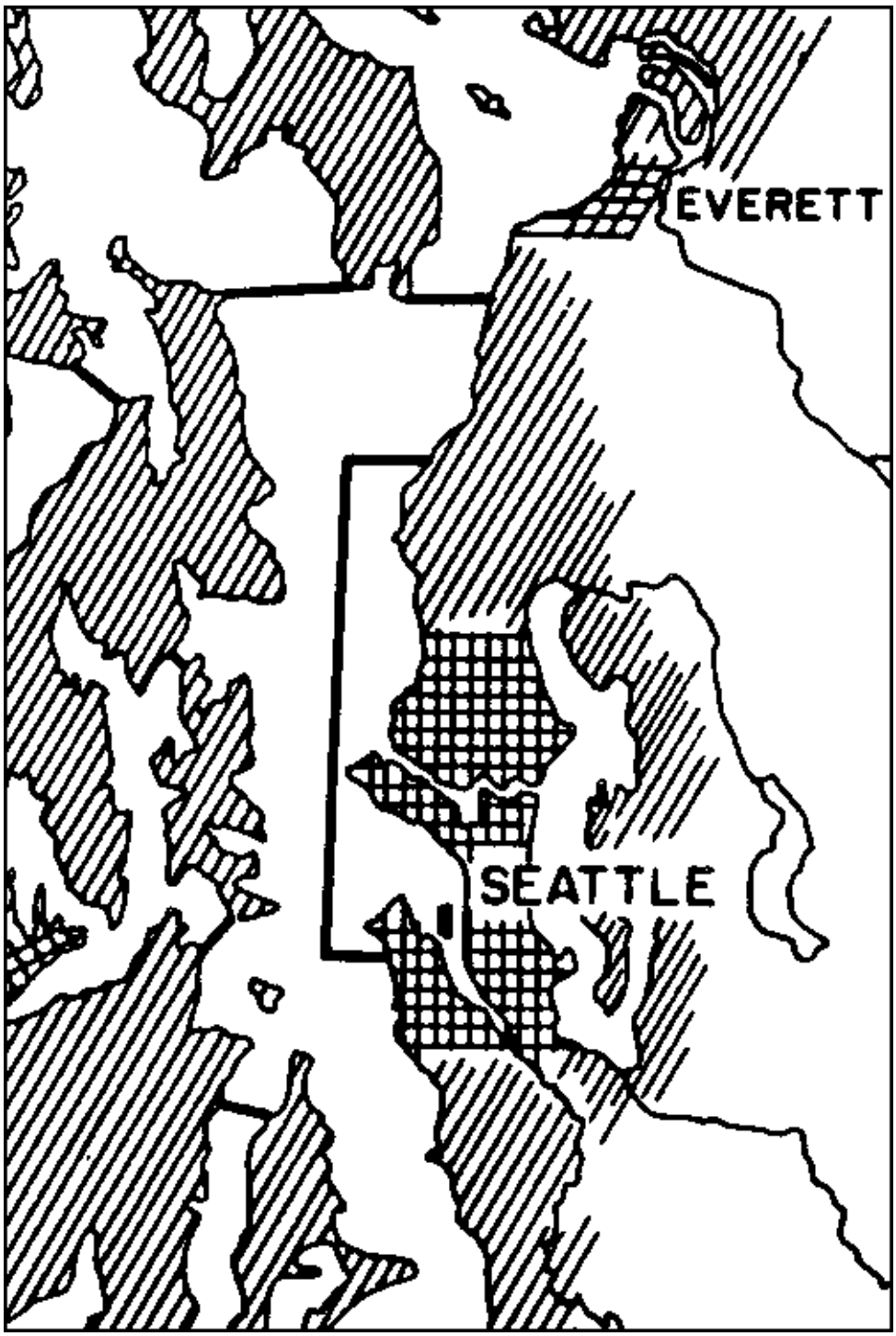

Figure B-22. Geographic distribution (represented by black dots) of *Sebastes entomelus* (Widow Rockfish) in the Puget Sound. From: Miller, B.S. and S.F. Borton. 1980. Geographical distribution of Puget Sound fishes: Maps and data source sheets. Volumes 1 and 2. Fisheries Research Institute, College of Fisheries, University of Washington.

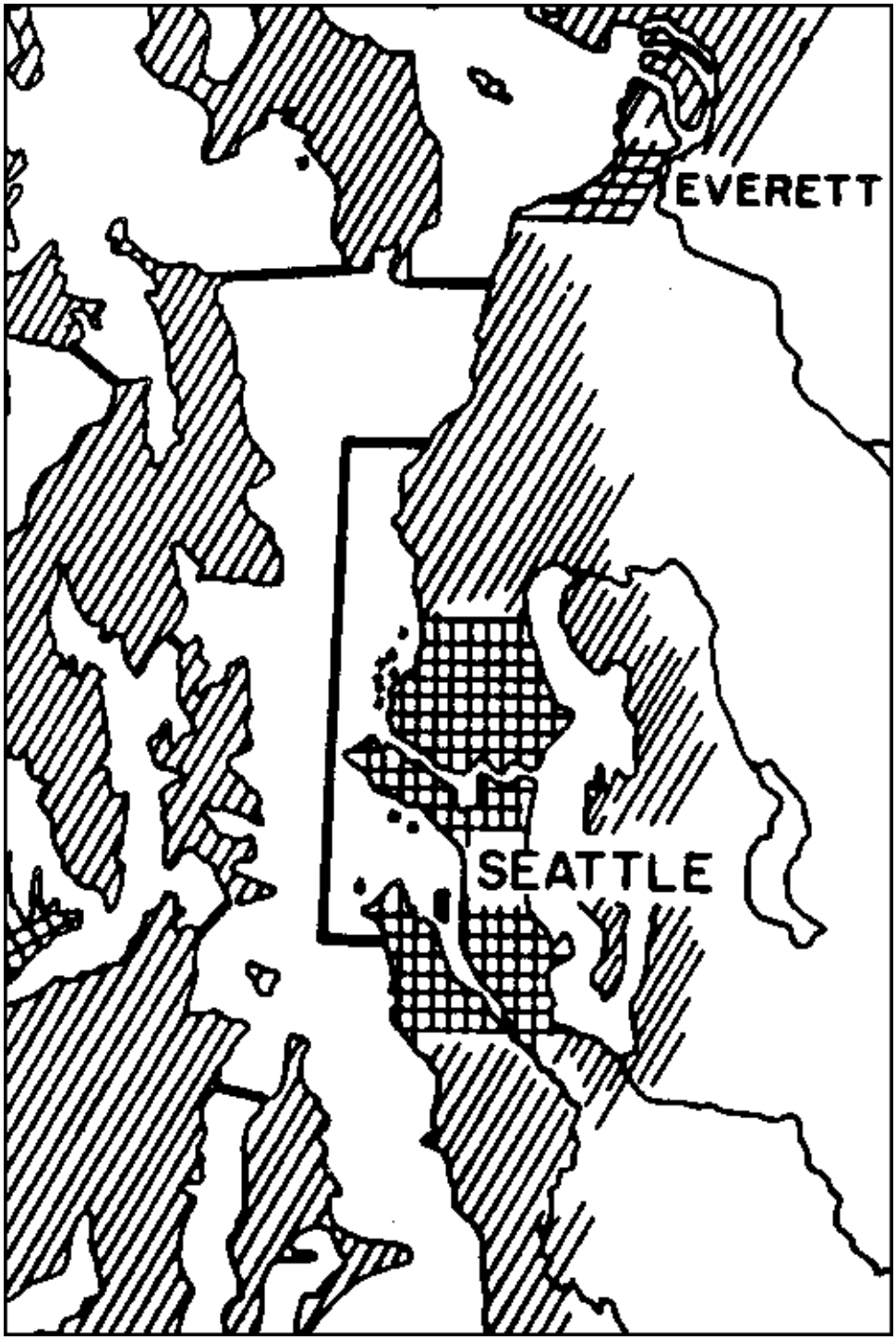

Figure B-23. Geographic distribution (represented by black dots) of *Sebastes flavidus* (Yellowtail Rockfish) in the Puget Sound. From: Miller, B.S. and S.F. Borton. 1980. Geographical distribution of Puget Sound fishes: Maps and data source sheets. Volumes 1 and 2. Fisheries Research Institute, College of Fisheries, University of Washington.

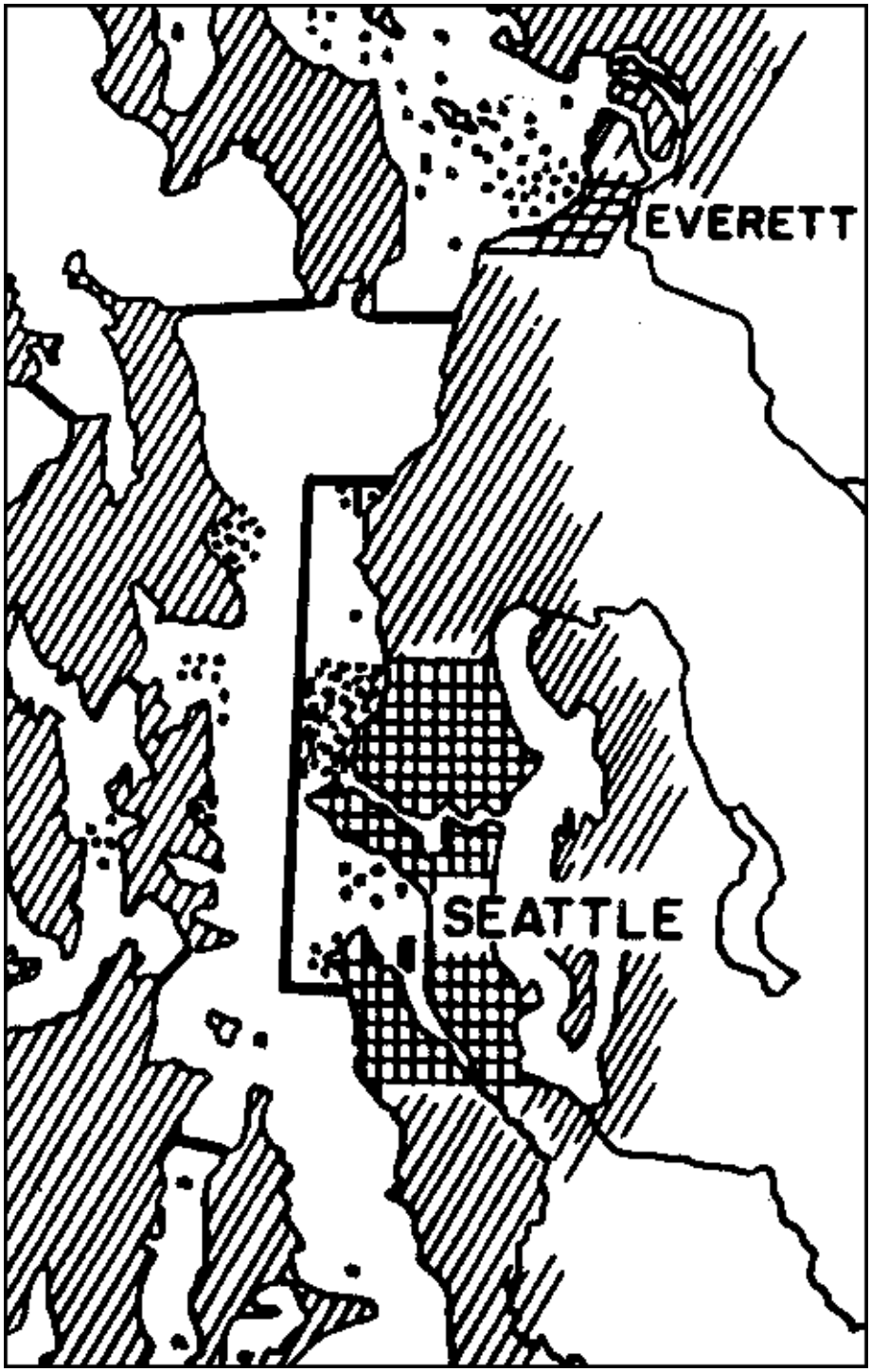

Figure B-24. Geographic distribution (represented by black dots) of *Sebastes maliger* (Quillback Rockfish) in the Puget Sound. From: Miller, B.S. and S.F. Borton. 1980. Geographical distribution of Puget Sound fishes: Maps and data source sheets. Volumes 1 and 2. Fisheries Research Institute, College of Fisheries, University of Washington.

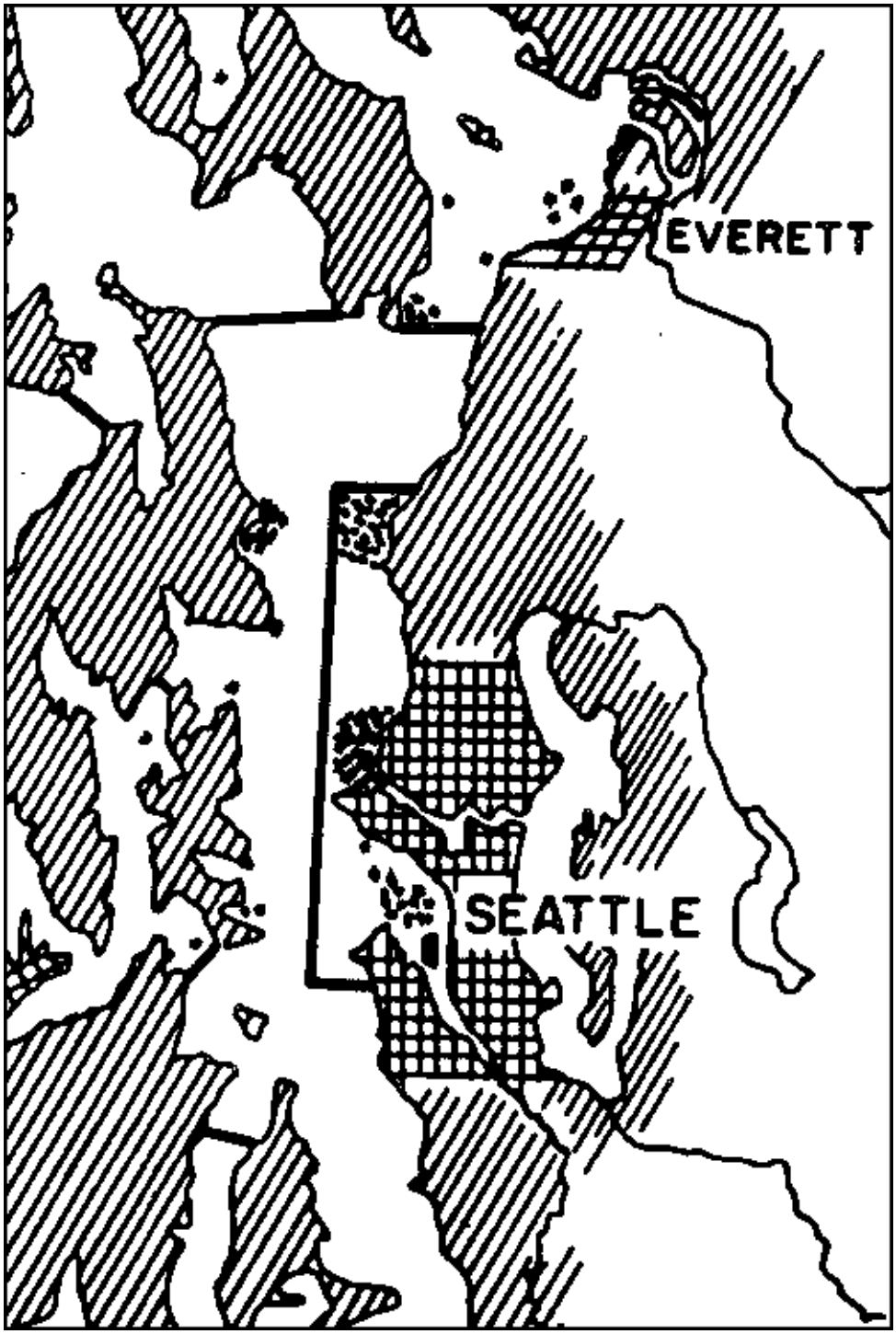

Figure B-25. Geographic distribution (represented by black dots) of *Sebastes melanops* (Black Rockfish) in the Puget Sound. From: Miller, B.S. and S.F. Borton. 1980. Geographical distribution of Puget Sound fishes: Maps and data source sheets. Volumes 1 and 2. Fisheries Research Institute, College of Fisheries, University of Washington.

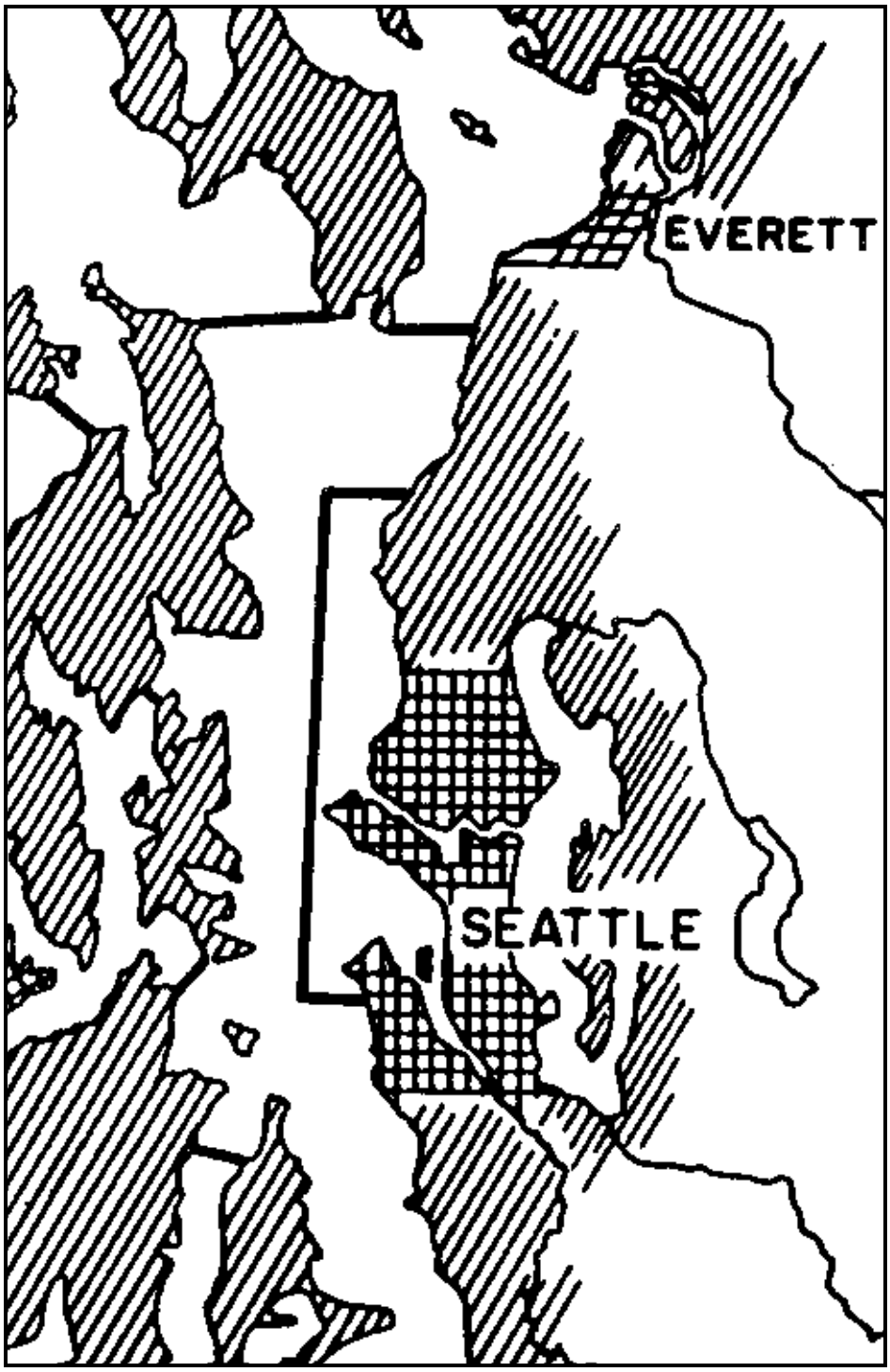

Figure B-26. Geographic distribution (represented by black dots) of *Sebastes mystinus* (Blue Rockfish) in the Puget Sound. From: Miller, B.S. and S.F. Borton. 1980. Geographical distribution of Puget Sound fishes: Maps and data source sheets. Volumes 1 and 2. Fisheries Research Institute, College of Fisheries, University of Washington.

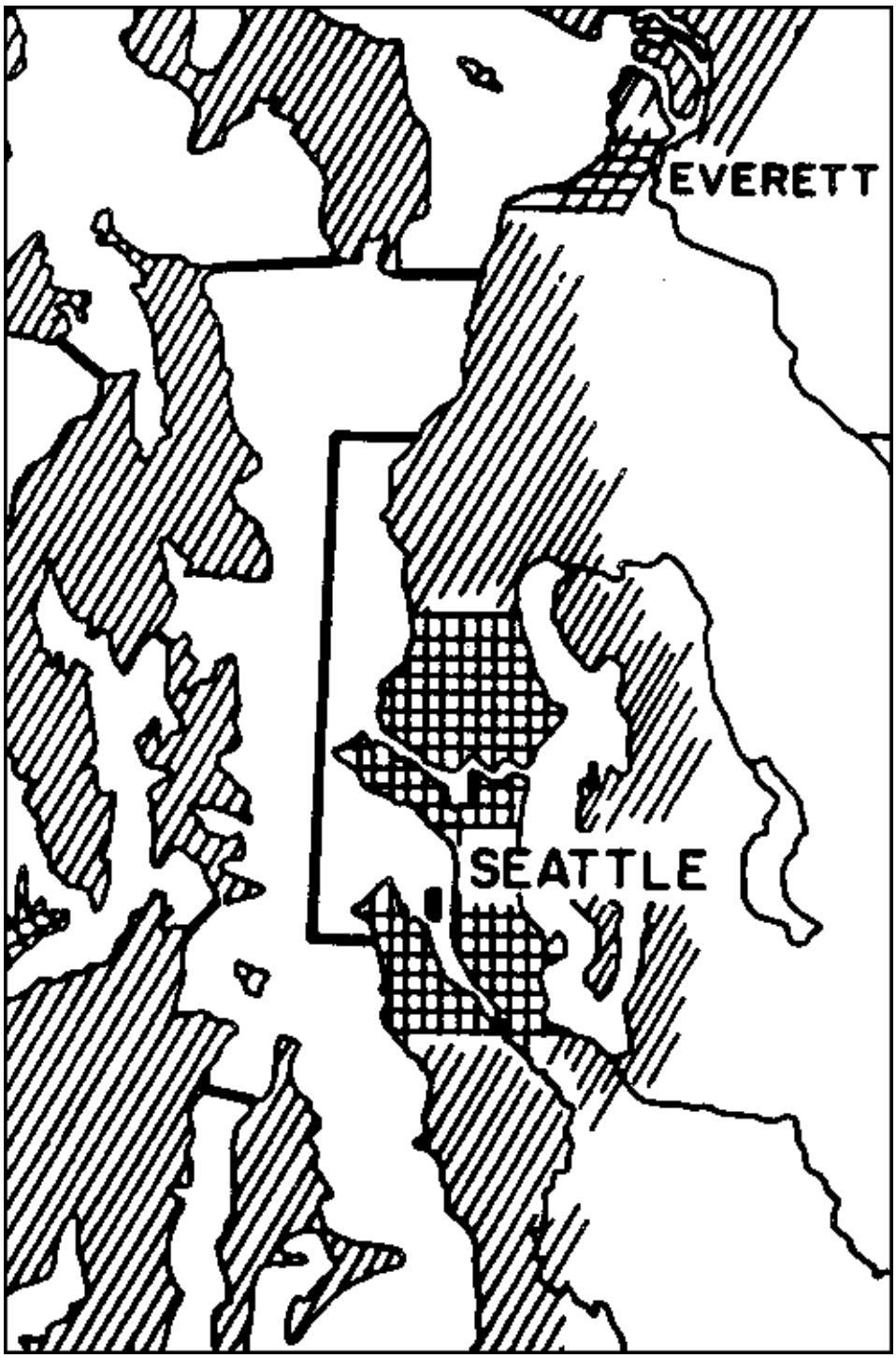

Figure B-27. Geographic distribution (represented by black dots) of *Sebastes nebulosus* (China Rockfish) in the Puget Sound. From: Miller, B.S. and S.F. Borton. 1980. Geographical distribution of Puget Sound fishes: Maps and data source sheets. Volumes 1 and 2. Fisheries Research Institute, College of Fisheries, University of Washington.

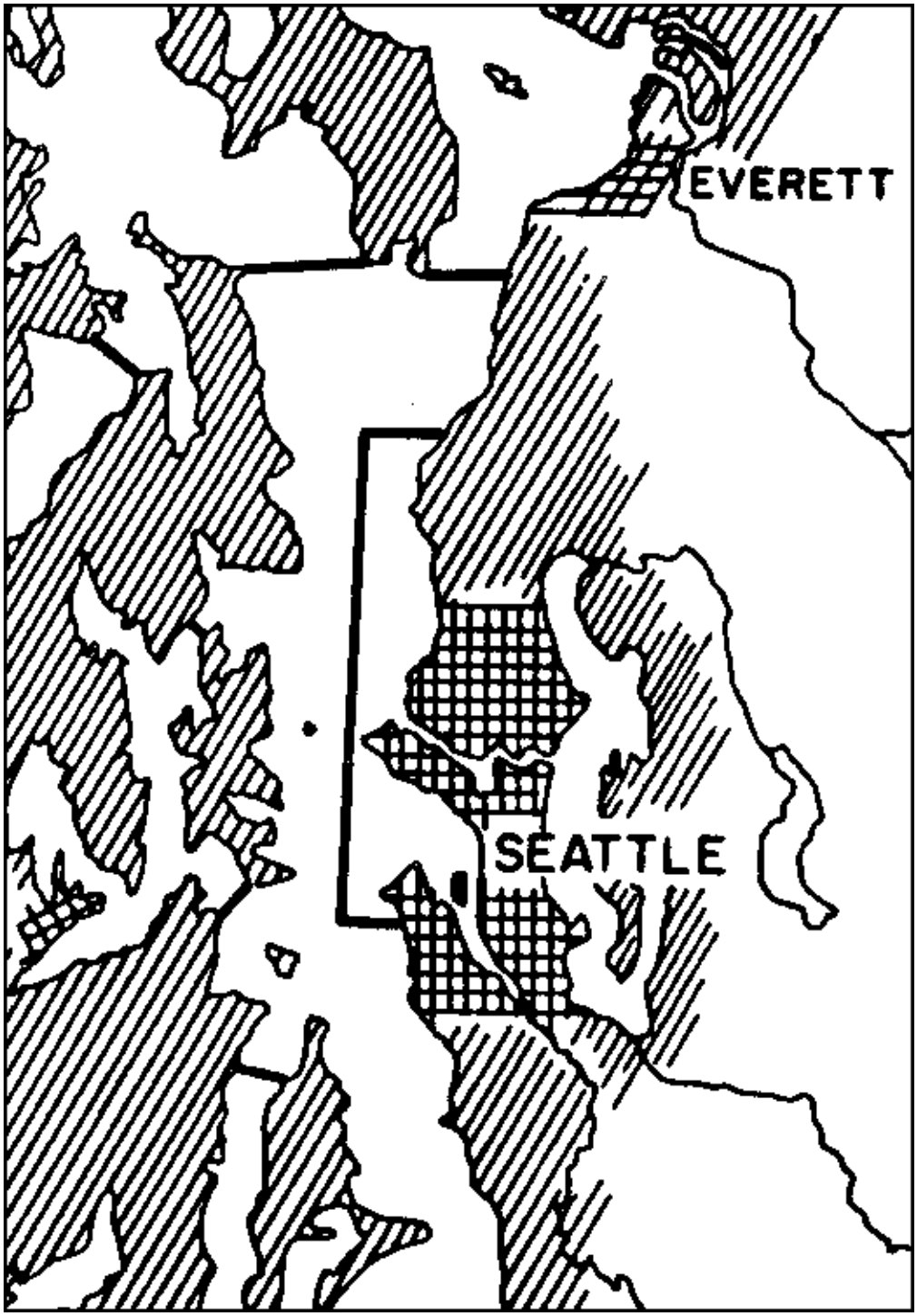

Figure B-28. Geographic distribution (represented by black dots) of *Sebastes nigrocinctus* (Tiger Rockfish) in the Puget Sound. From: Miller, B.S. and S.F. Borton. 1980. Geographical distribution of Puget Sound fishes: Maps and data source sheets. Volumes 1 and 2. Fisheries Research Institute, College of Fisheries, University of Washington.

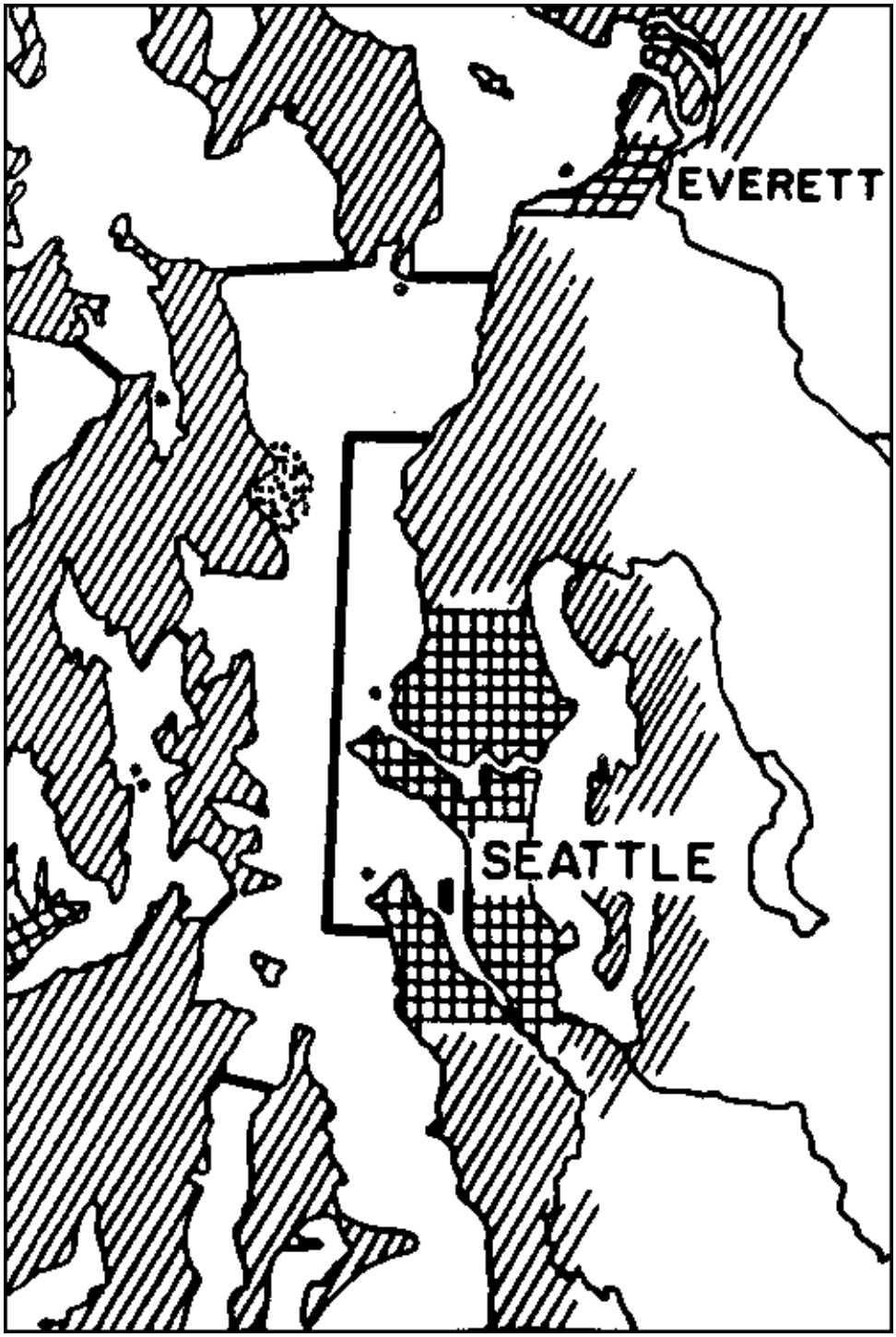

Figure B-29. Geographic distribution (represented by black dots) of *Sebastes paucispinus* (Bocaccio Rockfish) in the Puget Sound. From: Miller, B.S. and S.F. Borton. 1980. Geographical distribution of Puget Sound fishes: Maps and data source sheets. Volumes 1 and 2. Fisheries Research Institute, College of Fisheries, University of Washington.

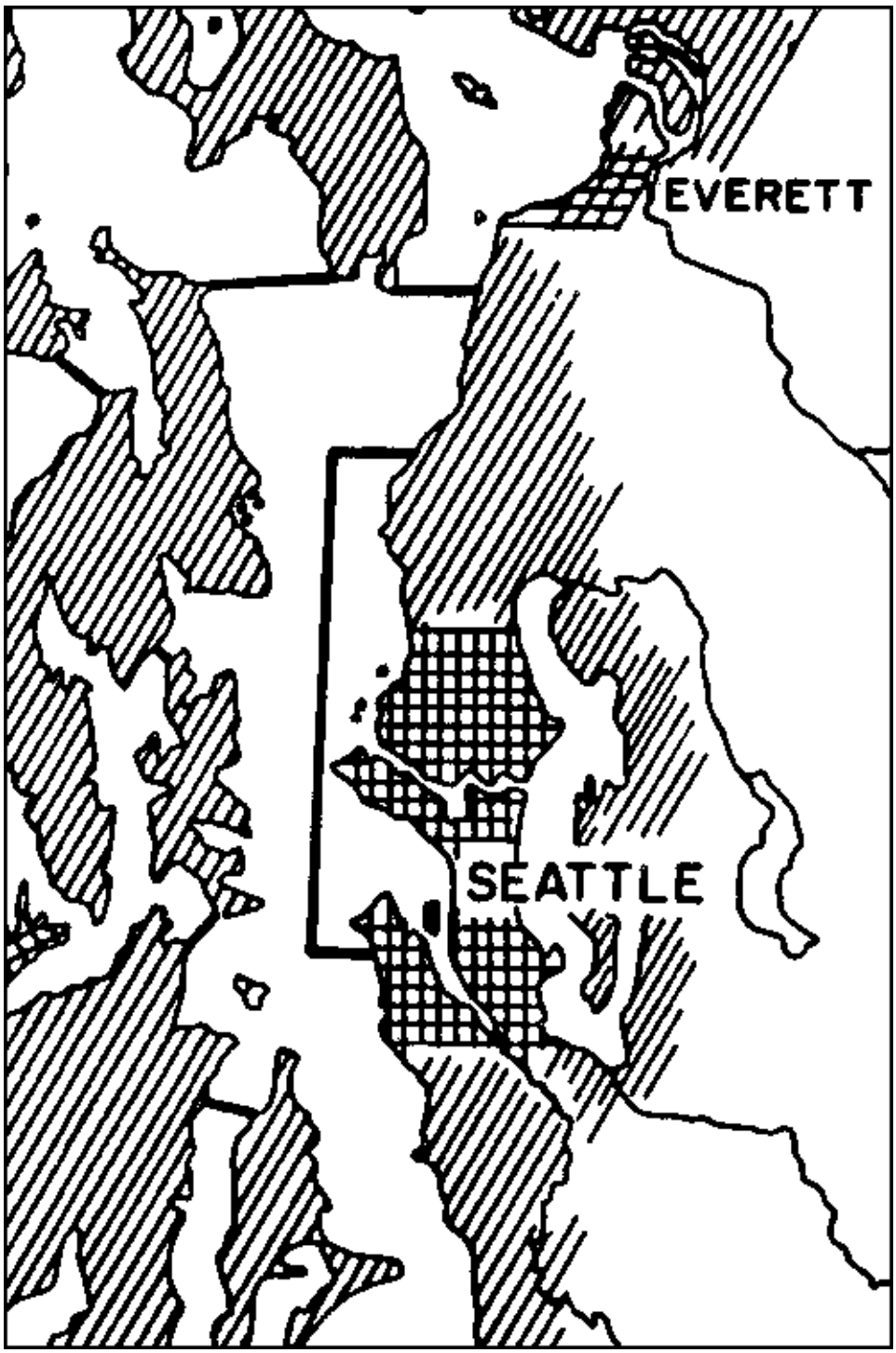

Figure B-30. Geographic distribution (represented by black dots) of *Sebastes pinniger* (Canary Rockfish) in the Puget Sound. From: Miller, B.S. and S.F. Borton. 1980. Geographical distribution of Puget Sound fishes: Maps and data source sheets. Volumes 1 and 2. Fisheries Research Institute, College of Fisheries, University of Washington.

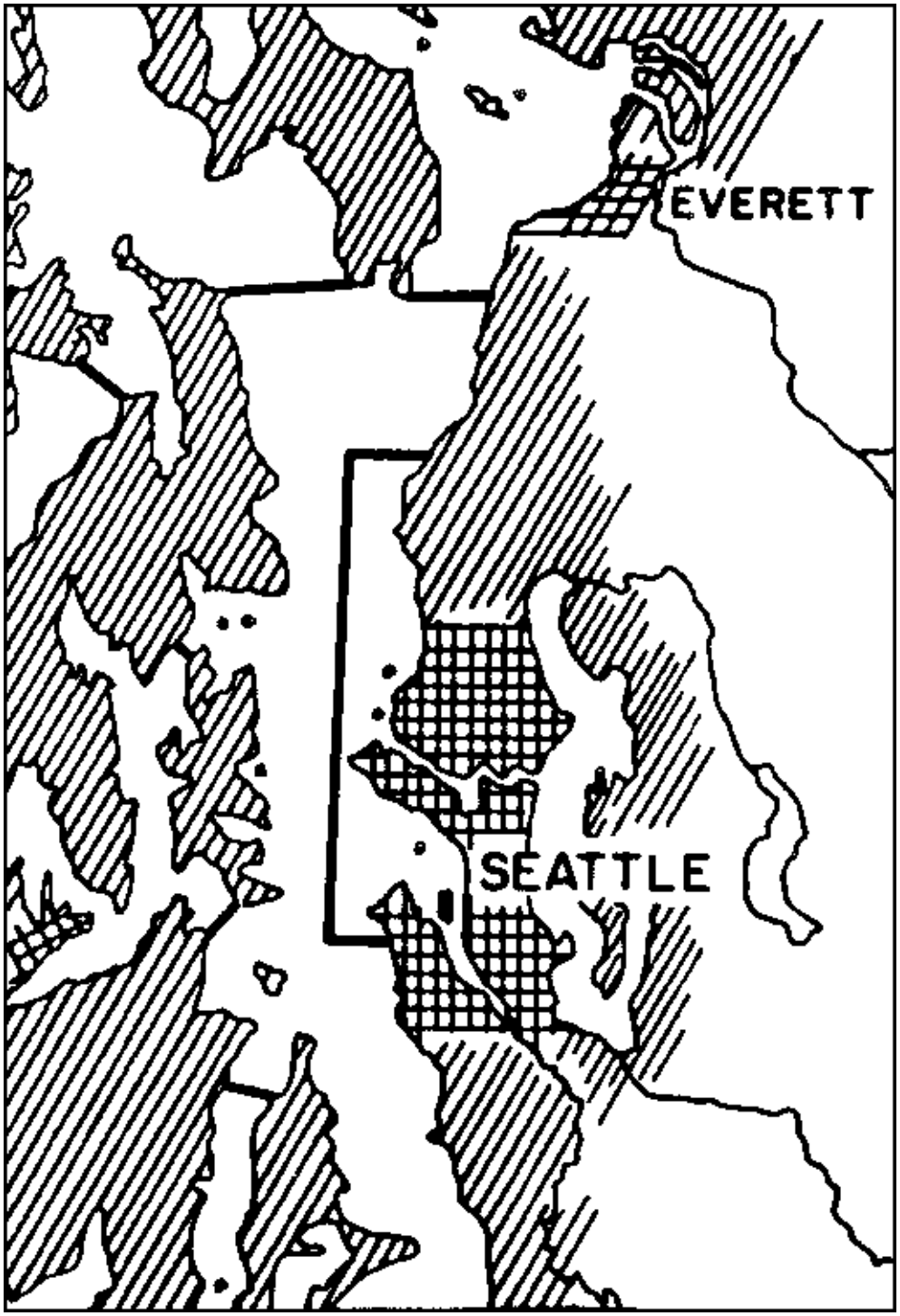

Figure B-31. Geographic distribution (represented by black dots) of *Sebastes proriger* (Redstripe Rockfish) in the Puget Sound. From: Miller, B.S. and S.F. Borton. 1980. Geographical distribution of Puget Sound fishes: Maps and data source sheets. Volumes 1 and 2. Fisheries Research Institute, College of Fisheries, University of Washington.

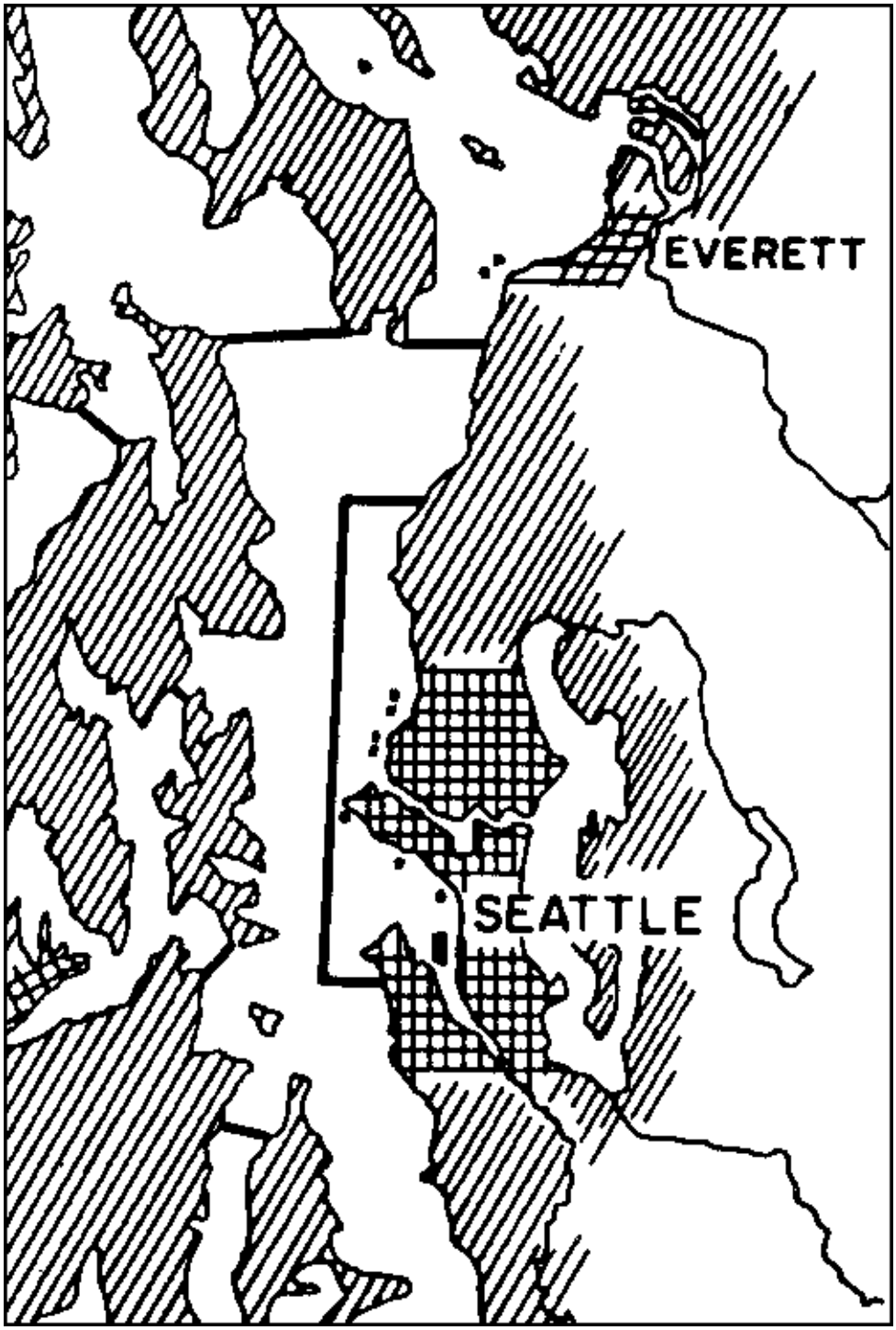

Figure B-32. Geographic distribution (represented by black dots) of *Sebastes ruberrimus* (Yelloweye Rockfish) in the Puget Sound. From: Miller, B.S. and S.F. Borton. 1980. Geographical distribution of Puget Sound fishes: Maps and data source sheets. Volumes 1 and 2. Fisheries Research Institute, College of Fisheries, University of Washington.

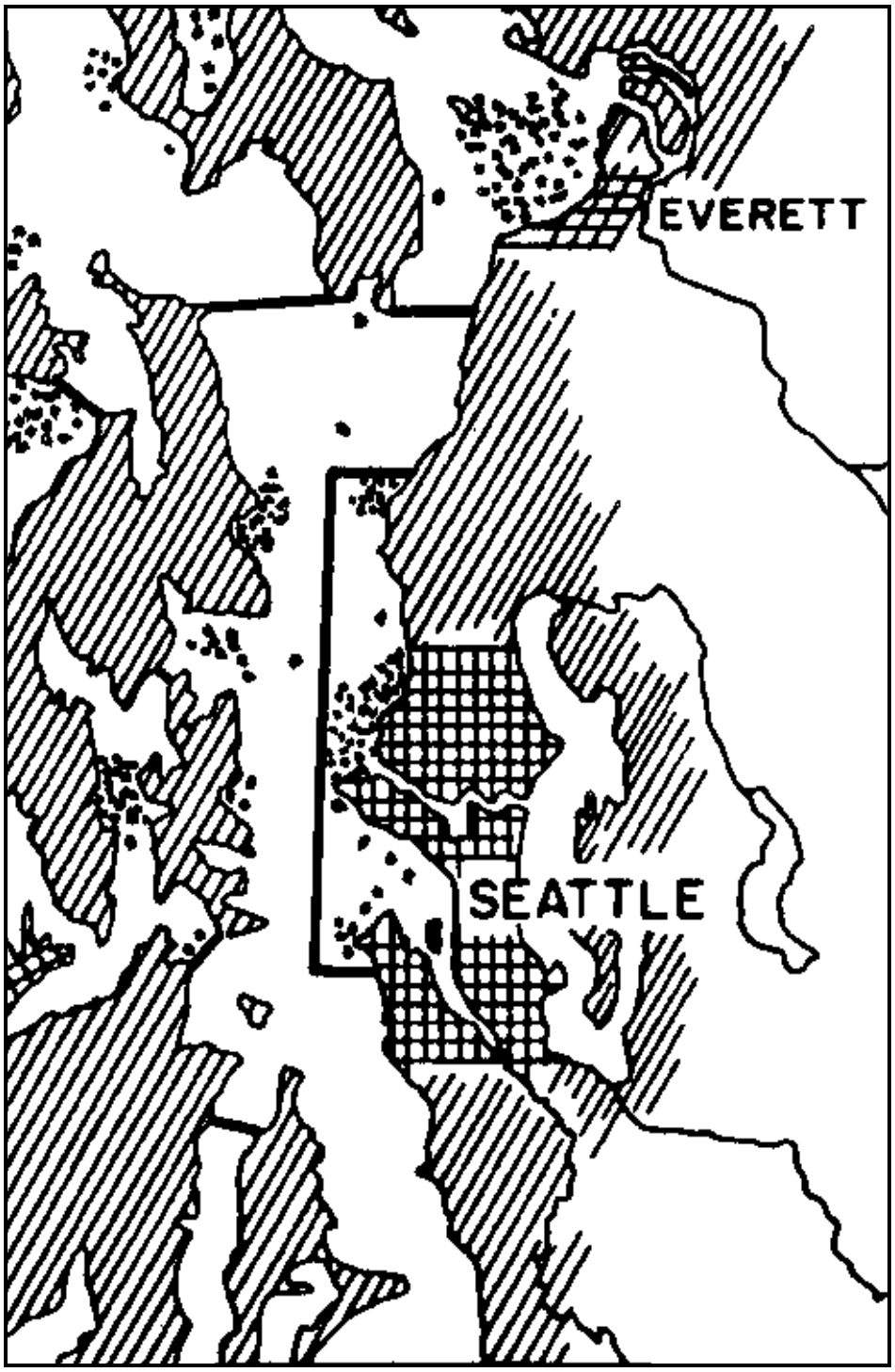

Figure B-33. Geographic distribution (represented by black dots) of *Ophiodon elongates* (Lingcod) in the Puget Sound. From: Miller, B.S. and S.F. Borton. 1980. Geographical distribution of Puget Sound fishes: Maps and data source sheets. Volumes 1 and 2. Fisheries Research Institute, College of Fisheries, University of Washington.

FINAL

King County Marine Habitat Report
Prepared in support of the Wastewater Treatment Division Habitat Conservation Plan and the Brightwater Marine Outfall Siting Study

Appendix C
Washington State Department of Fish and Wildlife Video and Trawl Data

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January 2001

Submitted to:

King County Department of Natural Resources
201 South Jackson Street
Seattle, WA 98104

Submitted by:

Washington State Department of Fish and Wildlife
Fish Management Program
Marine Resources Division
600 Capital Way North
Olympia, WA 98501

WASHINGTON STATE DEPARTMENT OF FISH AND WILDLIFE VIDEO AND TRAWL SURVEYS

(from Wayne Palsson, WDFW)

The following codes were used to describe information collected by the WDFW during video and trawl surveys performed between 1987 and 1995.

VIDEO SURVEY CODES

STATION
6 digit numeric (123456)

123 = last 3 digits of chart number
456 = station number

SUB1 (dominant substrate type)
SUB2 (secondary substrate type)
1 = artificial (pilings, tires, ships, etc)
2 = hardpan (e.g., sandstone)
3 = bedrock
4 = boulder (rocks >256 mm/10" diam.)
5 = cobble (rocks 64-256 mm diam.)
6 = mixed course (cobble/gravel/shell)
7 = gravel (small rocks and pebbles 4-64 mm diam.)
8 = sand (or sand/shell)
9 = mud (or mud/shell)

REEF (derived field from SUB1 and SUB2)

1 = Rocky reef (if SUB1 or SUB2 = 2, 3 or 4)
2 = Coarse (cobble, pebble, gravel)
3 = Fine sand/mud
4 = Artificial

BIO (derive field from BIO1 and BIO2)

1 = encrusting organism complex
0 = other

BIOCOVER 1 (BIO1) (dominant cover type)
BIOCOVER 2 (BIO2) (secondary cover type)

1 = bare (<10% cover)
2 = kelp
3 = ulva
4 = other algae
5 = algal mat
6 = scallops
7 = barnacles

8 = anemones (mainly ***Metridium***)
9 = encrusting organism complex (e.g., barnacle/anemone/hydroid/Solus sp.-cucumber/bryozoan)
10 = eelgrass
11 = ophiuroids
12 = tube worms, worm tubes
13 = debris, detritus
14 = sea pens/sea whips
15 = sponges
99 = unidentified

Abbreviation	Species	HCP Target Species?
COP	copper rockfish	Yes
QB	quillback rockfish	Yes
BLK	black rockfish	Yes
BRN	brown rockfish	Yes
BLU	blue rockfish	Yes
TIG	tiger rockfish	Yes
YT	yellowtail rockfish	Yes
YE	yelloweye rockfish	Yes
PUG	puget sound rockfish	No
UNIDRF	unidentified rockfish	?
LC	lingcod	Yes
KG	kelp greenling	No
WSG	whitespotted greenling	No
PG	painted greenling	No
SSP	striped seaperch	No
PP	pile perch	No
SP	shiner perch	No
KP	kelp perch	No
FF	flatfish	No
RURC	red sea urchin	No
GURC	green urchin	No
CUC	red sea cucumber	No
DUNG	dungeness crab	No

Notes:

1. Depth is given in feet (not normalized to mean low tide)
2. Densities are given in fish per square meter
3. Video plots generally ranged from 20 to 60 square meters

TRAWL SURVEY CODES

STATIONID

5th place corresponds to depth:

- S = 5 – 20 fms
- T = 21 – 40 fms
- U = 41 – 60 fms
- V = > 60 fms

Notes:

1. Density is given in both individual and kg per hectare
2. Trawl station areas were generally 0.7 to 2 hectares
3. PACIFIC WHITING (HAKE) = Pacific Hake
4. ROCKFISH UNIDEN. = HCP target species?
5. SMELT UNIDEN. = HCP target species?

GIS Number	Date	Year	Station	GMR	Latitude (N)	Longitude (W)	Depth	SUB1	SUB2	REEF	BIO	BIO1	BIO2	COP	QB	BLK	BRN	BLU	TIG	YT	YE	PUG
1	7/7/95	95	473002.3	5	47.68708	-122.40567	29	7	4	1	1	2	0	0.000	0.051	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	7/7/95	95	473003.3	5	47.74982	-122.38598	66	7	4	1	1	2	0	0.000	0.153	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	7/7/95	95	473003.4	5	47.75005	-122.38593	48	4	9	1	1	8	0	0.000	2.122	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9	7/10/95	95	473001.0	5	47.99990	-122.31008	47	4	8	1	1	8	9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
11	7/10/95	95	473003.0	5	47.99970	-122.31112	46	4	8	1	1	9	0	0.153	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
17	7/11/95	95	473005.0	5	47.89770	-122.39428	0	4	8	1	1	9	0	0.159	0.000	0.000	0.080	0.000	0.000	0.000	0.000	0.000
39	7/12/95	95	473040.0	5	47.96270	-122.67272	44	5	4	1	1	9	0	0.000	0.102	0.000	0.000	0.000	0.000	0.000	0.000	0.000
46	7/12/95	95	473078.2	5	47.96415	-122.62055	37	3	8	1	0	4	0	0.168	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
62	7/17/95	95	473001.2	5	47.67273	-122.42313	69	8	1	4	0	1	0	0.283	0.849	0.000	0.141	0.000	0.000	0.000	0.000	0.000
63	7/17/95	95	473001.3	5	47.67907	-122.41238	18	3	3	1	1	2	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
65	7/17/95	95	473002.1	5	47.68338	-122.40772	21	7	4	1	1	2	0	0.071	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
69	7/17/95	95	473005.1	5	47.80795	-122.39405	17	4	8	1	1	2	0	0.000	0.424	0.000	0.000	0.000	0.000	0.000	0.000	0.000
71	7/17/95	95	473005.3	5	47.81245	-122.38840	41	9	1	4	1	2	4	0.106	0.318	0.000	0.000	0.000	0.000	0.000	0.000	0.000
87	7/18/95	95	473033.0	5	47.90445	-122.42630	60	9	8	3	0	1	0	0.042	0.042	0.000	0.000	0.000	0.000	0.000	0.000	0.000
113	7/20/95	95	474002.0	5	47.64055	-122.42722	77	1	8	4	1	9	8	0.000	0.239	0.000	0.000	0.000	0.000	0.000	0.000	0.000
120	7/20/95	95	474007.0	5	47.62717	-122.39315	30	4	4	1	1	2	0	0.063	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
123	7/20/95	95	474005.0	5	47.62098	-122.36603	43	4	9	1	1	9	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
128	7/20/95	95	474010.0	5	47.62650	-122.37935	39	8	1	4	1	9	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
140	8/1/95	95	471019.0	5	48.09152	-122.69007	35	1	8	4	0	0	0	0.042	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
142	8/1/95	95	471026.0	5	48.04358	-122.59623	20	7	4	1	1	2	0	0.080	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
173	8/2/95	95	471014.0	5	48.13763	-122.75987	29	8	8	3	1	2	0	0.260	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
180	8/3/95	95	471003.0	5	48.13687	-122.68113	100	4	3	1	1	8	9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
187	8/3/95	95	471022.0	5	48.13575	-122.66738	113	7	4	1	1	9	0	0.106	0.141	0.000	0.000	0.000	0.000	0.000	0.000	0.000
190	8/3/95	95	471004.0	5	48.15680	-122.67093	28	4	7	1	1	8	2	0.000	0.060	0.000	0.000	0.000	0.000	0.000	0.000	0.181
196	8/3/95	95	471009.0	5	48.16155	-122.68555	30	7	7	2	1	2	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
215	8/17/95	95	427021.0	5	48.40987	-122.63520	62	3	4	1	1	9	0	0.000	0.000	0.071	0.000	0.000	0.000	0.000	0.000	0.106
249	8/22/95	95	441003.0	5	48.18688	-122.53775	54	4	1	4	1	8	0	0.000	0.071	0.000	0.000	0.000	0.000	0.000	0.000	0.000
250	8/22/95	95	441004.0	5	48.05447	-122.37063	120	2	4	1	1	8	0	0.255	0.611	0.000	0.000	0.000	0.000	0.000	0.000	0.000
253	8/22/95	95	441002.0	5	48.18648	-122.53813	52	1	9	4	1	8	0	0.030	0.060	0.000	0.000	0.000	0.000	0.000	0.000	0.000
260	8/23/95	95	441006.0	5	48.05778	-122.37857	120	8	8	3	0	1	0	0.126	0.505	0.000	0.000	0.000	0.000	0.000	0.000	0.000
261	8/23/95	95	441007.0	5	48.05878	-122.35597	78	9	3	1	0	1	0	0.102	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
263	8/28/95	95	474086.0	5	47.59670	-122.49585	47	4	8	1	1	2	8	0.000	0.000	0.000	0.080	0.000	0.000	0.000	0.000	0.000
264	8/28/95	95	474087.0	5	47.59955	-122.49627	52	4	4	1	0	1	0	0.080	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
281	8/29/95	95	474082.0	5	47.59870	-122.48240	55	8	8	3	1	8	0	0.153	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
292	8/29/95	95	474079.0	5	47.59428	-122.47745	41	3	4	1	1	9	0	0.000	0.030	0.000	0.000	0.000	0.000	0.000	0.000	0.000
293	8/29/95	95	474081.0	5	47.59723	-122.48100	35	3	4	1	1	2	0	0.071	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
313	8/31/95	95	474067.0	5	47.56547	-122.53150	33	1	6	4	1	9	0	0.000	0.000	0.000	0.071	0.000	0.000	0.000	0.000	0.000
323	8/31/95	95	474071.0	5	47.56832	-122.51642	59	9	4	1	1	8	4	0.253	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
327	9/5/95	95	474012.0	5	47.59813	-122.34122	85	4	9	1	0	1	0	0.000	0.000	0.000	0.042	0.000	0.000	0.000	0.000	0.042
329	9/5/95	95	474013.0	5	47.59022	-122.34735	39	9	4	1	0	4	0	0.000	0.042	0.000	0.000	0.000	0.000	0.000	0.000	0.000
333	9/5/95	95	474017.0	5	47.58678	-122.36152	52	9	1	4	1	8	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
338	9/6/95	95	474019.0	5	47.57160	-122.42062	79	5	1	4	1	8	0	0.051	0.153	0.000	0.153	0.000	0.000	0.000	0.000	0.000
339	9/6/95	95	474020.0	5	47.55775	-122.40920	52	4	4	1	1	8	9	0.000	0.084	0.000	0.000	0.000	0.000	0.000	0.000	0.000
340	9/6/95	95	474020.0	5	47.55737	-122.40772	45	4	4	1	1	9	0	0.000	0.000	0.000	0.106	0.000	0.000	0.000	0.000	0.000
341	9/6/95	95	474021.0	5	47.55650	-122.40710	66	4	4	1	1	8	9	0.051	0.051	0.000	0.051	0.000	0.000	0.000	0.000	0.000

GIS Number	Date	Year	Station	GMR	Latitude (N)	Longitude (W)	Depth	SUB1	SUB2	REEF	BIO	BIO1	BIO2	COP	QB	BLK	BRN	BLU	TIG	YT	YE	PUG
342	9/6/95	95	474022.0	5	47.54007	-122.40038	34	8	1	4	1	2	0	0.030	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
343	9/6/95	95	474065.0	5	47.52873	-122.49168	62	5	1	4	1	8	0	0.035	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
347	9/6/95	95	474065.0	5	47.52973	-122.49490	59	1	5	4	1	9	0	0.051	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
349	9/6/95	95	474075.0	5	47.58237	-122.47537	43	6	1	4	0	4	0	0.102	0.000	0.000	0.102	0.000	0.000	0.000	0.000	0.000
352	9/7/95	95	474064.0	5	47.51880	-122.47193	64	4	5	1	1	8	0	0.181	0.181	0.000	0.000	0.000	0.000	0.000	0.000	0.000
353	9/7/95	95	474133.0	5	47.52060	-122.47378	71	5	4	1	1	9	0	0.035	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
354	9/7/95	95	474134.0	5	47.51788	-122.47237	56	5	4	1	1	9	0	0.000	0.035	0.000	0.000	0.000	0.000	0.000	0.000	0.000
357	10/3/95	95	473004.2	5	47.78395	-122.39623	34	1	8	4	1	8	0	0.052	0.026	0.000	0.000	0.000	0.000	0.000	0.000	0.000
362	10/4/95	95	473039.0	5	47.96658	-122.67508	68	7	4	1	1	9	0	0.030	0.060	0.000	0.000	0.000	0.000	0.000	0.000	0.000
367	10/4/95	95	473078.4	5	47.95943	-122.67673	50	3	4	1	1	2	0	0.071	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
369	10/4/95	95	473081.0	5	47.90595	-122.37608	40	3	4	1	1	2	4	0.301	0.000	0.121	0.000	0.000	0.000	0.000	0.000	0.000

GIS Number	Date	Year	Station	UNIDRF	LC	KG	WSG	PG	SSP	PP	SP	KP	FF	RURC	GURC	CUC	DUNG
1	7/7/95	95	473002.3	0.000	0.000	0.000	0.000	0.051	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	7/7/95	95	473003.3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	7/7/95	95	473003.4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9	7/10/95	95	473001.0	0.495	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
11	7/10/95	95	473003.0	0.000	0.000	0.000	0.000	0.306	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
17	7/11/95	95	473005.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
39	7/12/95	95	473040.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
46	7/12/95	95	473078.2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
62	7/17/95	95	473001.2	0.990	0.000	0.141	0.000	0.000	0.000	0.000	0.000	0.000	0.283	0.000	0.000	0.000	0.000
63	7/17/95	95	473001.3	0.141	0.000	0.000	0.000	0.000	0.000	0.141	0.000	0.141	0.000	0.000	0.000	0.000	0.000
65	7/17/95	95	473002.1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
69	7/17/95	95	473005.1	0.212	0.000	0.000	0.000	0.106	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
71	7/17/95	95	473005.3	0.000	0.106	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.106	0.000
87	7/18/95	95	473033.0	0.084	0.000	0.000	0.000	0.000	0.168	0.000	0.000	0.000	0.126	0.000	0.000	0.000	0.000
113	7/20/95	95	474002.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
120	7/20/95	95	474007.0	0.000	0.000	0.000	0.000	0.000	0.252	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
123	7/20/95	95	474005.0	0.000	0.051	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
128	7/20/95	95	474010.0	0.035	0.000	0.000	0.000	0.000	0.000	0.000	0.071	0.000	0.000	0.000	0.000	0.000	0.000
140	8/1/95	95	471019.0	0.000	0.084	0.000	0.000	0.000	0.000	0.042	0.000	0.000	0.000	0.000	0.000	0.000	0.000
142	8/1/95	95	471026.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.159	0.000	0.000	0.000	0.000	0.000
173	8/2/95	95	471014.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
180	8/3/95	95	471003.0	0.000	0.042	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
187	8/3/95	95	471022.0	0.000	0.035	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
190	8/3/95	95	471004.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
196	8/3/95	95	471009.0	0.000	0.042	0.042	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
215	8/17/95	95	427021.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.212	0.000	0.000
249	8/22/95	95	441003.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
250	8/22/95	95	441004.0	0.255	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
253	8/22/95	95	441002.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.030	0.000
260	8/23/95	95	441006.0	0.253	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
261	8/23/95	95	441007.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.051	0.000	0.000	0.000	0.051
263	8/28/95	95	474086.0	0.000	0.000	0.000	0.000	0.000	0.000	0.080	0.477	0.000	0.000	0.000	0.000	0.000	0.000
264	8/28/95	95	474087.0	0.000	0.000	0.000	0.000	0.000	0.000	0.080	0.000	0.000	0.000	0.000	0.000	0.000	0.000
281	8/29/95	95	474082.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
292	8/29/95	95	474079.0	0.030	0.000	0.000	0.000	0.181	0.151	0.000	0.060	0.000	0.000	0.000	0.000	0.121	0.000
293	8/29/95	95	474081.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.318	0.035	0.000	0.000	0.000	0.000	0.000
313	8/31/95	95	474067.0	0.000	0.000	0.000	0.000	0.000	0.248	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
323	8/31/95	95	474071.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.042	0.000
327	9/5/95	95	474012.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
329	9/5/95	95	474013.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.253	0.000	0.000	0.000	0.000	0.000
333	9/5/95	95	474017.0	0.000	0.042	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.042
338	9/6/95	95	474019.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.204	0.000
339	9/6/95	95	474020.0	0.000	0.000	0.000	0.000	0.000	0.253	0.126	42.049	0.000	0.000	0.000	0.000	0.000	0.000
340	9/6/95	95	474020.0	0.000	0.000	0.000	0.000	0.000	0.283	0.000	0.460	0.000	0.000	0.000	0.035	0.000	0.000
341	9/6/95	95	474021.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.102	0.102	0.000	0.000	0.000	0.000	0.000

WDFW Video Data: Subset for King County HCP Area
GIS Number Codes for Figure 3-15, Figure 4-8, and Figure 5-9.

GIS Number	Date	Year	Station	UNIDRF	LC	KG	WSG	PG	SSP	PP	SP	KP	FF	RURC	GURC	CUC	DUNG
342	9/6/95	95	474022.0	0.030	0.000	0.000	0.000	0.000	0.121	0.090	0.060	0.000	0.060	0.000	0.000	0.000	0.000
343	9/6/95	95	474065.0	0.000	0.000	0.000	0.000	0.000	0.000	0.177	0.000	0.000	0.000	0.000	0.000	0.000	0.000
347	9/6/95	95	474065.0	0.000	0.000	0.000	0.000	0.000	0.051	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
349	9/6/95	95	474075.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
352	9/7/95	95	474064.0	0.000	0.000	0.000	0.000	0.030	0.723	0.151	0.000	0.000	0.000	0.000	0.000	0.000	0.000
353	9/7/95	95	474133.0	0.000	0.000	0.000	0.000	0.000	0.141	0.212	0.000	0.000	0.035	0.000	0.000	0.000	0.000
354	9/7/95	95	474134.0	0.000	0.000	0.000	0.000	0.000	0.035	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
357	10/3/95	95	473004.2	0.078	0.026	0.000	0.000	0.000	0.338	0.130	0.130	0.000	0.000	0.000	0.000	0.000	0.000
362	10/4/95	95	473039.0	0.090	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
367	10/4/95	95	473078.4	0.071	0.000	0.035	0.000	0.071	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.071	0.000
369	10/4/95	95	473081.0	0.000	0.000	0.000	0.000	0.090	0.241	0.151	0.000	0.000	0.000	0.000	0.000	0.000	0.000

GIS Number	Survey ID	Year	Region	Station ID	Haul ID	Date	Name	Density (Ind./hectare)	Density (kg/hectare)	Average Latitude (N)	Average Longitude (W)
231	87CS	1987	CS	87CSV01	CS-H035	87/10/09	PACIFIC COD	11.7956	7.9040	48.04234	-122.63575
231	87CS	1987	CS	87CSV01	CS-H035	87/10/09	WALLEYE POLLOCK	11.2594	0.7296	48.04234	-122.63575
231	87CS	1987	CS	87CSV01	CS-H035	87/10/09	LINGCOD	1.0723	2.6265	48.04234	-122.63575
231	87CS	1987	CS	87CSV01	CS-H035	87/10/09	QUILLBACK ROCKFISH	24.6634	16.8295	48.04234	-122.63575
231	87CS	1987	CS	87CSV01	CS-H035	87/10/09	REDSTRIPE ROCKFISH	0.5362	0.0730	48.04234	-122.63575
232	87CS	1987	CS	87CST01	CS-H036	87/10/09	PACIFIC COD	16.9576	7.4497	47.99675	-122.65675
232	87CS	1987	CS	87CST01	CS-H036	87/10/09	QUILLBACK ROCKFISH	12.7182	6.3843	47.99675	-122.65675
234	87CS	1987	CS	87CSS01	CS-H037	87/10/09	PACIFIC HERRING	34.2713	0.5623	48.00633	-122.71025
234	87CS	1987	CS	87CSS01	CS-H037	87/10/09	PACIFIC COD	6.5626	0.3738	48.00633	-122.71025
234	87CS	1987	CS	87CSS01	CS-H037	87/10/09	WALLEYE POLLOCK	5.8334	0.0629	48.00633	-122.71025
236	87CS	1987	CS	87CSV02	CS-H039	87/10/09	WALLEYE POLLOCK	14.1785	4.5938	47.87842	-122.35833
236	87CS	1987	CS	87CSV02	CS-H039	87/10/09	PACIFIC WHITING (HAKE)	6.7516	3.1544	47.87842	-122.35833
236	87CS	1987	CS	87CSV02	CS-H039	87/10/09	QUILLBACK ROCKFISH	0.6752	0.4287	47.87842	-122.35833
237	87CS	1987	CS	87CSV03	CS-H040	87/10/12	PACIFIC COD	1.1574	1.8375	47.73133	-122.40292
237	87CS	1987	CS	87CSV03	CS-H040	87/10/12	WALLEYE POLLOCK	28.3570	5.3813	47.73133	-122.40292
237	87CS	1987	CS	87CSV03	CS-H040	87/10/12	PACIFIC WHITING (HAKE)	6.3659	3.1501	47.73133	-122.40292
238	87CS	1987	CS	87CSS02	CS-H041	87/10/12	PACIFIC COD	1.1218	0.6361	47.70725	-122.39042
238	87CS	1987	CS	87CSS02	CS-H041	87/10/12	QUILLBACK ROCKFISH	1.6827	0.0255	47.70725	-122.39042
258	87CS	1987	CS	87CSV04	CS-H056	87/10/15	WALLEYE POLLOCK	19.3931	4.9613	47.98625	-122.29367
258	87CS	1987	CS	87CSV04	CS-H056	87/10/15	PACIFIC WHITING (HAKE)	12.4116	7.7410	47.98625	-122.29367
258	87CS	1987	CS	87CSV04	CS-H056	87/10/15	QUILLBACK ROCKFISH	6.2058	2.6390	47.98625	-122.29367
259	87CS	1987	CS	87CSV05	CS-H057	87/10/15	WALLEYE POLLOCK	17.4803	4.8480	48.00934	-122.34375
259	87CS	1987	CS	87CSV05	CS-H057	87/10/15	PACIFIC WHITING (HAKE)	18.9786	3.7380	48.00934	-122.34375
259	87CS	1987	CS	87CSV05	CS-H057	87/10/15	QUILLBACK ROCKFISH	0.9989	0.7249	48.00934	-122.34375
260	87CS	1987	CS	87CSU01	CS-H058	87/10/15	PACIFIC COD	3.0382	6.2016	48.06417	-122.31192
260	87CS	1987	CS	87CSU01	CS-H058	87/10/15	WALLEYE POLLOCK	11.3934	4.0311	48.06417	-122.31192
260	87CS	1987	CS	87CSU01	CS-H058	87/10/15	PACIFIC WHITING (HAKE)	218.7536	54.4364	48.06417	-122.31192
260	87CS	1987	CS	87CSU01	CS-H058	87/10/15	QUILLBACK ROCKFISH	15.1912	6.2361	48.06417	-122.31192
260	87CS	1987	CS	87CSU01	CS-H058	87/10/15	REDSTRIPE ROCKFISH	0.7596	0.1034	48.06417	-122.31192
261	87CS	1987	CS	87CST02	CS-H059	87/10/15	PACIFIC COD	2.0637	4.8989	48.13775	-122.43067
261	87CS	1987	CS	87CST02	CS-H059	87/10/15	WALLEYE POLLOCK	1.3758	0.0312	48.13775	-122.43067
261	87CS	1987	CS	87CST02	CS-H059	87/10/15	PACIFIC WHITING (HAKE)	66.0388	6.2718	48.13775	-122.43067
261	87CS	1987	CS	87CST02	CS-H059	87/10/15	SMELT UNIDEN.	0.6879	0.0156	48.13775	-122.43067
262	87CS	1987	CS	87CSU02	CS-H060	87/10/16	PACIFIC COD	8.1847	8.1001	47.84817	-122.49067
262	87CS	1987	CS	87CSU02	CS-H060	87/10/16	WALLEYE POLLOCK	46.1320	11.9477	47.84817	-122.49067
262	87CS	1987	CS	87CSU02	CS-H060	87/10/16	PACIFIC WHITING (HAKE)	63.9895	32.2317	47.84817	-122.49067
262	87CS	1987	CS	87CSU02	CS-H060	87/10/16	QUILLBACK ROCKFISH	4.4644	1.1475	47.84817	-122.49067
263	87CS	1987	CS	87CST03	CS-H061	87/10/16	PACIFIC HERRING	36.4590	2.0290	47.83267	-122.49350
263	87CS	1987	CS	87CST03	CS-H061	87/10/16	PACIFIC COD	3.5057	2.7319	47.83267	-122.49350
263	87CS	1987	CS	87CST03	CS-H061	87/10/16	WALLEYE POLLOCK	241.1902	2.7319	47.83267	-122.49350
263	87CS	1987	CS	87CST03	CS-H061	87/10/16	PACIFIC WHITING (HAKE)	20.3329	1.7174	47.83267	-122.49350
263	87CS	1987	CS	87CST03	CS-H061	87/10/16	QUILLBACK ROCKFISH	53.2862	16.4709	47.83267	-122.49350
264	87CS	1987	CS	87CSU03	CS-H062	87/10/16	PACIFIC HERRING	15.5288	1.7028	47.96667	-122.49317
264	87CS	1987	CS	87CSU03	CS-H062	87/10/16	WALLEYE POLLOCK	43.8857	11.6438	47.96667	-122.49317
264	87CS	1987	CS	87CSU03	CS-H062	87/10/16	PACIFIC WHITING (HAKE)	72.2426	5.5370	47.96667	-122.49317
264	87CS	1987	CS	87CSU03	CS-H062	87/10/16	ROCKFISH UNIDEN.	9.4523	1.4210	47.96667	-122.49317
265	87CS	1987	CS	87CSS08	CS-H063	87/10/16	PACIFIC HERRING	229.0560	6.0722	47.97375	-122.50525
265	87CS	1987	CS	87CSS08	CS-H063	87/10/16	PACIFIC COD	4.7555	6.0722	47.97375	-122.50525
275	87CS	1987	CS	87CSV06	CS-H071	87/10/22	PACIFIC COD	5.3169	5.1681	47.86450	-122.39559
275	87CS	1987	CS	87CSV06	CS-H071	87/10/22	WALLEYE POLLOCK	3.0382	1.3093	47.86450	-122.39559

GIS Number	Survey ID	Year	Region	Station ID	Haul ID	Date	Name	Density (Ind./hectare)	Density (kg/hectare)	Average Latitude (N)	Average Longitude (W)
275	87CS	1987	CS	87CSV06	CS-H071	87/10/22	PACIFIC WHITING (HAKE)	19.7486	9.1302	47.86450	-122.39559
276	87CS	1987	CS	87CST04	CS-H072	87/10/23	PACIFIC WHITING (HAKE)	13.6040	6.0473	48.22400	-122.59367
278	87CS	1987	CS	87CST05	CS-H073	87/10/23	PACIFIC COD	0.7292	2.4807	48.22784	-122.55708
278	87CS	1987	CS	87CST05	CS-H073	87/10/23	WALLEYE POLLOCK	2.1875	0.8600	48.22784	-122.55708
278	87CS	1987	CS	87CST05	CS-H073	87/10/23	PACIFIC WHITING (HAKE)	8.7501	5.3912	48.22784	-122.55708
278	87CS	1987	CS	87CST05	CS-H073	87/10/23	QUILLBACK ROCKFISH	0.7292	0.2976	48.22784	-122.55708
279	87CS	1987	CS	87CSS03	CS-H074	87/10/23	PACIFIC HERRING	2.1136	0.1918	48.25642	-122.56134
279	87CS	1987	CS	87CSS03	CS-H074	87/10/23	PACIFIC WHITING (HAKE)	5.8123	2.5166	48.25642	-122.56134
281	87CS	1987	CS	87CSU04	CS-H075	87/10/23	PACIFIC COD	1.0723	2.3834	48.15225	-122.54084
281	87CS	1987	CS	87CSU04	CS-H075	87/10/23	WALLEYE POLLOCK	2.1446	1.2646	48.15225	-122.54084
281	87CS	1987	CS	87CSU04	CS-H075	87/10/23	PACIFIC WHITING (HAKE)	164.6016	68.0234	48.15225	-122.54084
281	87CS	1987	CS	87CSU04	CS-H075	87/10/23	QUILLBACK ROCKFISH	7.5063	6.0314	48.15225	-122.54084
283	87CS	1987	CS	87CSV07	CS-H077	87/10/23	WALLEYE POLLOCK	7.1488	3.7291	48.09909	-122.46217
283	87CS	1987	CS	87CSV07	CS-H077	87/10/23	PACIFIC WHITING (HAKE)	20.0166	9.3389	48.09909	-122.46217
283	87CS	1987	CS	87CSV07	CS-H077	87/10/23	QUILLBACK ROCKFISH	2.8595	1.7835	48.09909	-122.46217
285	87CS	1987	CS	87CSU05	CS-H078	87/10/23	PACIFIC COD	0.7926	1.2583	48.07158	-122.44067
285	87CS	1987	CS	87CSU05	CS-H078	87/10/23	WALLEYE POLLOCK	6.3407	3.1637	48.07158	-122.44067
285	87CS	1987	CS	87CSU05	CS-H078	87/10/23	PACIFIC WHITING (HAKE)	64.9917	25.7052	48.07158	-122.44067
285	87CS	1987	CS	87CSU05	CS-H078	87/10/23	QUILLBACK ROCKFISH	21.3997	9.8866	48.07158	-122.44067
305	87CS	1987	CS	87CST06	CS-H094	87/10/29	WALLEYE POLLOCK	114.3463	8.0432	47.76209	-122.39309
305	87CS	1987	CS	87CST06	CS-H094	87/10/29	PACIFIC WHITING (HAKE)	124.2895	87.1970	47.76209	-122.39309
305	87CS	1987	CS	87CST06	CS-H094	87/10/29	QUILLBACK ROCKFISH	8.2860	2.2551	47.76209	-122.39309
307	87CS	1987	CS	87CSS05	CS-H096	87/10/29	PACIFIC COD	2.8045	0.1272	47.62942	-122.40125
307	87CS	1987	CS	87CSS05	CS-H096	87/10/29	QUILLBACK ROCKFISH	16.8270	0.4452	47.62942	-122.40125
308	87CS	1987	CS	87CSV08	CS-H097	87/10/29	PACIFIC COD	1.6204	1.9845	47.54600	-122.40942
308	87CS	1987	CS	87CSV08	CS-H097	87/10/29	WALLEYE POLLOCK	31.5979	11.2089	47.54600	-122.40942
308	87CS	1987	CS	87CSV08	CS-H097	87/10/29	PACIFIC WHITING (HAKE)	21.0653	11.5029	47.54600	-122.40942
308	87CS	1987	CS	87CSV08	CS-H097	87/10/29	QUILLBACK ROCKFISH	1.6204	0.6247	47.54600	-122.40942
311	87CS	1987	CS	87CSV09	CS-H100	87/10/29	PACIFIC COD	2.8045	4.1026	47.62750	-122.45142
311	87CS	1987	CS	87CSV09	CS-H100	87/10/29	WALLEYE POLLOCK	32.2522	9.5410	47.62750	-122.45142
311	87CS	1987	CS	87CSV09	CS-H100	87/10/29	PACIFIC WHITING (HAKE)	11.9193	4.3571	47.62750	-122.45142
313	87CS	1987	CS	87CSS06	CS-H101	87/10/30	PACIFIC COD	275.8497	206.5336	47.64625	-122.50084
313	87CS	1987	CS	87CSS06	CS-H101	87/10/30	WALLEYE POLLOCK	2.7516	0.6553	47.64625	-122.50084
313	87CS	1987	CS	87CSS06	CS-H101	87/10/30	QUILLBACK ROCKFISH	0.6879	0.1560	47.64625	-122.50084
315	87CS	1987	CS	87CSS07	CS-H102	87/10/30	PACIFIC HERRING	61.5244	0.4479	47.71709	-122.53825
315	87CS	1987	CS	87CSS07	CS-H102	87/10/30	PACIFIC COD	12.1530	4.4790	47.71709	-122.53825
315	87CS	1987	CS	87CSS07	CS-H102	87/10/30	LINGCOD	0.7596	4.8235	47.71709	-122.53825
315	87CS	1987	CS	87CSS07	CS-H102	87/10/30	QUILLBACK ROCKFISH	6.0765	3.2731	47.71709	-122.53825
326	89CS	1989	CS	89CSS01	CS-H010	89/04/26	PACIFIC HERRING	0.7479	0.0170	48.00184	-122.70967
327	89CS	1989	CS	89CST01	CS-H011	89/04/26	PACIFIC COD	14.0226	2.9683	48.00067	-122.66242
327	89CS	1989	CS	89CST01	CS-H011	89/04/26	ROCKFISH UNIDEN.	99.0932	5.3006	48.00067	-122.66242
327	89CS	1989	CS	89CST01	CS-H011	89/04/26	QUILLBACK ROCKFISH	3.7394	0.1272	48.00067	-122.66242
328	89CS	1989	CS	89CSU01	CS-H012	89/04/26	WALLEYE POLLOCK	0.5928	0.3764	47.96617	-122.49534
328	89CS	1989	CS	89CSU01	CS-H012	89/04/26	PACIFIC WHITING (HAKE)	3.5570	0.1882	47.96617	-122.49534
328	89CS	1989	CS	89CSU01	CS-H012	89/04/26	ROCKFISH UNIDEN.	0.5928	0.0269	47.96617	-122.49534
328	89CS	1989	CS	89CSU01	CS-H012	89/04/26	QUILLBACK ROCKFISH	0.5928	0.1345	47.96617	-122.49534
329	89CS	1989	CS	89CSV01	CS-H013	89/04/26	WALLEYE POLLOCK	0.5787	0.1575	47.86917	-122.37934
329	89CS	1989	CS	89CSV01	CS-H013	89/04/26	PACIFIC WHITING (HAKE)	9.8381	9.7126	47.86917	-122.37934
329	89CS	1989	CS	89CSV01	CS-H013	89/04/26	ROCKFISH UNIDEN.	0.5787	0.0263	47.86917	-122.37934
329	89CS	1989	CS	89CSV01	CS-H013	89/04/26	QUILLBACK ROCKFISH	1.1574	0.4462	47.86917	-122.37934

GIS Number	Survey ID	Year	Region	Station ID	Haul ID	Date	Name	Density (Ind./hectare)	Density (kg/hectare)	Average Latitude (N)	Average Longitude (W)
330	89CS	1989	CS	89CSU02	CS-H015	89/04/27	PACIFIC HERRING	3.8127	0.3026	47.85208	-122.49325
330	89CS	1989	CS	89CSU02	CS-H015	89/04/27	QUILLBACK ROCKFISH	27.6420	7.5662	47.85208	-122.49325
330	89CS	1989	CS	89CSU02	CS-H015	89/04/27	REDSTRIPE ROCKFISH	0.9532	0.1729	47.85208	-122.49325
331	89CS	1989	CS	89CST02	CS-H016	89/04/27	QUILLBACK ROCKFISH	1.8004	0.0817	47.75942	-122.38859
332	89CS	1989	CS	89CSV02	CS-H017	89/04/27	WALLEYE POLLOCK	1.1048	0.5763	47.72075	-122.41875
332	89CS	1989	CS	89CSV02	CS-H017	89/04/27	PACIFIC WHITING (HAKE)	3.3145	0.5262	47.72075	-122.41875
333	89CS	1989	CS	89CSS02	CS-H019	89/04/29	QUILLBACK ROCKFISH	3.6827	2.9400	47.63334	-122.41025
334	89CS	1989	CS	89CSV03	CS-H020	89/04/29	WALLEYE POLLOCK	9.1505	2.6201	47.61792	-122.45592
334	89CS	1989	CS	89CSV03	CS-H020	89/04/29	PACIFIC WHITING (HAKE)	9.1505	1.0377	47.61792	-122.45592
335	89CS	1989	CS	89CSS03	CS-H021	89/04/29	LINGCOD	1.6763	14.0664	47.71859	-122.54042
336	89CS	1989	CS	89CSS04	CS-H022	89/04/29	QUILLBACK ROCKFISH	0.7969	0.0036	47.70575	-122.39334
350	89CS	1989	CS	89CSV04	CS-H038	89/05/04	PACIFIC COD	2.3148	5.5126	47.98967	-122.30225
350	89CS	1989	CS	89CSV04	CS-H038	89/05/04	WALLEYE POLLOCK	1.1574	0.4200	47.98967	-122.30225
350	89CS	1989	CS	89CSV04	CS-H038	89/05/04	PACIFIC WHITING (HAKE)	71.7601	29.7939	47.98967	-122.30225
350	89CS	1989	CS	89CSV04	CS-H038	89/05/04	QUILLBACK ROCKFISH	4.6297	3.5438	47.98967	-122.30225
352	89CS	1989	CS	89CST03	CS-H039	89/05/04	PACIFIC WHITING (HAKE)	58.6692	5.6076	48.14025	-122.43567
352	89CS	1989	CS	89CST03	CS-H039	89/05/04	SMELT UNIDEN.	0.8381	0.0381	48.14025	-122.43567
353	89CS	1989	CS	89CSU03	CS-H040	89/05/04	PACIFIC HERRING	0.4910	0.0668	48.06467	-122.31259
353	89CS	1989	CS	89CSU03	CS-H040	89/05/04	PACIFIC WHITING (HAKE)	61.3786	2.7841	48.06467	-122.31259
353	89CS	1989	CS	89CSU03	CS-H040	89/05/04	QUILLBACK ROCKFISH	0.4910	0.2673	48.06467	-122.31259
354	89CS	1989	CS	89CSS05	CS-H041	89/05/04	LINGCOD	0.4960	1.8000	48.06142	-122.53825
356	89CS	1989	CS	89CSV05	CS-H042	89/05/05	PACIFIC COD	0.5787	1.5750	48.10175	-122.45725
356	89CS	1989	CS	89CSV05	CS-H042	89/05/05	PACIFIC WHITING (HAKE)	32.9867	6.7463	48.10175	-122.45725
357	89CS	1989	CS	89CSU04	CS-H043	89/05/05	PACIFIC HERRING	11.7692	1.2302	48.15734	-122.54650
357	89CS	1989	CS	89CSU04	CS-H043	89/05/05	WALLEYE POLLOCK	0.5117	0.2785	48.15734	-122.54650
357	89CS	1989	CS	89CSU04	CS-H043	89/05/05	PACIFIC WHITING (HAKE)	34.7960	2.3675	48.15734	-122.54650
358	89CS	1989	CS	89CST04	CS-H044	89/05/05	PACIFIC HERRING	11.3428	0.7595	48.21600	-122.59658
358	89CS	1989	CS	89CST04	CS-H044	89/05/05	WALLEYE POLLOCK	0.5401	0.3920	48.21600	-122.59658
358	89CS	1989	CS	89CST04	CS-H044	89/05/05	PACIFIC WHITING (HAKE)	5.4013	0.2940	48.21600	-122.59658
358	89CS	1989	CS	89CST04	CS-H044	89/05/05	SMELT UNIDEN.	5.4013	0.0735	48.21600	-122.59658
359	89CS	1989	CS	89CSS06	CS-H045	89/05/05	PACIFIC HERRING	11.0481	0.2506	48.25467	-122.58250
359	89CS	1989	CS	89CSS06	CS-H045	89/05/05	SMELT UNIDEN.	2.2096	0.0101	48.25467	-122.58250
455	91CS	1991	CS	91CSU04	CS-H046	91/05/17	PACIFIC WHITING (HAKE)	3016.9716	75.2738	48.15383	-122.54234
455	91CS	1991	CS	91CSU04	CS-H046	91/05/17	QUILLBACK ROCKFISH	12.1530	9.2611	48.15383	-122.54234
427	91CS	1991	CS	91CSS01	CS-H010	91/05/07	PACIFIC HERRING	5.3355	0.2151	48.00142	-122.70975
429	91CS	1991	CS	91CST01	CS-H012	91/05/08	REDSTRIPE ROCKFISH	28.7563	1.2112	48.00384	-122.66175
430	91CS	1991	CS	91CSU01	CS-H013	91/05/08	PACIFIC COD	3.3758	3.8282	47.96384	-122.49609
430	91CS	1991	CS	91CSU01	CS-H013	91/05/08	LINGCOD	0.6752	0.5206	47.96384	-122.49609
430	91CS	1991	CS	91CSU01	CS-H013	91/05/08	PACIFIC WHITING (HAKE)	39.1596	18.4670	47.96384	-122.49609
430	91CS	1991	CS	91CSU01	CS-H013	91/05/08	QUILLBACK ROCKFISH	2.0255	0.7350	47.96384	-122.49609
432	91CS	1991	CS	91CSV01	CS-H014	91/05/08	PACIFIC WHITING (HAKE)	7.9811	6.0556	47.86667	-122.38717
432	91CS	1991	CS	91CSV01	CS-H014	91/05/08	QUILLBACK ROCKFISH	1.4511	0.9873	47.86667	-122.38717
433	91CS	1991	CS	91CSU02	CS-H015	91/05/08	PACIFIC HERRING	0.7841	0.0711	47.84992	-122.49475
433	91CS	1991	CS	91CSU02	CS-H015	91/05/08	PACIFIC COD	1.5681	1.0670	47.84992	-122.49475
433	91CS	1991	CS	91CSU02	CS-H015	91/05/08	WALLEYE POLLOCK	16.4653	2.9519	47.84992	-122.49475
433	91CS	1991	CS	91CSU02	CS-H015	91/05/08	PACIFIC WHITING (HAKE)	21.1697	6.9351	47.84992	-122.49475
433	91CS	1991	CS	91CSU02	CS-H015	91/05/08	QUILLBACK ROCKFISH	36.0668	12.3055	47.84992	-122.49475
434	91CS	1991	CS	91CSS02	CS-H018	91/05/09	LINGCOD	0.6847	0.3106	47.63633	-122.41600
434	91CS	1991	CS	91CSS02	CS-H018	91/05/09	QUILLBACK ROCKFISH	2.0540	0.3727	47.63633	-122.41600
435	91CS	1991	CS	91CSV02	CS-H020	91/05/10	PACIFIC WHITING (HAKE)	0.8381	0.0381	47.62017	-122.45542

GIS Number	Survey ID	Year	Region	Station ID	Haul ID	Date	Name	Density (Ind./hectare)	Density (kg/hectare)	Average Latitude (N)	Average Longitude (W)
449	91CS	1991	CS	91CSV03	CS-H036	91/05/16	PACIFIC WHITING (HAKE)	21.7914	7.0332	47.71734	-122.41892
452	91CS	1991	CS	91CST02	CS-H038	91/05/16	PACIFIC HERRING	6.0764	0.1837	47.75675	-122.39000
452	91CS	1991	CS	91CST02	CS-H038	91/05/16	PACIFIC WHITING (HAKE)	2.0255	0.0920	47.75675	-122.39000
452	91CS	1991	CS	91CST02	CS-H038	91/05/16	QUILLBACK ROCKFISH	2.0255	0.3674	47.75675	-122.39000
453	91CS	1991	CS	91CSV04	CS-H039	91/05/16	PACIFIC HERRING	0.8681	0.0197	47.81983	-122.43500
453	91CS	1991	CS	91CSV04	CS-H039	91/05/16	PACIFIC WHITING (HAKE)	26.0421	6.3788	47.81983	-122.43500
182	91CS	1991	CS	91CST03	CS-H040	91/05/16	PACIFIC WHITING (HAKE)	211.8530	20.2536	48.13975	-122.43367
182	91CS	1991	CS	91CST03	CS-H040	91/05/16	QUILLBACK ROCKFISH	1.2003	0.6806	48.13975	-122.43367
454	91CS	1991	CS	91CSV05	CS-H042	91/05/17	PACIFIC WHITING (HAKE)	20.7316	1.3295	47.99050	-122.30234
454	91CS	1991	CS	91CSV05	CS-H042	91/05/17	QUILLBACK ROCKFISH	0.7149	0.1297	47.99050	-122.30234
183	91CS	1991	CS	91CSU03	CS-H043	91/05/17	PACIFIC WHITING (HAKE)	131.1749	10.3251	48.05584	-122.30842
183	91CS	1991	CS	91CSU03	CS-H043	91/05/17	QUILLBACK ROCKFISH	21.6053	12.3201	48.05584	-122.30842
459	91CS	1991	CS	91CSV06	CS-H044	91/05/17	PACIFIC COD	0.6752	1.0412	48.10317	-122.45783
459	91CS	1991	CS	91CSV06	CS-H044	91/05/17	PACIFIC WHITING (HAKE)	3.3758	0.1531	48.10317	-122.45783
459	91CS	1991	CS	91CSV06	CS-H044	91/05/17	QUILLBACK ROCKFISH	1.3503	0.4287	48.10317	-122.45783
461	91CS	1991	CS	91CSS06	CS-H049	91/05/20	PACIFIC HERRING	81.2332	2.2050	48.25134	-122.58075
461	91CS	1991	CS	91CSS06	CS-H049	91/05/20	PACIFIC WHITING (HAKE)	10.8737	0.2321	48.25134	-122.58075
461	91CS	1991	CS	91CSS06	CS-H049	91/05/20	SURF SMELT	14.0719	0.2321	48.25134	-122.58075
462	91CS	1991	CS	91CST04	CS-H050	91/05/20	PACIFIC HERRING	30.0251	2.1726	48.21250	-122.59617
462	91CS	1991	CS	91CST04	CS-H050	91/05/20	SURF SMELT	42.8930	0.8431	48.21250	-122.59617
462	91CS	1991	CS	91CST04	CS-H050	91/05/20	QUILLBACK ROCKFISH	0.7149	0.4540	48.21250	-122.59617
674	95CS	1995	CS	95CSS10	CS-H013(B)	95/04/28	PACIFIC HERRING	70.9986	1.5402	47.64384	-122.59842
675	95CS	1995	CS	95CSS11	CS-H032	95/05/12	QUILLBACK ROCKFISH	11.9777	0.8292	47.96592	-122.24217
676	95CS	1995	CS	95CSS12	CS-H060	95/06/01	QUILLBACK ROCKFISH	1.3564	0.1085	48.11017	-122.55625
677	95CS	1995	CS	95CSS13	CS-H026	95/05/11	PACIFIC HERRING	23.1520	0.4189	48.22534	-122.70809
678	95CS	1995	CS	95CSS14	CS-H025	95/05/10	PACIFIC HERRING	681.6505	20.5266	48.25058	-122.56884
679	95CS	1995	CS	95CSS15	CS-H027	95/05/11	PACIFIC HERRING	29.2503	1.9626	48.27892	-122.60409
665	95CS	1995	CS	95CSS02	CS-H042	95/05/19	LINGCOD	1.9101	0.5730	48.12000	-122.60925
667	95CS	1995	CS	95CSS04	CS-H036	95/05/18	PACIFIC HERRING	1432.0442	33.2481	47.99108	-122.69950
668	95CS	1995	CS	95CSS05	CS-H049	95/05/30	PACIFIC HERRING	1.2758	0.1403	47.93942	-122.44992
669	95CS	1995	CS	95CSS06	CS-H009	95/04/22	QUILLBACK ROCKFISH	1.2348	0.9878	47.88550	-122.42409
670	95CS	1995	CS	95CSS07	CS-H006	95/04/21	PACIFIC HERRING	13.9947	0.6636	47.73450	-122.49334
671	95CS	1995	CS	95CSS08	CS-H022	95/05/05	PACIFIC HERRING	1.4641	0.0146	47.58783	-122.36375
671	95CS	1995	CS	95CSS08	CS-H022	95/05/05	QUILLBACK ROCKFISH	1.4641	0.7613	47.58783	-122.36375
672	95CS	1995	CS	95CSS09	CS-H016	95/04/28	PACIFIC HERRING	3.0802	0.0559	47.57150	-122.58725
681	95CS	1995	CS	95CST01	CS-H040	95/05/19	WALLEYE POLLOCK	1.5269	0.0305	48.18009	-122.75425
693	95CS	1995	CS	95CST10	CS-H029	95/05/11	PACIFIC HERRING	3.9400	0.1182	48.12117	-122.49767
693	95CS	1995	CS	95CST10	CS-H029	95/05/11	PACIFIC WHITING (HAKE)	0.9850	0.0394	48.12117	-122.49767
695	95CS	1995	CS	95CST11	CS-H058	95/06/01	PACIFIC HERRING	378.3025	18.5871	48.21400	-122.58767
695	95CS	1995	CS	95CST11	CS-H058	95/06/01	PACIFIC WHITING (HAKE)	2.0504	0.0923	48.21400	-122.58767
683	95CS	1995	CS	95CST03	CS-H043	95/05/19	WALLEYE POLLOCK	6.7030	0.2234	48.08508	-122.66825
684	95CS	1995	CS	95CST04	CS-H050	95/05/30	PACIFIC HERRING	33.7675	1.5975	47.97842	-122.58117
685	95CS	1995	CS	95CST05	CS-H038	95/05/18	PACIFIC HERRING	3.0959	0.0310	47.94309	-122.62834
685	95CS	1995	CS	95CST05	CS-H038	95/05/18	WALLEYE POLLOCK	5.1598	0.0310	47.94309	-122.62834
688	95CS	1995	CS	95CST06	CS-H054	95/05/31	PACIFIC HERRING	43.5958	2.4414	47.87075	-122.50234
688	95CS	1995	CS	95CST06	CS-H054	95/05/31	PACIFIC WHITING (HAKE)	1.2456	0.3488	47.87075	-122.50234
688	95CS	1995	CS	95CST06	CS-H054	95/05/31	WALLEYE POLLOCK	2.4912	0.1495	47.87075	-122.50234
689	95CS	1995	CS	95CST07	CS-H063	95/06/01	PACIFIC COD	3.4321	4.4045	47.69567	-122.41134
689	95CS	1995	CS	95CST07	CS-H063	95/06/01	PACIFIC HERRING	1.1440	0.0686	47.69567	-122.41134
689	95CS	1995	CS	95CST07	CS-H063	95/06/01	QUILLBACK ROCKFISH	6.8641	1.8533	47.69567	-122.41134

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689	95CS	1995	CS	95CST07	CS-H063	95/06/01	WALLEYE POLLOCK	10.2962	1.6703	47.69567	-122.41134
692	95CS	1995	CS	95CST09	CS-H057	95/05/31	PACIFIC HERRING	15.2351	0.6446	48.04558	-122.40692
692	95CS	1995	CS	95CST09	CS-H057	95/05/31	PACIFIC WHITING (HAKE)	1.1719	0.2227	48.04558	-122.40692
692	95CS	1995	CS	95CST09	CS-H057	95/05/31	QUILLBACK ROCKFISH	3.5158	1.3829	48.04558	-122.40692
696	95CS	1995	CS	95CSU01	CS-H053	95/06/02	QUILLBACK ROCKFISH	2.4572	2.7029	48.06467	-122.66158
696	95CS	1995	CS	95CSU01	CS-H053	95/06/02	WALLEYE POLLOCK	18.4287	0.7740	48.06467	-122.66158
697	95CS	1995	CS	95CSU02	CS-H051	95/05/30	PACIFIC COD	1.0294	0.6691	47.99459	-122.62459
697	95CS	1995	CS	95CSU02	CS-H051	95/05/30	QUILLBACK ROCKFISH	4.1177	3.0677	47.99459	-122.62459
697	95CS	1995	CS	95CSU02	CS-H051	95/05/30	WALLEYE POLLOCK	1606.9259	83.5169	47.99459	-122.62459
698	95CS	1995	CS	95CSU03	CS-H039	95/05/18	PACIFIC HERRING	1.3833	0.0277	47.94475	-122.64467
698	95CS	1995	CS	95CSU03	CS-H039	95/05/18	QUILLBACK ROCKFISH	1.3833	1.9366	47.94475	-122.64467
698	95CS	1995	CS	95CSU03	CS-H039	95/05/18	WALLEYE POLLOCK	1.3833	0.0138	47.94475	-122.64467
699	95CS	1995	CS	95CSU04	CS-H056	95/05/31	PACIFIC HERRING	1.8441	0.1291	47.86167	-122.34134
699	95CS	1995	CS	95CSU04	CS-H056	95/05/31	PACIFIC WHITING (HAKE)	32.2723	2.1023	47.86167	-122.34134
699	95CS	1995	CS	95CSU04	CS-H056	95/05/31	QUILLBACK ROCKFISH	141.0762	48.7128	47.86167	-122.34134
699	95CS	1995	CS	95CSU04	CS-H056	95/05/31	WALLEYE POLLOCK	5.5324	0.3227	47.86167	-122.34134
700	95CS	1995	CS	95CSU05	CS-H019	95/05/04	PACIFIC HERRING	1.0320	0.0413	47.62575	-122.40925
700	95CS	1995	CS	95CSU05	CS-H019	95/05/04	PACIFIC WHITING (HAKE)	91.8444	3.3745	47.62575	-122.40925
700	95CS	1995	CS	95CSU05	CS-H019	95/05/04	QUILLBACK ROCKFISH	17.5433	4.8915	47.62575	-122.40925
700	95CS	1995	CS	95CSU05	CS-H019	95/05/04	WALLEYE POLLOCK	8.2557	0.7740	47.62575	-122.40925
701	95CS	1995	CS	95CSU06	CS-H034	95/05/12	LINGCOD	1.9776	7.1688	47.97434	-122.24442
701	95CS	1995	CS	95CSU06	CS-H034	95/05/12	PACIFIC WHITING (HAKE)	3113.7215	307.7927	47.97434	-122.24442
701	95CS	1995	CS	95CSU06	CS-H034	95/05/12	QUILLBACK ROCKFISH	16.8095	8.2169	47.97434	-122.24442
702	95CS	1995	CS	95CSU07	CS-H062	95/06/01	PACIFIC WHITING (HAKE)	3931.3150	317.9911	48.06442	-122.31417
702	95CS	1995	CS	95CSU07	CS-H062	95/06/01	QUILLBACK ROCKFISH	13.8329	5.4041	48.06442	-122.31417
703	95CS	1995	CS	95CSU08	CS-H028	95/05/11	PACIFIC HERRING	1.6240	0.1868	48.13192	-122.52934
703	95CS	1995	CS	95CSU08	CS-H028	95/05/11	PACIFIC WHITING (HAKE)	416.5685	23.1752	48.13192	-122.52934
704	95CS	1995	CS	95CSU09	CS-H059	95/06/01	PACIFIC HERRING	34.7993	2.5602	48.17292	-122.54800
704	95CS	1995	CS	95CSU09	CS-H059	95/06/01	PACIFIC WHITING (HAKE)	765.5851	24.0281	48.17292	-122.54800
704	95CS	1995	CS	95CSU09	CS-H059	95/06/01	QUILLBACK ROCKFISH	2.4857	1.2428	48.17292	-122.54800
705	95CS	1995	CS	95CSV01	CS-H055	95/05/31	PACIFIC COD	15.5640	18.7475	47.87058	-122.46075
705	95CS	1995	CS	95CSV01	CS-H055	95/05/31	PACIFIC HERRING	1.4149	0.0424	47.87058	-122.46075
705	95CS	1995	CS	95CSV01	CS-H055	95/05/31	PACIFIC WHITING (HAKE)	19.8087	5.0654	47.87058	-122.46075
705	95CS	1995	CS	95CSV01	CS-H055	95/05/31	WALLEYE POLLOCK	165.5442	28.7509	47.87058	-122.46075
706	95CS	1995	CS	95CSV02	CS-H007	95/04/21	PACIFIC COD	1.5731	1.9623	47.72608	-122.43750
706	95CS	1995	CS	95CSV02	CS-H007	95/04/21	PACIFIC WHITING (HAKE)	12.5851	1.9266	47.72608	-122.43750
706	95CS	1995	CS	95CSV02	CS-H007	95/04/21	WALLEYE POLLOCK	7.8657	1.8196	47.72608	-122.43750
707	95CS	1995	CS	95CSV04	CS-H061	95/06/01	PACIFIC WHITING (HAKE)	5567.0495	258.3031	48.07292	-122.35758
707	95CS	1995	CS	95CSV04	CS-H061	95/06/01	QUILLBACK ROCKFISH	1.9989	1.0394	48.07292	-122.35758
707	95CS	1995	CS	95CSV04	CS-H061	95/06/01	REDSTRIPE ROCKFISH	1.9989	0.3998	48.07292	-122.35758
288	--	1987	SS	--	SS-H080	87/10/26	PACIFIC HERRING	10.3036	0.1079	47.28450	-122.84050
289	--	1987	SS	--	SS-H081	87/10/26	PACIFIC HERRING	4.4644	0.0338	47.16084	-122.83042
292	--	1987	SS	--	SS-H083	87/10/27	PACIFIC COD	1.7361	5.6306	47.15833	-122.65042
292	--	1987	SS	--	SS-H083	87/10/27	WALLEYE POLLOCK	0.8681	0.5119	47.15833	-122.65042
292	--	1987	SS	--	SS-H083	87/10/27	QUILLBACK ROCKFISH	13.0209	7.9931	47.15833	-122.65042
293	--	1987	SS	--	SS-H084	87/10/27	PACIFIC WHITING (HAKE)	1.0128	0.0919	47.21442	-122.63617
293	--	1987	SS	--	SS-H084	87/10/27	QUILLBACK ROCKFISH	10.1275	4.5938	47.21442	-122.63617
295	--	1987	SS	--	SS-H086	87/10/27	PACIFIC HERRING	2.3272	0.1056	47.32800	-122.70342
295	--	1987	SS	--	SS-H086	87/10/27	WALLEYE POLLOCK	4.6543	0.0704	47.32800	-122.70342
295	--	1987	SS	--	SS-H086	87/10/27	PACIFIC WHITING (HAKE)	8.5330	0.3519	47.32800	-122.70342

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296	--	1987	SS	--	SS-H087	87/10/27	WALLEYE POLLOCK	0.7292	0.3308	47.29475	-122.71200
296	--	1987	SS	--	SS-H087	87/10/27	QUILLBACK ROCKFISH	0.7292	0.2646	47.29475	-122.71200
299	--	1987	SS	--	SS-H088	87/10/27	PACIFIC COD	33.4207	30.5258	47.25925	-122.56367
301	--	1987	SS	--	SS-H090	87/10/28	PACIFIC COD	1.3758	1.9346	47.48742	-122.43200
301	--	1987	SS	--	SS-H090	87/10/28	WALLEYE POLLOCK	8.2549	4.1188	47.48742	-122.43200
301	--	1987	SS	--	SS-H090	87/10/28	PACIFIC WHITING (HAKE)	3.4395	2.7147	47.48742	-122.43200
301	--	1987	SS	--	SS-H090	87/10/28	QUILLBACK ROCKFISH	3.4395	3.0579	47.48742	-122.43200
302	--	1987	SS	--	SS-H091	87/10/28	PACIFIC COD	3.5057	8.7459	47.37234	-122.36459
302	--	1987	SS	--	SS-H091	87/10/28	WALLEYE POLLOCK	9.8159	4.7069	47.37234	-122.36459
302	--	1987	SS	--	SS-H091	87/10/28	PACIFIC WHITING (HAKE)	13.3216	11.7672	47.37234	-122.36459
302	--	1987	SS	--	SS-H091	87/10/28	QUILLBACK ROCKFISH	0.7011	0.4135	47.37234	-122.36459
303	--	1987	SS	--	SS-H092	87/10/28	PACIFIC COD	1.8538	3.8681	47.33650	-122.43584
303	--	1987	SS	--	SS-H092	87/10/28	WALLEYE POLLOCK	8.6513	3.7841	47.33650	-122.43584
303	--	1987	SS	--	SS-H092	87/10/28	PACIFIC WHITING (HAKE)	4.9436	3.1394	47.33650	-122.43584
303	--	1987	SS	--	SS-H092	87/10/28	QUILLBACK ROCKFISH	0.6179	0.2803	47.33650	-122.43584
304	--	1987	SS	--	SS-H093	87/10/28	QUILLBACK ROCKFISH	4.4774	1.4507	47.33909	-122.47375
309	--	1987	SS	--	SS-H098	87/10/29	WALLEYE POLLOCK	26.0422	1.7955	47.40658	-122.40950
309	--	1987	SS	--	SS-H098	87/10/29	QUILLBACK ROCKFISH	21.5779	6.4126	47.40658	-122.40950
310	--	1987	SS	--	SS-H099	87/10/29	PACIFIC COD	8.7501	5.4674	47.40750	-122.40767
310	--	1987	SS	--	SS-H099	87/10/29	WALLEYE POLLOCK	178.6483	6.2777	47.40750	-122.40767
310	--	1987	SS	--	SS-H099	87/10/29	PACIFIC WHITING (HAKE)	48.8548	7.2931	47.40750	-122.40767
310	--	1987	SS	--	SS-H099	87/10/29	QUILLBACK ROCKFISH	46.6673	15.8761	47.40750	-122.40767
338	--	1989	SS	--	SS-H024	89/05/01	PACIFIC WHITING (HAKE)	2.0834	1.6695	47.48825	-122.43275
339	--	1989	SS	--	SS-H025	89/05/01	PACIFIC HERRING	7.7498	0.4794	47.41125	-122.41650
339	--	1989	SS	--	SS-H025	89/05/01	PACIFIC COD	0.7045	2.2370	47.41125	-122.41650
339	--	1989	SS	--	SS-H025	89/05/01	PACIFIC WHITING (HAKE)	13.3859	0.3196	47.41125	-122.41650
339	--	1989	SS	--	SS-H025	89/05/01	QUILLBACK ROCKFISH	27.4764	7.9892	47.41125	-122.41650
340	--	1989	SS	--	SS-H026	89/05/01	PACIFIC WHITING (HAKE)	1.6204	0.0735	47.34058	-122.43217
341	--	1989	SS	--	SS-H028	89/05/02	PACIFIC HERRING	2.9641	0.1345	47.25933	-122.56292
341	--	1989	SS	--	SS-H028	89/05/02	PACIFIC COD	7.1139	3.3613	47.25933	-122.56292
341	--	1989	SS	--	SS-H028	89/05/02	WALLEYE POLLOCK	0.5928	0.2689	47.25933	-122.56292
341	--	1989	SS	--	SS-H028	89/05/02	PACIFIC WHITING (HAKE)	1.1857	0.1075	47.25933	-122.56292
341	--	1989	SS	--	SS-H028	89/05/02	QUILLBACK ROCKFISH	0.5928	0.2958	47.25933	-122.56292
342	--	1989	SS	--	SS-H030	89/05/02	PACIFIC HERRING	9.3910	0.6765	47.16583	-122.73450
342	--	1989	SS	--	SS-H030	89/05/02	SMELT UNIDEN.	0.5524	0.0251	47.16583	-122.73450
343	--	1989	SS	--	SS-H031	89/05/03	PACIFIC HERRING	11.4381	0.1621	47.32359	-122.80783
344	--	1989	SS	--	SS-H032	89/05/03	QUILLBACK ROCKFISH	0.5227	0.0948	47.28009	-122.84209
345	--	1989	SS	--	SS-H033	89/05/03	PACIFIC WHITING (HAKE)	11.9538	2.6822	47.15875	-122.65475
345	--	1989	SS	--	SS-H033	89/05/03	QUILLBACK ROCKFISH	53.3937	27.6533	47.15875	-122.65475
346	--	1989	SS	--	SS-H034	89/05/03	PACIFIC HERRING	8.2744	0.1408	47.36767	-122.65017
346	--	1989	SS	--	SS-H034	89/05/03	QUILLBACK ROCKFISH	2.0686	1.1729	47.36767	-122.65017
347	--	1989	SS	--	SS-H035	89/05/03	PACIFIC HERRING	21.7018	1.2797	47.29259	-122.71333
347	--	1989	SS	--	SS-H035	89/05/03	WALLEYE POLLOCK	2.6042	0.8269	47.29259	-122.71333
347	--	1989	SS	--	SS-H035	89/05/03	PACIFIC WHITING (HAKE)	5.2084	0.1969	47.29259	-122.71333
349	--	1989	SS	--	SS-H037	89/05/04	PACIFIC COD	2.0255	0.6891	47.41008	-122.41884
349	--	1989	SS	--	SS-H037	89/05/04	WALLEYE POLLOCK	5.0638	0.7351	47.41008	-122.41884
349	--	1989	SS	--	SS-H037	89/05/04	QUILLBACK ROCKFISH	3.0383	1.4241	47.41008	-122.41884
436	--	1991	SS	--	SS-H021	91/05/13	PACIFIC WHITING (HAKE)	5.2351	1.5266	47.48367	-122.43042
437	--	1991	SS	--	SS-H022	91/05/13	PACIFIC COD	0.9532	0.5188	47.41075	-122.42050
437	--	1991	SS	--	SS-H022	91/05/13	WALLEYE POLLOCK	0.9532	0.0865	47.41075	-122.42050

GIS Number	Survey ID	Year	Region	Station ID	Haul ID	Date	Name	Density (Ind./hectare)	Density (kg/hectare)	Average Latitude (N)	Average Longitude (W)
437	--	1991	SS	--	SS-H022	91/05/13	PACIFIC WHITING (HAKE)	15.2507	0.2595	47.41075	-122.42050
437	--	1991	SS	--	SS-H022	91/05/13	QUILLBACK ROCKFISH	2.8595	1.8159	47.41075	-122.42050
438	--	1991	SS	--	SS-H023	91/05/13	PACIFIC WHITING (HAKE)	7.6390	0.7875	47.41050	-122.41250
438	--	1991	SS	--	SS-H023	91/05/13	QUILLBACK ROCKFISH	15.2780	5.9536	47.41050	-122.41250
440	--	1991	SS	--	SS-H025	91/05/13	PACIFIC COD	0.6002	0.8984	47.33567	-122.42850
440	--	1991	SS	--	SS-H025	91/05/13	PACIFIC WHITING (HAKE)	3.6009	2.4501	47.33567	-122.42850
440	--	1991	SS	--	SS-H025	91/05/13	QUILLBACK ROCKFISH	0.6002	0.6261	47.33567	-122.42850
441	--	1991	SS	--	SS-H026	91/05/13	PACIFIC COD	1.1857	0.4840	47.25767	-122.56459
441	--	1991	SS	--	SS-H026	91/05/13	WALLEYE POLLOCK	1.1857	0.2151	47.25767	-122.56459
441	--	1991	SS	--	SS-H026	91/05/13	PACIFIC WHITING (HAKE)	11.8566	2.6353	47.25767	-122.56459
442	--	1991	SS	--	SS-H027	91/05/13	PACIFIC WHITING (HAKE)	15.7988	1.4250	47.16033	-122.64975
442	--	1991	SS	--	SS-H027	91/05/13	QUILLBACK ROCKFISH	3.6459	1.2679	47.16033	-122.64975
443	--	1991	SS	--	SS-H028	91/05/14	PACIFIC HERRING	5.0042	0.1297	47.16742	-122.73250
444	--	1991	SS	--	SS-H030	91/05/15	PACIFIC HERRING	81.4248	1.4608	47.32275	-122.80909
444	--	1991	SS	--	SS-H030	91/05/15	PACIFIC WHITING (HAKE)	0.6076	0.0276	47.32275	-122.80909
445	--	1991	SS	--	SS-H031	91/05/15	PACIFIC HERRING	31.1614	0.8481	47.28225	-122.84375
446	--	1991	SS	--	SS-H032	91/05/15	PACIFIC HERRING	5.6525	0.0513	47.36542	-122.65525
447	--	1991	SS	--	SS-H033	91/05/15	PACIFIC HERRING	1.3889	0.0315	47.28917	-122.71633
447	--	1991	SS	--	SS-H033	91/05/15	PACIFIC WHITING (HAKE)	2.7778	0.0630	47.28917	-122.71633
786	--	1996	SS	--	SS-H035	96/05/08	QUILLBACK ROCKFISH	1.9897	1.4892	47.30525	-122.45784
788	--	1996	SS	--	SS-H037	96/05/08	PACIFIC WHITING (HAKE)	26.8801	1.3322	47.34608	-122.38450
788	--	1996	SS	--	SS-H037	96/05/08	QUILLBACK ROCKFISH	3.9822	2.6192	47.34608	-122.38450
789	--	1996	SS	--	SS-H038	96/05/08	PACIFIC COD	0.9009	1.1850	47.37025	-122.41658
789	--	1996	SS	--	SS-H038	96/05/08	PACIFIC WHITING (HAKE)	4.5045	1.2464	47.37025	-122.41658
789	--	1996	SS	--	SS-H038	96/05/08	QUILLBACK ROCKFISH	47.7477	18.3686	47.37025	-122.41658
789	--	1996	SS	--	SS-H038	96/05/08	WALLEYE POLLOCK	0.9009	1.1033	47.37025	-122.41658
793	--	1996	SS	--	SS-H040	96/05/09	PACIFIC WHITING (HAKE)	2.5191	0.1428	47.26309	-122.55559
794	--	1996	SS	--	SS-H041	96/05/10	PACIFIC HERRING	10.8239	0.6137	47.32092	-122.56358
794	--	1996	SS	--	SS-H041	96/05/10	PACIFIC WHITING (HAKE)	10.8239	1.0555	47.32092	-122.56358
794	--	1996	SS	--	SS-H041	96/05/10	QUILLBACK ROCKFISH	8.6591	5.7444	47.32092	-122.56358
794	--	1996	SS	--	SS-H041	96/05/10	WALLEYE POLLOCK	2.1648	0.3682	47.32092	-122.56358
795	--	1996	SS	--	SS-H042	96/05/10	PACIFIC HERRING	13.7195	0.8402	47.32325	-122.51942
795	--	1996	SS	--	SS-H042	96/05/10	PACIFIC WHITING (HAKE)	2.7439	0.0933	47.32325	-122.51942
795	--	1996	SS	--	SS-H042	96/05/10	QUILLBACK ROCKFISH	1.3719	0.8090	47.32325	-122.51942
796	--	1996	SS	--	SS-H043	96/05/10	PACIFIC HERRING	23.9181	0.3051	47.37225	-122.52359
798	--	1996	SS	--	SS-H045	96/05/15	PACIFIC COD	15.0015	9.1078	47.43750	-122.52525
798	--	1996	SS	--	SS-H045	96/05/15	PACIFIC WHITING (HAKE)	8.0777	0.7852	47.43750	-122.52525
798	--	1996	SS	--	SS-H045	96/05/15	QUILLBACK ROCKFISH	19.6173	12.1437	47.43750	-122.52525
798	--	1996	SS	--	SS-H045	96/05/15	WALLEYE POLLOCK	1.1540	0.0785	47.43750	-122.52525
799	--	1996	SS	--	SS-H046	96/05/15	PACIFIC HERRING	2.2720	0.0258	47.50033	-122.44992
799	--	1996	SS	--	SS-H046	96/05/15	PACIFIC WHITING (HAKE)	1.1360	0.0412	47.50033	-122.44992
799	--	1996	SS	--	SS-H046	96/05/15	QUILLBACK ROCKFISH	17.0396	4.3799	47.50033	-122.44992
799	--	1996	SS	--	SS-H046	96/05/15	WALLEYE POLLOCK	1.1360	0.1030	47.50033	-122.44992
800	--	1996	SS	--	SS-H047	96/05/15	PACIFIC WHITING (HAKE)	41.4311	3.7391	47.49450	-122.42942
800	--	1996	SS	--	SS-H047	96/05/15	QUILLBACK ROCKFISH	2.5894	1.5269	47.49450	-122.42942
802	--	1996	SS	--	SS-H049	96/05/16	PACIFIC HERRING	1.3516	0.0307	47.19133	-122.69442
803	--	1996	SS	--	SS-H050	96/05/16	PACIFIC HERRING	189.2515	2.2127	47.15517	-122.62559
803	--	1996	SS	--	SS-H050	96/05/16	PACIFIC WHITING (HAKE)	1.1755	0.0267	47.15517	-122.62559
804	--	1996	SS	--	SS-H051	96/05/16	PACIFIC WHITING (HAKE)	5.4574	0.1945	47.18659	-122.80050
804	--	1996	SS	--	SS-H051	96/05/16	QUILLBACK ROCKFISH	2.3389	0.2652	47.18659	-122.80050

GIS Number	Survey ID	Year	Region	Station ID	Haul ID	Date	Name	Density (Ind./hectare)	Density (kg/hectare)	Average Latitude (N)	Average Longitude (W)
810	--	1996	SS	--	SS-H054	96/05/17	PACIFIC HERRING	9.2269	0.0930	47.20425	-122.82233
810	--	1996	SS	--	SS-H054	96/05/17	SURF SMELT	1.0252	0.0279	47.20425	-122.82233
812	--	1996	SS	--	SS-H056	96/05/20	QUILLBACK ROCKFISH	8.3222	1.8403	47.16400	-122.67025
812	--	1996	SS	--	SS-H056	96/05/20	REDSTRIPE ROCKFISH	3.1208	0.4719	47.16400	-122.67025
815	--	1996	SS	--	SS-H058	96/05/21	PACIFIC WHITING (HAKE)	10.8428	0.7624	47.21900	-122.63592
815	--	1996	SS	--	SS-H058	96/05/21	QUILLBACK ROCKFISH	1.0843	0.0983	47.21900	-122.63592
815	--	1996	SS	--	SS-H058	96/05/21	WALLEYE POLLOCK	1.0843	0.0737	47.21900	-122.63592
820	--	1996	SS	--	SS-H060	96/05/22	PACIFIC HERRING	19.2474	0.3395	47.33667	-122.80134
821	--	1996	SS	--	SS-H061	96/05/23	PACIFIC HERRING	4.5098	0.2045	47.14467	-122.78450
823	--	1996	SS	--	SS-H063	96/05/23	PACIFIC HERRING	92.5739	1.6170	47.29650	-122.80075
824	--	1996	SS	--	SS-H064	96/05/23	PACIFIC HERRING	26.6343	1.1665	47.27292	-122.85034
825	--	1996	SS	--	SS-H065	96/05/23	PACIFIC HERRING	21.0367	0.4120	47.23825	-122.84484
826	--	1996	SS	--	SS-H066	96/05/24	PACIFIC HERRING	87.7458	4.1727	47.24550	-122.67517
826	--	1996	SS	--	SS-H066	96/05/24	PACIFIC WHITING (HAKE)	182.0961	9.3083	47.24550	-122.67517
826	--	1996	SS	--	SS-H066	96/05/24	QUILLBACK ROCKFISH	0.9435	0.2568	47.24550	-122.67517
827	--	1996	SS	--	SS-H067	96/05/24	PACIFIC HERRING	32.8955	1.1937	47.27025	-122.69800
827	--	1996	SS	--	SS-H067	96/05/24	PACIFIC WHITING (HAKE)	20.8338	1.2683	47.27025	-122.69800
828	--	1996	SS	--	SS-H068	96/05/24	PACIFIC HERRING	542.7919	11.4795	47.30492	-122.71958
828	--	1996	SS	--	SS-H068	96/05/24	PACIFIC WHITING (HAKE)	14.4616	0.8091	47.30492	-122.71958
829	--	1996	SS	--	SS-H069	96/05/24	PACIFIC HERRING	1.2815	0.0174	47.26959	-122.73008
833	--	1996	SS	--	SS-H071	96/05/29	PACIFIC COD	0.9268	0.5044	47.32325	-122.47750
833	--	1996	SS	--	SS-H071	96/05/29	PACIFIC WHITING (HAKE)	0.9268	0.0210	47.32325	-122.47750
833	--	1996	SS	--	SS-H071	96/05/29	QUILLBACK ROCKFISH	15.7553	7.3567	47.32325	-122.47750
834	--	1996	SS	--	SS-H072	96/05/29	PACIFIC COD	0.9234	2.1989	47.36292	-122.37117
834	--	1996	SS	--	SS-H072	96/05/29	PACIFIC WHITING (HAKE)	9.2337	2.0313	47.36292	-122.37117
834	--	1996	SS	--	SS-H072	96/05/29	QUILLBACK ROCKFISH	5.5402	3.1203	47.36292	-122.37117
835	--	1996	SS	--	SS-H073	96/05/29	PACIFIC WHITING (HAKE)	26.3152	2.9570	47.39392	-122.35108
835	--	1996	SS	--	SS-H073	96/05/29	QUILLBACK ROCKFISH	1.1961	1.0308	47.39392	-122.35108
837	--	1996	SS	--	SS-H074	96/05/29	PACIFIC WHITING (HAKE)	12.8904	0.6822	47.42042	-122.37709
837	--	1996	SS	--	SS-H074	96/05/29	QUILLBACK ROCKFISH	0.8594	0.7601	47.42042	-122.37709
838	--	1996	SS	--	SS-H075	96/05/29	PACIFIC WHITING (HAKE)	29.6915	3.6935	47.47042	-122.41859
838	--	1996	SS	--	SS-H075	96/05/29	QUILLBACK ROCKFISH	2.6992	1.7753	47.47042	-122.41859
838	--	1996	SS	--	SS-H075	96/05/29	WALLEYE POLLOCK	2.6992	0.6530	47.47042	-122.41859
840	--	1996	SS	--	SS-H077	96/05/30	PACIFIC WHITING (HAKE)	3.4065	0.1288	47.49800	-122.38784
840	--	1996	SS	--	SS-H077	96/05/30	QUILLBACK ROCKFISH	18.1682	8.8848	47.49800	-122.38784