R E S O U R C E S

N A T U R A L

Habitat Conservation Plan for Washington Department of Natural Resources' Geoduck Fishery

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Aquatic Resources Program

WASHINGTON STATE DEPARTMENT OF
Natural Resources
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1. Introduction and Background

The Washington Department of Natural Resources (DNR) has developed this Wild Stock Geoduck Fishery Habitat Conservation Plan (Geoduck HCP) in response to the federal listings of certain fish and wildlife species under the Endangered Species Act. This Geoduck HCP only considers the geoduck fishery that is administered and managed by Washington DNR.

Washington DNR is seeking authorization for incidental take of certain ESA-listed species under Section 10 of the ESA. Such authorization is gained through the development of this Geoduck HCP and the subsequent issuance of Incidental Take Permits under Section 10 of the ESA from both U.S. Fish and Wildlife Service and the National Marine Fisheries Service.

1-1 Background

The Washington State Department of Natural Resources manages over 2.4 million acres of state-owned aquatic lands and their associated biota in marine and freshwater environments. These are submerged marine and freshwater bedlands, marine tidelands, and freshwater shorelands that contain a variety of aquatic plants and algae, numerous animals living on or within the substrate, and other valuable materials in and on the substrate.

The geoduck clam (*Panopea abrupta*) is one infaunal species that occurs on state-owned subtidal bedlands and tidelands and is managed by DNR. A commercial fishery on the geoducks has occurred for over 35 years and is the subject of this HCP.

1-1.1 Aquatic Land Management, RCWs

As the proprietary manager of state-owned aquatic lands, DNR has unique obligations. State law recognizes aquatic lands to be a finite natural resource, and charges DNR with managing the land for the benefit of the public (Revised Code of Washington [RCW] 79.105.010). In RCW 79.105.030, the legislature has directed DNR to endeavor to provide a balance of public benefits that include:

- Encouraging direct public use and access;
- Fostering water-dependent uses;
- Ensuring environmental protection;
- Utilizing renewable resources; and

- Generating revenue in a manner consistent with the other defined benefits.

There are a number of state laws in the RCW and rules in the Washington Administrative Code (WAC) specifically guiding the use of state-owned aquatic land for geoduck harvest and specifying certain management parameters of the fishery (Appendix A).

1-1.2 History of the Geoduck Fishery

In 1967, the agency that is now the Washington Department of Fish and Wildlife (WDFW) began conducting subtidal surveys to determine if the geoduck resource could support commercial harvest. The geoduck resource of Puget Sound and the Strait of Juan de Fuca was found to have sufficient biomass to support a commercial fishery. In l969, DNR and WDFW jointly petitioned the Legislature to open a commercial geoduck fishery. The Legislature created statute to control harvest, and directed DNR and WDFW to manage the fishery cooperatively.

In 1970, the first harvesting contract was offered for sale. Demand for geoducks was limited initially, but by the mid-1970s, it grew significantly when the industry found a market for geoducks in Japan. In the first five years of the fishery (1970-1974), the average annual harvest was about 491,000 pounds. From 2000 to 2004 it was about 4,130,000 pounds (This is the total harvest; tribal and state). The fishery has grown to be a large and economically important clam fishery on the west coast of North America.

1-1.3 How the Fishery is Managed

Washington's geoduck fishery is jointly managed by Washington Department of Natural Resources, the Washington Department of Fish and Wildlife (WDFW), and the sixteen tribes that have a right to up to 50 percent of the harvestable surplus of geoducks (as affirmed in United States v. Washington, 873 F. Supp. 1422 W.D. Wash. 1994 and United States v. Washington, 898 F. Supp. 1453 W.D. Wash. 1995). The state agencies and the tribes are jointly responsible for estimating population size, determining sustainable yield, and ensuring that adverse effects to the environment are kept to a minimum.

The commercial geoduck fishery is managed on a sustainable basis and at a conservative level. Management of the geoduck resource is designed to be responsive to changes in market demand, resource economics, and new information on geoduck biology and population dynamics.

Washington DNR has proprietary rights over the state's harvest opportunity on half of the harvestable geoducks and offers the right to harvest specific quantities in specific areas to private companies and individuals. The terms of harvest are stipulated in a harvesting agreement, which is a legally binding contract between the state and each private harvest company that participates in the fishery (Appendix B).

Washington Department of Fish and Wildlife is the manager of the biological aspects of the fishery and has licensing and enforcement responsibilities for the geoduck fishery. It manages the fishery as part of its larger authority under RCW's 77.65, 77.12.043 and 77.12.047.

Although each state agency has separate and distinct responsibilities, DNR and WDFW share enforcement responsibility for Washington State laws, regulations, and harvesting agreement conditions as appropriate within the responsibilities and mandates of each agency. For example DNR is responsible for on-tract compliance of geoduck harvest and WDFW is responsible for general off-tract enforcement (e.g., poaching curtailment).

1-2 Permit Duration

Washington Department of Natural Resources is requesting Incidental Take Permits for 50 years. Geoduck harvest has been occurring for over 35 years, and has been occurring at about the same levels since the late 1990's; about 7 years. The fishery is managed using a sustainable harvest rate model and it is expected to continue in the future at a similar harvest level.

1-3 Plan Area

The Geoduck HCP plan area occurs within the submerged lands of Puget Sound, the Strait of Juan de Fuca and areas north to the Canadian border (Figure 1, which also shows management regions, discussed in Chapter 3). Within this broad area, commercial geoduck harvest occurs subtidally in areas that have been surveyed between depth contours of –18 and –70 feet (corrected to mean lower low water [MLLW]) and found to contain geoducks at sufficient densities (Figure 2). Following environmental and health review, specific areas (tracts) are identified as appropriate for commercial harvest. Details of harvest locations and activities are in Chapter 3.

1-4 Species to be Covered

Washington Department of Natural Resources is requesting coverage under Incidental Take Permits for seven species currently federally listed as threatened or endangered, and another eight species with some other listing status (Table 1.1). Throughout the remainder of this document, the term –covered species" refers to all listed and unlisted species included in the HCP and listed in Table 1.1.

Table 1.1. Species for which DNR is requesting coverage in Incidental Take Permits.

Common Name	*Scientific Name*	*Federal Status*	*State Status*
Birds			
Bald eagle	*Haliaeetus leucocephalus*	De-listed	Threatened
California brown pelican	*Pelecanus occidentalis*	Endangered	Endangered
Marbled murrelet	*Brachyramphus marmoratus*	Threatened	Threatened
Tufted puffin	*Fratercula cirrhata*	Species of Concern	Candidate
Fish			
Bull trout	*Salvelinus confluentus*	Threatened	Candidate
Chinook salmon	*Oncorhynchus tshawytscha*	Endangered/ Threatened	Candidate
Chum salmon	*Oncorhynchus keta*	Threatened	Candidate
Coastal cutthroat trout	*Oncorhynchus clarki clarki*	Species of Concern	None
Coho salmon	*Oncorhynchus kisutch*	Concern/Candidate	Not Listed
Pink salmon	*Oncorhynchus gorbuscha*	None	None
Pacific herring	*Clupea harengus pallasi*	Candidate	Candidate
Steelhead	*Oncorhynchus mykiss*	Threatened	Candidate
Marine Mammals			
Southern resident orca	*Orcinus orca*	Endangered	Endangered
Invertebrates			
Pinto abalone	*Haliotis kamtschatkana*	Candidate	Candidate
Olympia oyster	*Ostrea conchaphila*	None	Candidate

Figure 1: Six Current Geoduck Management Regions in Washington

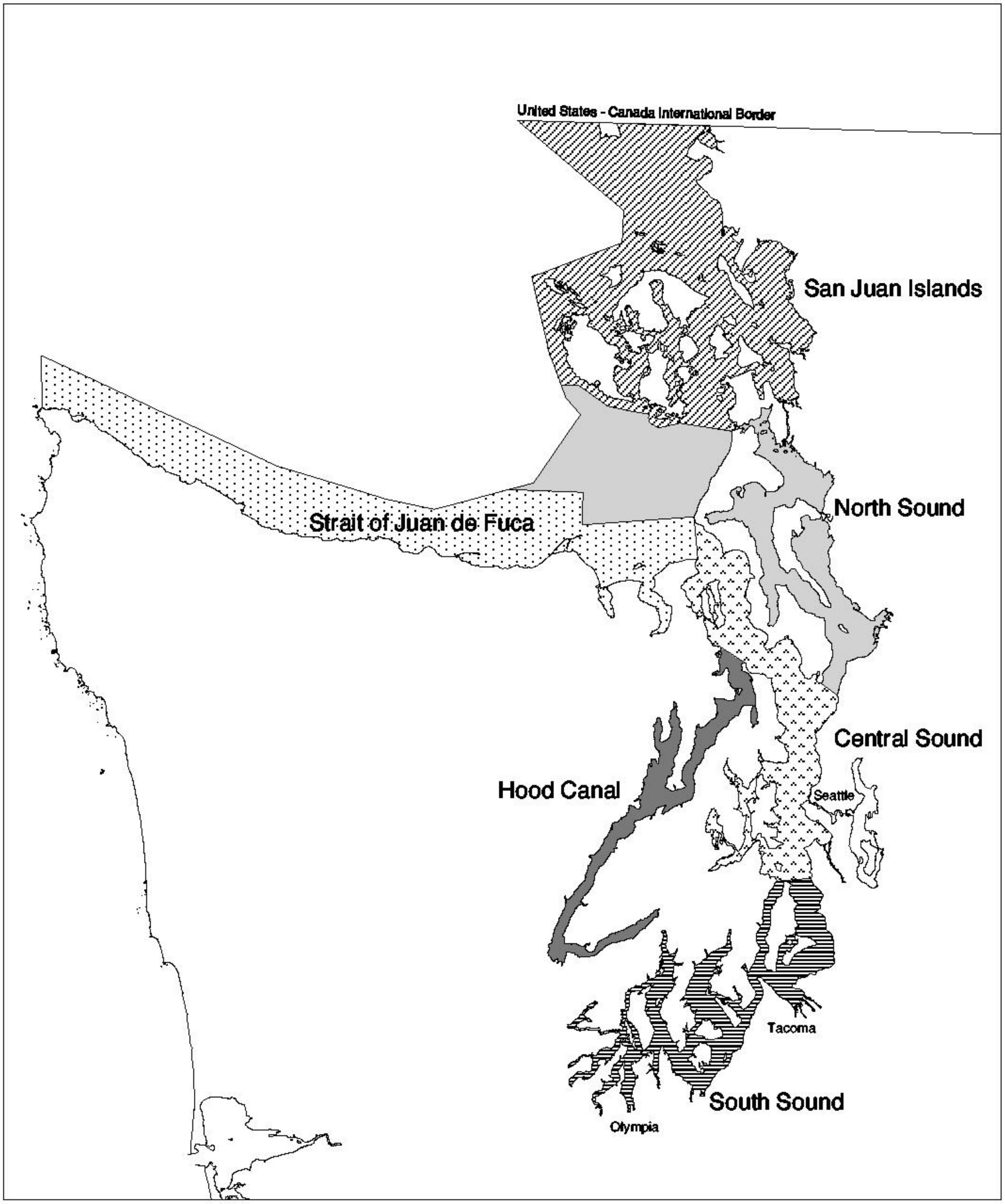
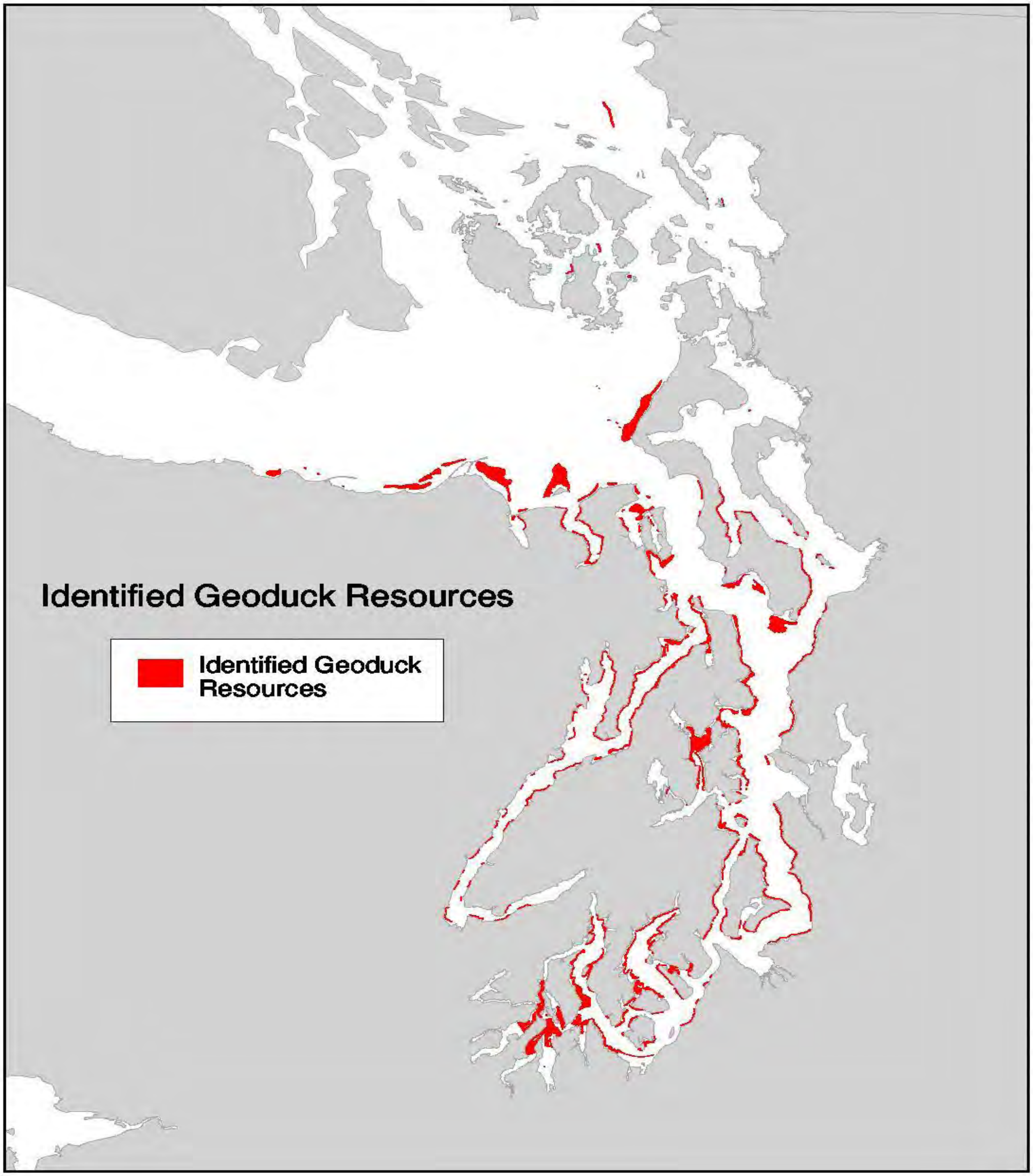


Figure 2: Map of Identified Geoduck Tracts in Washington



1-5 Regulatory and Legal Framework

1-5.1 Endangered Species Act and Assurances

Initially passed in 1973, the Endangered Species Act (16 U.S.C. § 1531-1544, 87 Stat. 884, as amended), provides for the special designation and protection of invertebrates, wildlife, fish and plant species that are in danger of becoming extinct. A fundamental purpose of the ESA is to protect and recover endangered and threatened species and to provide a means to conserve the ecosystems on which they depend.

The ESA defines an *endangered* species as any species that is in danger of becoming extinct throughout all or a significant portion of its range (16 U.S.C. § 1532(6)). A *threatened* species is one that is likely to become endangered in the foreseeable future (16 U.S.C. § 1532(20)).

The U.S. Fish and Wildlife Service, housed within the Department of the Interior, and the National Marine Fisheries Service, housed within the Department of Commerce, share responsibility in administering the ESA. Generally, the USFWS is responsible for terrestrial species and freshwater aquatic species and the NMFS is responsible for marine mammals, anadromous fish and other marine species.

Section 9 of the ESA makes it unlawful to “take” a species that is listed as endangered. The term “take” under the ESA is defined as: “to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct” (16 U.S.C. § 1532 (19)). By federal regulation, the take prohibitions can be extended to species listed as threatened as well (16 U.S.C. § 1538(a)).

Section 10 of the ESA provides an exception to the Section 9 take prohibition. It states that the Secretary of the Interior or the Secretary of Commerce (depending on the species involved) may permit any taking otherwise prohibited by Section 9, if such taking is incidental to, and not the purpose of, carrying out an otherwise lawful activity (16 U.S.C. § 1539(a). A landowner can obtain an Incidental Take Permit under this provision if they submit a conservation plan (i.e., an HCP) that meets certain requirements.

The plan must specify:

- The impact which will likely result from the take;
- What steps the applicant will take to monitor, minimize and mitigate such impacts; the funding available to implement such steps; and as well as the procedures to be used to deal with changed and unforeseen circumstances;
- What alternative actions to such taking the applicant considered and the reasons why such alternatives are not being utilized; and
- Other measures that the Secretary of the Interior and/or Commerce may require as being necessary or appropriate for purposes of the plan. (16 U.S.C. 1539(a)(2)(A))

1-5.2 Issuance Criteria

When the USFWS and NMFS determine that all criteria for a habitat conservation plan have been met, and after an opportunity for public comment, an Incidental Take Permit must be issued if the agencies find that:

- The taking will be incidental;
- The applicant will, to the maximum extent practicable, minimize and mitigate the impacts of such taking;
- The applicant will ensure that adequate funding for the plan will be provided;
- The taking will not appreciably reduce the likelihood of the survival and recovery of the species in the wild; and
- Such measures that the secretaries of the Interior and Commerce may require as being necessary or appropriate for the purposes of the plan will be met. (16 U.S.C. 1539(a)(2)(B)):

1-5.3 Section 7 Consultation

Section 7(a)(2) of the ESA requires Federal agencies in consultation with, and with the assistance of, the Secretary to ensure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of designated critical habitat. The issuance of an Incidental Take Permit requires an analysis under Section 7 of the ESA. The Section 7 implementing regulations (50 CFR Part 402) require, among other things, analysis of the direct and indirect effects of a proposed action, the cumulative effects of other activities on listed species, and effects of the action on critical habitat, if applicable. Consultation under Section 7 of the ESA is the responsibility of the Federal agencies. However, DNR's Geoduck HCP is designed to assist the Services in addressing potential effects from geoduck harvest in their Section 7 consultation process.

2. Environmental Setting

2-1 Overview

Commercial geoduck harvest occurs within specific water depth boundaries in Puget Sound and the Strait of Juan de Fuca. Future harvest will occur to the north, in the vicinity of the San Juan archipelago (Figures 1 and 2).

2-1.1 The Nearshore

The nearshore environment is considered to encompass the shoreline area from extreme high water seaward to the 66-foot (20 m) bathymetric contour. This encompasses the area of intertidal and subtidal marine bedlands that receive enough sunlight to (potentially) support the growth of attached algae (Redman et al. 2005). The –18 to –70 foot water depths where geoduck harvest takes place occur within the subtidal portion of the nearshore environment.

Within Puget Sound, the Strait of Juan de Fuca and the San Juan archipelago, nearshore environments play a critical role in the life history of many organisms. Nearshore marine waters are important for juvenile and adult food production and serve as critical areas for salmon migration, nursery areas, residence, and refugia (Mavros and Brennan 2001; Williams et al. 2001; Brennan et al. 2004). These areas are rich, complex, and important parts of the ecosystem. Kelp beds, eelgrass meadows, salt marshes, rocky shores, beaches and tidal flats are important nearshore environments. They support populations of shellfish, salmon, groundfish, seabirds, and marine mammals.

2-1.2 Eelgrass

Eelgrass is a flowering plant that grows primarily in the shallow, subtidal areas of the nearshore on sandy or muddy substrate. The plant spreads by rhizomes or rootstock. Expanses of eelgrass meadows expand during spring and summer then decline in the fall and winter. Multiple environmental factors influence the distribution of eelgrass, including light, substrata type, salinity, and wave action (Thom et al. 1998).

Eelgrass is an important component of the nearshore environment. Eelgrass meadows cushion the impact of waves and currents, preventing erosion. The rhizomes and roots of the plants hold sediments in place, which helps preserve the highly productive bacteria in the sediments. These bacteria in turn nourish large numbers of invertebrates such as isopods, amphipods, polychaete worms, brittle stars, and some clams. The abundance of invertebrates makes eelgrass meadows excellent foraging areas for fish and marine birds. Some species of birds, snails, and crabs feed directly on the leaves of eelgrass as well. Others species (e.g., urchins) feed on detritus from decaying eelgrass plants.

During low tides, eelgrass provides shelter from direct sunlight and extreme temperatures for small animals and plants (Phillips 1984; Hemminga and Duarte 2000; Blackmon et al. 2006).

Eelgrass beds of two species (*Zostera marina* and *Zostera japonica*) occur along 37 percent of Washington's shorelines. The distribution of *Z. marina* (the native species) in Puget Sound is highly aggregated with about 27% of the total located in Padilla and Samish Bays. Eelgrass has not been observed in the extreme southern reaches of the Sound such as Budd Inlet, Eld Inlet and Totten Inlet (Dowty et al. 2005).

Eelgrass is light limited and in Puget Sound rarely occurs deeper than –18 feet MLLW. It can occur deeper where clearer waters allow a greater depth of light penetration.

Data collected from 2002-2004 were used to assess the depth distribution of eelgrass in Puget Sound. *Z. marina*, at the sound-wide scale, is most frequently found (measured in hectares) from 0 ft (MLLW) to –5 ft (MLLW) in depth. In the San Juan area, a substantially greater proportion of total *Z. marina* is found below –10 ft (MLLW) (Selleck et al. 2005).

Ultimately, because of the role of eelgrass as the basic energy source for a variety of food web interactions, and because of the other functions it provides, the covered species use, or benefit in some manner from eelgrass.

2-1.3 Other Vegetation

Kelp beds are important to fish, invertebrates, marine mammals and marine birds dependent on nearshore habitats. Floating kelp is most common in rocky, high-energy environments. For example, floating kelp is common along the rocky outer coast headlands and along the north coast of the Olympic Peninsula (e.g., around Port Townsend), but it is rare in Hood Canal. Floating kelp abundance decreases gradually as energy decreases and rocky habitat is less common. Floating kelp is rare in lower energy waters that have predominantly sand and mud shallow subtidal substrate. Like floating kelp, non-floating kelp is most common in areas with relatively high energy rocky shorelines. Non-floating kelp, principally *Laminaria saccharina,* occurs in protected, lower energy areas and embayments.

Seaweeds occur throughout the marine nearshore where the water is saline and there is adequate light to support their growth. Most grow attached to consolidated substrata, but some green seaweeds can grow without being attached to the bottom. Rocky shores along the Strait of Juan de Fuca and rocky outcrops on Washington's outer coast support hundreds of species of seaweed. In central Puget Sound, the occurrence of intertidal seaweed at five beaches was surveyed and 157 species identified (Thom et al. 1976).

Common macroalgae in Puget Sound include *Laminaria, Alaria, Gracilaria, Desmarestia*, and *Neoagardhiella* species. They need hard substrate for attachment and are found in rocky areas and consolidated substrate. Smaller species such as sea lettuce (*Ulva sp.)* occur as well. Numerous foliose red algae species are common, and articulated coraline red algae species occur in the Strait of Juan de Fuca and the San Juan Island area.

Phytoplankton is an important food source for suspension feeders. In Puget Sound, phytoplankton concentrations generally exceed 0.2 mg chlorophyll-a/cubic meter (m^3) throughout the year—one of the highest concentrations found in saltwater environments (Strickland 1983).

2-1.4 Substrate

Substrate composition in the nearshore is mud, sand, harder consolidated material (clay) gravel, cobble and boulders. Solid rock outcrops can occur as well.

Unconsolidated sediments play an important role in Puget Sound, harboring microorganisms and invertebrates important in nutrient cycling and in the food web. They are the ultimate repository of both natural changes (e.g., grain size changes due to fluvial input) and human caused contaminants entering the Sound through both point and nonpoint sources. Sediment quality, in terms of contamination levels, differs dramatically around Puget Sound. Certain regions in the Sound have degraded conditions as a result of pollution, while other regions are uncontaminated.

Environmental variables, both natural and human caused, influence sediment conditions, and sediment-dwelling biota. These include the level of dissolved oxygen present in the sediments, concentrations of nutrients in the sediments and their movement between the sediment bed and water column, unregulated pollutants including the newly emerging pollutants of concern such as polybrominated diphenyl ethers (PBDEs) and endocrine disruptors, effects of reproduction and recruitment of infaunal species, and effects of predation and oceanographic conditions. The effects of these environmental variables play a large role in influencing the quality of sediments throughout Puget Sound (Partridge et al. 2005).

2-1.5 Benthic Invertebrates

A wide variety of animals that are either buried or partly buried in the substrate occur in the nearshore, and others live on the substrate or are free-living in the waters above the substrate. These include clam species, anemones, polychaete tube worms, flat worms, ribbon worms, peanut worms, crustaceans and others. Small isopods, amphipods, and copepods are also common within and on the substrate. These are an important food source for higher trophic level fish and animals. The structure of benthic infaunal communities is largely dependent on sediment composition and hydrographic conditions (i.e. depth, current velocity) so that the abundance and diversity of species found is not consistent across the substrate.

A number of crab species are common on the substrate in the nearshore. The large Dungeness crab is particularly abundant in Puget Sound waters north of Vashon Island. Dungeness crabs are often associated with sand/silt substrate, especially near eelgrass beds. Like most crabs, Dungeness crabs are benthic predators and scavengers. The graceful crab is also abundant, particularly in southern Puget Sound (Goodwin and Pease 1987).

Red rock crabs are another species widely distributed across Puget Sound. A variety of smaller crabs such as the kelp crab can also be found in the nearshore.

Various pandalid shrimp are present in waters of the nearshore. Common species include ocean pink shrimp, northern pink shrimp, spot shrimp, and coonstripe shrimp.

Several species of epibenthic mollusks are associated with sandy or muddy substrate, including the stubby squid, opalescent squid, snails and nudibranchs.

Where boulders, rock outcrops, or objects discarded by humans occur, the large gumboot chiton and octopus may occasionally be found.

Sea cucumbers are common on silt/sand substrate. Sea stars are also common. Herbivores such as the green sea urchin can also occasionally be found in nearshore environments.

2-1.6 Geoduck Biology and Habitats

Geoducks are burrowing clams that are found throughout Puget Sound, the Strait of Juan de Fuca, and the San Juan archipelago. They are abundant in subtidal substrate, but their distribution is contagious and is affected by water depth, substrate type and predation. Although they can occur intertidally, they are more common below extreme low tide and have been found at depths as great as 360 feet (Goodwin and Pease 1991).

Geoducks live in soft mud, sand, and pea gravel or gravel substrate (Goodwin and Pease 1989) and are abundant in mud, sand, and mixed mud and sand substrate. In Puget Sound, geoduck densities were higher in substrate of mud-sand or sand, compared to mud or pea gravel or gravel substrate (Goodwin and Pease 1987). Clay, shell and rock can also be found in the substrate in areas inhabited by geoducks, though hard substrate may affect recruitment and digging ability of this burrowing clam.

Geoducks cannot completely withdraw their siphon and mantle within their shell, nor can adults dig within the substrate to avoid predation. Their siphons are long, however, and can be withdrawn beneath the surface of the seabed throughout their life. In the early stages of their life cycle, they can eventually burrow into the softer seabed substrate to depths down to three feet.

Geoducks reach a harvestable size of 1.5 pounds in four to five years, with maximum growth attained in fifteen to twenty-five years (Hoffmann et al. 2000). In Puget Sound individual geoducks on average weigh around 2 pounds. The largest geoduck recorded during dig samples from 1973 and 1985 weighed 7.15 pounds (Goodwin and Pease 1991).

2-1.7 Environment of Geoduck Tracts

Commercial harvest occurs in specific areas called tracts. The topography of the tracts varies, but most are relatively flat or are gently sloping. Some tracts have as much as a 30-degree slope in places.

When initially considering a tract for geoduck harvest, biological surveys are conducted for geoducks by WDFW divers along standard belt transects. Divers conducting the surveys also note the most obvious and common animals and plants that are encountered. To gain a general understanding of the fauna on geoduck harvest tracts, transect data from 2001-2006 surveys were summarized for each management region. For each animal noted in the transect surveys, the total number of transects where it was seen was tallied.

Using the total number of transects surveyed by region, across the 2001-2006 timeframe, the percentage of transects on which the animal was seen out of the total transects surveyed was calculated. The most common and obvious animals seen and noted in at least 50 percent of the surveyed transects in each region were sea pens, tubeworms, hermit crabs, horse clams, anemones, and sea star species; and Dungeness and graceful crabs (Appendix C).

Because divers note presence of animals only, these data cannot be used to quantify the abundance of one species, only the relative distribution of a species across the surveyed areas.

Commercial geoduck tracts more commonly encompass soft sand or sand and silt substrate where the larger geoducks and the higher densities occur. Compact substrate, for example those containing clay, or substrate with large amounts of shell and rock are difficult to extract geoducks from and harvest cannot occur in such areas efficiently. Geoducks wedged into shell or gravel deposits can be extremely difficult to remove.

Substrate surfaces are often rippled by the action of waves and currents and non-compacted sediments sometimes form mobile sedimentary bedforms (sandwaves, sand and gravel ribbons) that can be several feet thick. As these bedforms move slowly across the tracts (sediment transport), they may smother geoducks and other benthic organisms (Washington Department of Natural Resources and Washington Department of Fish and Wildlife 2001).

Relatively few species of submerged aquatic vegetation or macroalgae grow in abundance on the sand and silt substrate common in commercial geoduck tracts. These plants generally need a hard substrate to attach to. Smaller vegetation species such as sea lettuce are often seen both attached and floating within geoduck tracts, along with other detached algae deposited by water currents (Washington Department of Natural Resources and Washington Department of Fish and Wildlife 2001). When plants were observed by divers during geoduck surveys, they were most often brown algae (*Laminaria sp*.), red algae (*Desmarestia sp*.), and green algae (sea lettuce, *Ulva sp*.) (Appendix C).

Horse Clams

Horse clams are large bivalves that can grow to over 2.2 pounds (Campbell et al. 1990; Breed-Willeke and Hancock 1980). They are typically found buried in the substrate to depths of 1.6 feet, but have been found in Puget Sound as deep as 4.2 feet below the substrate surface (Goodwin and Shaul 1978). Horse clams have been recorded during geoduck pre-harvest surveys but they prefer coarser substrate (pea gravel/gravel/shell) than geoducks, with lesser amounts of sand and silt (Washington Department of Natural Resources and Washington Department of Fish and Wildlife 2001).

Other Bivalves

Butter clams and native littleneck clams can be found in geoduck tracts with gravel patches. *Macoma inconspicua* and *Transennella tantilla* are more difficult for divers to identify due to their size. Cockles, mya clams, and false geoduck clams may also be present.

Polychaetes

The most abundant group of infauna found in geoduck tracts by Goodwin and Pease (1987) were polychaete tube worms. Polychaetes live in long, jointed tubes less than four hundredths of an inch (1 millimeter) in diameter and form dense root like mats in the sediments, with the mats sometimes used as spawning substrate by herring (Washington Department of Natural Resources and Washington Department of Fish and Wildlife 2001). Several other worms are found in the substrate in less abundance on geoduck tracts, including ribbon worms and peanut worms (Washington Department of Natural Resources and Washington Department of Fish and Wildlife 2001). Many of these worms feed on organic material in the sediments, while others feed on food particles in the water. Several species are carnivorous, often feeding on other worms.

Cnidarians

Sea pens are the most common cnidarian in geoduck tracts with sandy substrate. Sea pens are suspension feeders and live partially buried in the sediments utilizing their polyps to filter plankton from the water. On muddier substrate, burrowing anemones, plumose anemones, and sea-whips are more common (Washington Department of Natural Resources and Washington Department of Fish and Wildlife 2001).

Shrimp

Ghost shrimp are common infauna on geoduck tracts, particularly in Hood Canal. Ghost shrimp feed on organic detritus, building tunnels in the substrate that are used as habitat by a variety of small crabs, worms, and fish (Washington Department of Natural Resources and Washington Department of Fish and Wildlife 2001). In dense populations, their burrowing can increase turbidity to levels that limit the distribution of bivalves (Posey 1986; Posey et al. 1991).

Burrowing Sea Cucumber

The burrowing sea cucumber is sometimes found on geoduck tracts and attains a length of 2.4 inches.

Crabs

Dungeness crabs are often associated with sand/silt substrate and are common in geoduck tracts, especially near eelgrass beds. Due to their preference for rock and gravel substrate, red rock crabs tend to be less common within commercial geoduck tracts, but are widely distributed throughout Puget Sound.

2-2 Species of Concern in the Plan Area

Many species of birds, fish, mammals, and invertebrates are expected to occur in the vicinity of geoduck harvest activities and within harvest tracts because they move freely across a larger area than that where harvest occurs.

2-2.1 Birds

Many species of sea birds and migratory birds occur across Puget Sound, the Strait of Juan de Fuca and in the vicinity of the San Juan archipelago, adjacent to geoduck tracts. Species include bald eagle, marbled murrelet, common loon, and common murre. Puget Sound also provides important over-wintering habitat for a number of waterfowl species.

2-2.2 Fish

This nearshore environment provides habitat for marine and anadromous fish species. This habitat provides food resources and foraging areas, refuge (from predation, seasonal high flows, winter storms, etc.), and migratory corridors.

Salmon, trout and char species use nearshore habitats and may be in the vicinity of geoduck tracts during juvenile rearing and out-migration times, as well as during adult migration to and from their spawning grounds.

The principal fishes in nearshore waters are flatfish such as flounder and sole. Fish species seen in geoduck tracts during geoduck surveys include sanddab, sculpins, flatfish and flounder, and others (Appendix C).

2-2.3 Marine Mammals

Several species of marine mammals are found in the waters of Puget Sound, the Strait of Juan de Fuca and the San Juan archipelago. These include harbor seals, California sea lions, orcas, river otters, and gray whales. Less frequently observed species include Dall's porpoise and the harbor porpoise.

2-3 Covered Species

2-3.1 Birds

BALD EAGLES

In Washington State, bald eagle nests are most numerous near marine shorelines but also occur near the state's lakes, rivers, and reservoirs. In the Puget Sound area, the birds nest and roost in trees along shorelines and forage in nearby waters. Eagles are present year-round in Western Washington (Stinson et al. 2001), and can be roosting, foraging, and nesting in the vicinity of geoduck harvest activities.

In western Washington, most eagles are incubating eggs by the third week in March. The young hatch by late April (Watson and Pierce 1998). Adults are feeding young from the time they hatch to fledging, which occurs about mid-July.

Bald eagles are opportunistic feeders and eat fishes, waterfowl and seabirds, mammals, and carrion (NatureServe 2003a). Feeding behaviors include hunting live prey, scavenging, and pirating food from other birds such as osprey. Watson and Pierce (1998) observed nesting eagles in Puget Sound capturing fish (78%), birds (19%), and mammals (3%). Invertebrates (mollusks and crustaceans) were found in prey remains. Other studies found different relative abundances of prey types, reflecting the opportunistic nature of eagle feeding (Stinson et al. 2001).

In two studies cited by Stinson et al (2001), many fish species occurred in eagle diets including flounder, plainfin midshipman, dogfish shark, sculpin, rockfish, ling-cod, walleye pollock, Pacific hake, Pacific cod, cabezon, red Irish lord, and salmonid species (unidentified).

CALIFORNIA BROWN PELICAN

The California brown pelican is one of six recognized subspecies of brown pelican. Nesting by this subspecies does not occur in Washington and is restricted to islands in the Gulf of California and along the outer coast of California. Non-breeding California brown pelicans range northward along the Pacific Coast as far as Washington and into southern British Columbia.

Important roosting sites include offshore rocks and islands, river mouths with sand bars, breakwaters, pilings, and jetties along the Pacific Coast. Feeding occurs primarily in shallow estuarine waters with the birds seldom venturing more than 20 miles out to sea. Sand spits and offshore sand bars are used extensively as daily loafing and nocturnal roost areas.

California brown pelicans feed mainly on surface-schooling fish (NatureServe 2006) in shallow estuarine and inshore waters and may dive for their prey.

MARBLED MURRELET

Marbled murrelets are small, diving seabirds that live in coastal forests and nearshore marine environments (McShane et al. 2004). Murrelets generally select old-growth forests for nesting, within 37 miles of the coast. They can be found foraging in waters throughout Puget Sound, the Strait of Juan de Fuca and the San Juan archipelago. Their distribution varies spatially and temporally and their overall pattern of abundance (density) and occurrence in the marine habitats of Puget Sound is best characterized as variable (Speich and Wahl 1995).

Field observations in Puget Sound, during the course of formal censuses and other informal observations, suggest that the foraging distribution of marbled murrelets is closely linked to tidal patterns, in particular to specific locations when tidal flows are clearly evident. However, tidal activity occurs throughout Puget Sound and is likely the single dominant and persistent physical process there. More analysis at a detailed level may give insight into the relative importance of tidal activity in determining the movements and foraging areas of marbled murrelets (Speich and Wahl 1995).

Marbled murrelets are opportunistic feeders. Small schooling fish and pelagic crustaceans are important prey items. Pacific sand lance, Pacific herring, capelin, and smelt have been documented as common prey species (McShane et al. 2004). The birds dive to catch prey and for the most part forage in relatively shallow nearshore waters (<98 feet deep). They have been documented diving for foraging purposes as deep as 16 feet, and may even dive deeper than this (McShane et al. 2004).

TUFTED PUFFIN

Tufted puffins spend most of their lives over offshore marine waters, only returning to land to nest. Tufted puffins are found primarily off the western Pacific coast of Washington, but can occur along the northern coast of the Olympic peninsula and around the San Juan Islands. The birds arrive at their nesting colonies in early spring and nest in ground burrows or under piles of rocks (NatureServe 2003b).

Specifically within Washington‘s inland waters, Protection Island in the Strait of Juan de Fuca and Tatoosh Island, off the northwestern tip of the Olympic Peninsula, provide most of the nesting habitat for puffins (West 1997). Protection Island is a National Wildlife

Refuge and contains the 48-acre Zella M. Schultz Seabird Sanctuary. A 600-foot buffer around the island is closed year-round to protect wildlife resources.

Breeding numbers of puffins have fallen. West (1997) reported 13 pairs in the Strait of Juan de Fuca. Their breeding colonies in Washington's inland waters are now restricted primarily to Protection Island.

Breeding occurs from late April to June, with the eggs and young tended by both parents. Eggs hatch within 42 to 53 days, with the chicks remaining in the nest for a similar time span (NatureServe 2003b). Birds stay at the nesting colonies until mid-September (Piatt and Kitaysky 2002; Speich and Wahl 1989). After fledging, adults and the young return to the open ocean.

Tufted puffins feed on fish, preferring smelts, herring and other small surface-schooling fish, as well as sea urchins and mollusks. They are diving birds and feed in offshore waters with tidal upwellings that push prey to the surface (NatureServe 2003b). In Washington, Haro Strait, San Juan Passage and Rosario Strait are important feeding areas (Angell and Balcomb 1982).

2-3.2 Fish

Marine fish and anadromous salmonid species depend on intertidal and shallow subtidal nearshore environments for refuge, food, and migration. Juveniles use marine shoreline riparian vegetation for shading and cooler water temperatures, as well as a source of food from terrestrial insects associated with the vegetation. Nearshore vegetative communities such as eelgrass meadows provide refuge and prey items in the form of smaller fish and crustaceans, as well as larvae and larger zooplankton. Nearshore areas also provide foraging areas and migration routes for returning adults.

Where depths were reported in studies of juvenile Chinook, pink, coho, and chum salmon, the fish were generally found within the top 10-20 feet of the water column, along shorelines (Weitkamp 2000, citing others). Salmonid fry tended to school along shorelines and move offshore as they grew larger. The juvenile salmonids tended to be near the water surface, at least during the day.

PACIFIC HERRING

Pacific herring are pelagic schooling fish that depend heavily on the nearshore environment for the spawning and rearing portions of their lifecycle. They are ubiquitous in Washington's marine waters, but separate stocks exist and spawn in specific areas.

Herring spawning grounds are well documented and stocks show strong fidelity to their particular spawning areas. Pacific herring spawn at eighteen to twenty sites throughout Puget Sound and the Strait of Juan de Fuca including Squaxin Pass, Cherry Point, Quartermaster Harbor, Port Orchard/Port Madison, South Hood Canal, Port Gamble, Kilisut Harbor, the San Juan Islands, and Quilcene, Skagit, Fidalgo, Samish-Portage, Semiahmoo, Discovery and Dungeness Bay (Bargman 2001). In addition to specific spawning sites, each stock has specific growth rates, age structures, spawning timing, and pre-spawner holding areas (Lemberg et al. 1997).

Most herring stocks in Washington spawn from late January through early April. The Cherry Point stock spawns later, from early April through early June (WDFW 1997a).

The time of year that spawning occurs is very specific and seldom varies by more than seven days from year to year (WDFW 2000).

Puget Sound herring spawn in vegetated areas of semi-protected intertidal and shallow subtidal zones. They generally spawn between 0 and –10 feet, but eggs may be deposited from the upper limits of high tide to as deep as – 40 feet (WDFW 1997a). Eggs are deposited on eelgrass and marine algae (WDFW 1997a) and other substrate such as tube worm mats.

Eggs hatch after about ten to fourteen days. The larval herring are about ½ inch long and drift in currents for roughly 3 months before metamorphosing into their juvenile and finally adult forms (WDFW 1997a). Juvenile herring form schools and remain in the nearshore environment until they migrate to the open ocean during the fall of their second year, although some herring spend their entire lives within Puget Sound (McCrae 1994; WDFW 2000). Herring become sexually mature at two to four years of age and return then to their natal spawning grounds (Bargman 2001).

Fresh et al. (1981) analyzed stomach contents of juvenile herring caught in shallow, sublittoral habitats, and nearshore pelagic habitats in Puget Sound. The relative abundance of dietary components differed with fish size, the habitat sampled, and sampling method (beach seine, tow net, purse seine), but calanoid copepods, decapod crab larvae, chaetognaths, cyclopoid and harpacticoid copepods, euphausiids and brachyuran crab larvae were important prey species.

Herring at all life stages are an important prey item for seabirds, marine mammals and other fishes (WDFW 1997a). Deposited eggs are consumed by gulls and diving ducks, and larval-stage herring are eaten by fish, amphipods and jellyfish. Based on studies in British Columbia waters, juvenile and adult herring are important prey items for Pacific cod, Pacific whiting, lingcod, halibut, coho salmon, Chinook salmon, and harbor seals (Lemberg 1997 citing Environment Canada (1994)). West (1997) additionally lists rockfishes, hake, tufted puffins, marbled murrelets, and other fish and bird species as predators of herring.

COASTAL CUTTHROAT TROUT

Cutthroat trout prefer coastal habitats and can generally be found within 90 miles of shore (Wydoski and Whitney 2003). They are found throughout Puget Sound and are common in Hood Canal and the Strait of Juan de Fuca (Wydoski and Whitney 2003).

Puget Sound cutthroat rear in freshwater for one to six years before outmigrating, although most reach estuaries at two to three years of age. Outmigration occurs from March through June, with a peak in mid-May (Johnson et al. 1999). Puget Sound smolts generally make their first migration at age two and spend the summer close to shore in water less than 10 feet deep (Johnson et al. 1999). Juveniles stay within 31 miles of their natal stream throughout their marine existence, returning to fresh water after only a few months (Thorpe 1994). Their preferred marine habitat is gravel beaches that are vegetated above the high tide mark and gravel spits created by tidal currents. Puget Sound resident cutthroat are typically not found in areas where there is silt, mud, or solid rock substrate (Hickman and Raleigh 1982) and return to freshwater to feed and seek refuge during the winter (Johnson et al. 1999). In general, coastal cutthroat do not make long ocean migrations and they rarely overwinter at sea, instead returning to nearby streams for the winter.

In estuaries, both juveniles and adults are highly piscivorous (predators of fish) with euphasiids and decapod larvae of secondary importance. In the ocean, adults eat northern anchovy, kelp greenling, scorpaenids, salmonids, euphausiids, mysids, and crab megalapae (Emmett et al. 1991). Larger and presumably mature trout consume almost exclusively other fish (Brodeur 1990).

A study in South Puget Sound (Jauquet 2003) found that by weight, the overall diet of coastal cutthroat trout was dominated by salmon eggs and chum salmon fry (46%), followed by non-salmonid fish (23%), polychaetes (12%), other invertebrates (i.e. amphipods, isopods, shrimp and clam necks) (17%), and other items (2%). In this study, apparently cutthroat consumed salmon eggs and chum salmon fry when they were available in the estuary and shifted to alternative food items when they were absent. In descending order, by weight, the most important non-salmonid fishes in the diet were shiner perch, Pacific herring, Pacific sand lance and arrow goby. The most important invertebrates by weight were gammarid amphipods, shrimp, isopods, and clam necks.

BULL TROUT

Anadromous bull trout juveniles and adults forage and mature in nearshore marine habitats on the Washington coast, Strait of Juan de Fuca, and in Puget Sound and are found throughout accessible estuarine and nearshore areas. In Puget Sound the distribution of bull trout in nearshore waters has been hypothesized to be correlated to the nearshore distribution of forage species such as sand lance, surf smelt, and Pacific herring. Foraging bull trout may tend to seasonally concentrate in the spawning areas of forage fish.

Juvenile bull trout feed primarily on aquatic and terrestrial insects, as well as small crustaceans. Larger juveniles and adults are generally piscivorous. Field observations found surf smelt, Pacific herring, Pacific sand lance, pink salmon, chum salmon, and a number of invertebrates to be important prey species for bull trout (Kraemer 1994). Bull trout at different life stages may target different marine prey species. For example, younger bull trout (age one to three) that move to marine waters appear to select smaller prey items, such as shrimp. By age four, the diet of anadromous bull trout has shifted largely to fish.

Information provided by bull trout acoustic radio telemetry and habitat study projects indicates that bull trout in marine waters are more active at night than during the day, may prefer deeper nearshore habitat than shallow nearshore habitat, and can be found at depths as great as 246 feet.

Bull trout from different freshwater populations may overlap in their use of marine and estuarine waters. Although bull trout are likely to be found in nearshore marine waters year-round, the period of greatest use of nearshore habitat is March through July (Goetz and Jeanes 2004).

STEELHEAD TROUT

Puget Sound steelhead can be found from the Strait of Juan de Fuca east, including river basins as far west as the Elwha River and as far north as the Nooksack River (Busby et al. 1996).

Out-migrating smolts typically leave their natal streams between 2 and 4 years of age (Groot and Margolis 1991) traveling through most, if not all, of the marine environments, including estuaries, nearshore habitat and the open ocean. Steelhead juveniles spend very little time in estuaries and are rarely found along shoreline areas.

Adults spend one to five years at sea before returning to their natal stream to spawn and typically live from six to eight years (Wydoski and Whitney 2003, Emmett et al. 1991).

Adults are generally piscivorous (Wydoski and Whitney 2003), feeding on juvenile rockfish, sand lance, sculpin, and greenlings. They also feed on invertebrates, especially euphausiids, amphipods, copepods and squid (Groot and Margolis 1991).

CHINOOK SALMON

Juvenile and adult Chinook salmon of different runs and life-history types can be found in the waters of Puget Sound, including Hood Canal, the Strait of Juan de Fuca and around the San Juan Islands. Juveniles use estuarine and nearshore areas throughout Puget Sound for rearing. Adults move through these areas on their migrations to the ocean. Because of their different life-history types and lifestages, Chinook salmon can be found throughout the nearshore marine environment year-round.

Both ocean- and stream-type Chinook salmon exhibit extensive off-shore ocean migration, with stream-type fish entering freshwater to spawn in early spring or summer (National Marine Fisheries Service 2004, Myers et al. 1998) and ocean-type returning from spring to winter.

After moving into salt water, Puget Sound Chinook generally migrate north along the Canadian coast, although some fall Chinook spend their entire marine residence within Puget Sound. Ocean-type Chinook generally remain at sea from one to six years before they mature, with most spending two to four years in the ocean before returning to their natal streams to spawn (Wydoski and Whitney 2003).

Ocean-type Chinook are dependent on estuarine habitat, feeding and rearing within the top 6 to 10 feet of the water column for extended periods before moving to pelagic marine habitats (Williams and Thom 2001). Recreational catch statistics suggest that smaller juveniles use shoreline areas, while larger juveniles prefer deeper water areas (Shepard 1981). After juvenile Chinook salmon reach a size of about 2 ½ inches, they are large enough to avoid predators and forage for food in offshore areas.

In coastal marine and estuarine environments juvenile Chinook primarily feed on gammarid amphipods, euphausiids, insects, harpacticoid copepods, mysids, decapod larvae and fish. Adults feed primarily on bait fish (herring, sand lance, smelt), euphausiids, decapod larvae, squid, and other invertebrates (Emmett et al. 1991).

Stomach analysis of juvenile Chinook salmon caught in Puget Sound by tow net in nearshore pelagic habitats (< 70 feet depth) included euphausiids, decapod larvae, fish, and polychaetes, with insects dominating in late summer. The prey base of Chinook salmon collected by purse seine in offshore pelagic habitats (> 70 feet depth) in February and May was primarily herring, along with some sand lance and crustaceans. Fish were the major prey species of adult Chinook caught in Puget Sound, with some studies showing both sub-adults and adults to be primarily piscivorous (Fresh et al. 1981).

Collections with beach seines suggest that juvenile Chinook salmon are oriented to shallow water habitat located close to shore, and are most abundant in intertidal flats and shallow subtidal channels near estuarine and tidal marshes and eelgrass meadows (Williams et al. 2001; Toft et al. 2004).

CHUM SALMON

This species can be found at various life stages throughout Puget Sound, the Strait of Juan de Fuca, and areas north. Chum salmon exhibit a variety of life history strategies and regional differences in age and size at maturity and so they can occur in these areas year-round.

Emergent chum salmon have a limited freshwater residence period and an extensive nearshore and estuarine rearing period. Fry beginning their downstream migration shortly after hatching. The fish rear in productive, shallow eelgrass beds until they reach 1.8 to 2.4 inches in length and move offshore (Simenstad et al. 1982). Juvenile chum salmon reside in estuaries longer than most other anadromous salmon species (Wydoski and Whitney 2003; Quinn 2005).

Chum fry spend an average of ten weeks in sub-littoral habitats near their natal stream (Wydoski and Whitney 2003), generally occupying the water column at depths of –5 to –16 feet in or near eelgrass beds that connect to sub-estuary deltas (Tynan 1997). Eelgrass beds are extremely important for rearing chum salmon, with two species of copepods that make up a large portion of juvenile‘s diets found in eelgrass (Simenstad et al. 1988). During this transition period, kelp, other macroalgae and mud and sand flats serve as migratory corridors between deltas (Simenstad 1998).

Chum salmon rear in the ocean for the majority of their adult lives until they reach maturity (Groot and Margolis 1991; Wydoski and Whitney 2003). Chum salmon mature between the ages of 2 and 6, with adults having an average lifespan of 4 years (Wydoski and Whitney 2003). Migration into the Strait of Juan de Fuca begins in mid-July and continues through early September, with adults entering Hood Canal from early August through late September (Tynan 1997).

Most summer-run chum juveniles remain nearshore, rapidly out-migrating along the eastern shore of Hood Canal from June to early August (Wydoski and Whitney 2003).

Generally, juvenile chum salmon feed on epibenthic crustaceans, with larger juveniles preying on terrestrial insects, copepods, amphipods and other zooplankton (Simenstad et al. 1982). Chum salmon are discriminate feeders and Fresh et al. (1981) found that the primary prey of juveniles caught in the shallow sublittoral zone in Puget Sound included calanoids in March, harpacticoids in April, euphausiids in May, calanoids in June, decapods and larvaceans in July, and myodocopa in August. Limitations in shallow water food supplies may cause juveniles to move to deeper waters in search of prey (Emmett et al. 1991). The rapid seaward migration of summer-run chum is thought to be influenced by low food availability, as well predator avoidance, and/or accelerated surface water flow from prevailing south winds (Bax et al. 1978; Bax 1982; Bax 1983; Simenstad et al. 1980).

COHO SALMON

Coho salmon occur in drainages throughout Puget Sound, Hood Canal, the Straits of Juan de Fuca, the Olympic Peninsula and Columbia River tributaries (Wydoski and Whitney 2003). Coho juveniles move rapidly through estuaries and out to sea. As smolts begin the ocean phase of their life, they travel through marine environments, including estuaries, nearshore habitat, and open ocean.

Most coho salmon in Washington spend the first year of their lives in freshwater, outmigrating from March to June (Wydoski and Whitney 2003). Adults generally return to spawn in their third year, although some precocious males (jacks) return at age two (Wydoski and Whitney 2003). The Puget Sound spawning migration begins in August, with spawning generally occurring from September through January (Weitkamp et al. 1995).

Smolts are believed to prefer pelagic conditions, but utilize intertidal and subtidal habitats as well (Emmett et al. 1991, Wynoski and Whitney 2003). Most coho juveniles leave Puget Sound and enter the coastal ocean from April to May (Emmett and Schiewe 1997).

In estuaries coho salmon diets consists primarily of large planktonic or small nektonic animals (amphipods, insects, mysids, decapods and fish larvae) and other juvenile fish. As with all salmonids, coho are piscivorous and are considered important predators on chum and pink salmon fry (Emmett et al. 1991). Other documented prey include Pacific sand lance, surf smelt, anchovy, and a variety of crab larvae. Adult coho feed on invertebrates but become more piscivorous as they grow larger commonly eating sand lance, sticklebacks, crab larvae and small herring (Groot and Margolis 1991).

PINK SALMON

Pink salmon occur in northern Puget Sound, southern Puget Sound, Hood Canal and the Strait of Juan de Fuca (Wydoski and Whitney 2003.) Some Puget Sound populations spend their entire marine life in marine nearshore habitats (Hard et al. 1996).

Pink salmon migrate downstream almost immediately after emergence and if the distance to saltwater is short, the migration may occur in one night (Groot and Margolis 1991). The species spends very little time in estuarine environments, moving quickly to marine nearshore habitats where they grow rapidly. Juveniles rear in estuaries from March until June, schooling in nearshore areas for two to three months before beginning their migration to the open ocean (Wydoski and Whitney 2003, Hard et al. 1996).

Pink salmon fry feed primarily on zooplankton as they move to the open ocean (Thorpe, 1994). In nearshore areas juveniles consume epibenthic prey such as harpacticoid copepods, pelagic zooplankton and other invertebrate larvae. Prey may be benthic or pelagic in nature, though foraging usually occurs in the water column in nearshore areas, along beaches or shorelines with complexity (Groot and Margolis 1991).

Pink salmon, the smallest of the Pacific salmon, mature and spawn on a two-year cycle. In Washington, pink salmon spawn in odd years except for the Snohomish River, which has both odd and even-year spawners (Wydoski and Whitney 2003).

This species is an opportunistic, generalized feeder, foraging on a variety of fish (herring, sand lance), crustaceans (crab larvae, copepods, amphipods, euphausiids), ichthyoplankton and zooplankton (Groot and Margolis 1991). Adults spend a little over a year in the open ocean before returning to spawn.

2-3.3. Marine Mammals

SOUTHERN RESIDENT ORCAS

Resident orcas (*Orcinus orca*) can occur throughout Washington's marine waters. The southern resident population in particular resides for part of the year (mostly spring, summer and fall) in the inland waterways of the Strait of Georgia, Strait of Juan de Fuca, and Puget Sound (Wiles 2004). Some movement occurs to the outer coasts of Washington and to southern Vancouver Island. The movements of each pod of the southern resident population (J, K, L) vary (Wiles 2004; Krahn et al. 2004). The total population of the three southern resident pods combined fluctuates but has been less than 100 animals since 1995.

The orca's position as a top-level predator makes the species vulnerable to changes in prey abundance. Orcas feed on a variety of organisms ranging from marine mammals to squid to fish, but the southern resident population appears to have a specialized diet with salmon being the preferred prey.

Existing dietary data are preliminary and come mostly from one study that focused on northern residents, but included a small number of observations from southern residents. Salmon made up 96 percent of the prey during spring, summer and fall, and Chinook salmon seemed to be selected over other salmon prey species, comprising 65 percent of the salmonids taken (Wiles 2004). Toxicology analyses seem to bear this out; Krahn et al. (2002) determined that the ratios of DDT and its metabolites to various PCB compounds in the orcas correspond with those of Puget Sound salmon rather than those of other fish. Rockfish, halibut, lingcod and herring are also eaten, but less frequently than salmon.

The movements of southern resident orcas relate to those of the preferred salmon prey. Pods commonly seek out and forage in areas where salmon occur, especially areas associated with migrating salmon (Heimlich-Boran 1986, 1988; Nichol and Shackleton 1996).

2-3.4 Invertebrates

PINTO ABALONE

In Washington waters, this benthic marine gastropod occurs in the Strait of Juan de Fuca and the San Juan archipelago. It is found on shallow, rocky substrate and feeds mostly on seaweeds. NOAA (2004) reports typical depth ranges from the low intertidal to –30 feet but with occurrences to –330 feet. West (1997) reports that in Washington waters the species occurs on substrate less than 65 feet deep. Adults attach to rocks mostly within kelp forests and forage over a relatively small range, or remain stationary (West 1997). Generally some level of water current is preferred. Surveys in the San Juan Islands by WDFW demonstrate that numbers of abalone are declining in that area. Abalone have not been encountered in geoduck harvest areas.

OLYMPIA OYSTER

The Olympia oyster (*Ostrea conchaphila=Ostrea lurida*) is also referred to as "native oyster" and is currently found throughout its documented historical range within Puget Sound. Within Hood Canal, south Puget Sound and central Puget Sound the native oyster is a commonly observed species in the intertidal zone. Scattered intertidal occurrences are observed in north Puget Sound (WDFW unpublished).

Ranson (1951) postulated that beds of oysters of the genus *Ostrea* could not persist in the intertidal zone, due to the inability of these oysters to survive the wide range of temperatures to which they would be exposed. Based on more recent field observations, and literature review, this claim may not be entirely true for the Olympia oyster in Puget Sound. *O. conchaphila* may be found in the intertidal zone from extreme low to plus 2 meters (6 ½ feet) (Baker 1995). In Puget Sound this species has been observed in dikes, tide pools and lagoons at that upper extreme (pers. obs., B. Blake, WDFW). Subtidally they have been found as deep as 50 meters (164 feet) (Bernard 1983) and 71 meters (233 feet) (Hertlein 1959) outside of Washington waters. A single specimen was recently recovered from a depth of approximately 40 feet in Hood Canal (pers. comm., Mark Millard, WDFW). Currently there are relatively few known historic or contemporary occurrences subtidally in Puget Sound in areas with known intertidal occurrences. Baker (1995) notes that the native oyster is only rarely reported in benthic invertebrate surveys of waters more than a few meters deep. The absence of the species from subtidal biological surveys and collections from Puget Sound is particularly notable. WDFW has not observed any Olympia oysters during geoduck surveys conducted between the –18 foot and –70 foot water depth contour (corrected to mean lower low water) since 1969 (pers. comm., B. Sizemore, WDFW). WDFW has in recent years discovered several occurrences where Olympia oysters exist in functionally subtidal habitats in lagoons in the upper tidal ranges. Whether or not this present tidal distribution is representative of historical distribution or a result of subtidal habitat alterations (such as siltation from upland or nearshore practices) is a matter of contention amongst those currently involved in management, conservation and restoration of the species in Puget Sound.

Olympia oyster larvae are free swimming from three to eight weeks before settlement (Baker 1995; Breese 1953). The larvae require hard substrate to settle on, but this substrate can range widely from small bits of shell, gravel, rocks, boulders, Pacific oysters, pilings, floating piers, tin, concrete, tires, battery cases and wood (Baker et al. 1999; Baker 1995; pers. obs. B. Blake, WDFW). They are intolerant of siltation and conditions of high turbidity (Couch and Hassler 1989). WDFW staff has not observed tidal flow as a factor affecting abundance of Olympia oysters. The maximum size attained by Olympia oysters, as reported by Hertlein (1959), is 75 mm and WDFW staff has observed this size to be reached in 3 years.

2-4 Food Web Interactions

The waters, substrate, and associated fauna that occur where geoduck harvest occurs, along with the covered species, are elements of complex interactions of nearshore marine ecosystems. Plants and animals here are part of trophic cycles, transferring energy and nutrients from one or more organisms to others in the nearshore ecosystem.

2-4.1 Forage Fish

Fish are a significant component in the diet of many birds, marine mammals, and fish in Puget Sound. Common forage fish are Pacific herring, surf smelt, and Pacific sand lance. Salmonid species are also food for birds, orcas, and other fish. These species and others play an important role as food for some of the species covered in this HCP. Nearshore habitats provide spawning areas for forage fish including Pacific herring, salmon species, Pacific sand lance, and surf smelt.

Pacific herring and salmon species that are prey for birds, marine mammals, and other fish and are discussed in Section 2-3.2.

PACIFIC SAND LANCE

Pacific sand lance are widely distributed and common in Puget Sound, the Straits of Juan de Fuca and Washington's coastal estuaries. They are commonly found in localized areas such as the eastern Strait and Admiralty Inlet. WDFW surveys have documented spawning activity on about 130 miles of Puget Sound shoreline (Lemberg et al. 1997; WDFW 1997b). Spawning activity appears to be distributed on shorelines throughout Puget Sound (Lemberg et al. 1997).

Sand lance spawn on intertidal beaches. In Puget Sound they are thought to prefer beaches with freshwater seeps, and spawn in upper intertidal areas at tidal elevations of plus 7 feet to the mean higher-high water line on sand and gravel, or sandy beaches (Lemberg et al. 1997; WDFW 1997b).

Little is known about sand lance life history. Spawning occurs from November through February and the eggs incubate for about thirty days. Eggs are dispersed by wave action over a broad area of the intertidal zone (Lemberg et al. 1997). After hatching, the sand lance larvae (about 2/10 inch long) disperse throughout the top 70 feet of the water column (WDFW 1997b) and appear to spend daylight hours near the bottom, moving up through the water column at night (Emmett et al. 1991). They move passively with local currents and tides until they are nearly an inch long at which time they form schools.

Schooling sand lance are concentrated in nearshore areas of embayments around the Sound (WDFW 1997b). Both adults and juveniles burrow into the substrate at night, which protects them from predation. Burrowing areas need to be clean unconsolidated sand with sufficient oxygen. Such areas generally occur where high bottom water velocities exist, such as the mouths of estuaries (Emmett et al. 1991). Adults are inactive during winter, and except when spawning, remain buried (Emmett et al. 1991).

All lifestages of sand lance are planktivorous carnivores. Smaller larvae consume diatoms and dinoflagellates, while larger larvae consume copepods. Juveniles and adults feed primarily on copepods and utilize other plankton as a supplementary source of food (Emmett et al. 1991; Fresh et al. 1981). Sand lance stomach samples analyzed by Fresh et al. (1981) found calanoids to be the most important prey item.

Sand lance are an important trophic link between zooplankton and larger predators in local food webs. This species seems to be especially important in the diets of juvenile salmon. Sixty percent of juvenile Chinook salmon diets can be sand lance (WDFW 1997b). Pacific cod, Pacific hake, and dogfish also feed heavily on both juvenile and adult sand lance.

SURF SMELT

Surf smelt are a pelagic, schooling fish. They occur in abundance throughout Washington's marine waters, including Puget Sound (WDFW 1997c). Although their movements within the Sound are unknown, a number of genetically distinct stocks are thought to occur, based on geographic and temporal distinctions in use of spawning grounds.

Spawning occurs throughout the year in Puget Sound on intertidal beaches of mixed sand and gravel. Surf smelt appear to have rather specific spawning habitat types. Penttila (1978) found that the frequency and intensity with which a spawning site would be used was largely influenced by tidal elevation. In Puget Sound, incubating spawn is generally found less than 30 feet waterward from mean higher high water. Eggs are deposited near the water's edge where water is just a few inches deep, on beaches with various substrate types often containing a mixture of coarse sand and fine gravel (mostly .04 - .27 inch). Fertilized eggs adhere to grains of sand for two to four weeks, with hatching time influenced by temperature and wave energy.

Surf smelt larvae are planktonic and are about 1/10 of an inch long just after hatching. They assume their adult body type after about three months and are just over 1 inch long by this time. Juveniles continue to rear and school in nearshore areas. Most will mature and return to the beaches to spawn in their second year but a small portion spawn after one year (WDFW 1997c; Lemberg et al. 1997; Penttila 1978).

Fresh et al. (1981) analyzed the stomach contents of surf smelt captured in beach seines. These fish ate primarily pelagic prey such as calanoids, urochordates, carideans, and euphausiids. Small numbers of harpacticoids in a large number of the sampled fish suggested surf smelt are also epibenthic feeders.

This species is used as a food source at all life stages (WDFW 1997c). Marine mammals, birds and other fish prey on surf smelt eggs, juveniles and adults.

2-5 Existing Land Use

Recreational boating on the waters surrounding commercial geoduck tracts is common. Other uses that can occur in areas near geoduck harvest activities include other commercial fisheries such as those for Dungeness crab and salmon, commercial navigation, and recreational crabbing and clamming and fishing. At a broader scale, aquatic lands are used for other purposes such as port operations and shipping, anchoring and mooring of recreational vessels, log storage and aquaculture. However due to water depth restrictions geoduck tracts rarely, if ever, encroach on commercial traffic lanes.

Geoduck harvest occurs in an environment that has been, and will continue to be influenced by many factors that are, for the most part, related to increases in human population in the surrounding lands. Geoduck beds offshore of urban areas (towns, marinas, industries) are often subject to pollution from the adjacent uplands, rendering the geoduck beds non-commercial for health reasons, therefore closed to harvest.

3. Project Description and Covered Activities

3-1 Project Description

The project encompasses the commercial harvest of geoducks as administered by DNR and for which DNR has proprietary rights. Removal of geoducks for research and health sampling, when performed by DNR or under contract with DNR is included as well.

A final Supplemental Environmental Impact Statement (Washington Department of Natural Resources and Washington Department of Fish and Wildlife 2001) and the 2001 Geoduck Fishery Management Plan (Washington Department of Natural Resources 2001) provide details on the fishery and an environmental analysis and are incorporated here by reference. As such, they become part of this HCP. Future changes to the 2001 Geoduck Fishery Management Plan will be anticipated and discussed with the Services at yearly meetings (see Section 8.1) to determine the need for amending this HCP.

This HCP was written to address DNR activities, but management of the fishery is complex, requiring constant coordination and negotiation between DNR, WDFW and the treaty tribes that are involved in geoduck harvest. Input from county governments, the Washington Department of Health and other agencies also factors into the management of the fishery.

Some of the parameters within which harvest activities occur are specified in state laws and rules (Appendix A).

3-1.1 Location

Commercial geoduck harvest occurs in western Washington in the general areas of Puget Sound and the Strait of Juan de Fuca. Future harvest will continue to occur here, and harvest activities will expand north to areas in the general vicinity of the San Juan Islands.

MANAGEMENT REGIONS

For management purposes, the waters of Puget Sound, the Strait of Juan de Fuca and the San Juan Islands are divided into six management regions (Figure 1 in Chapter 1). The extent of surveyed geoduck resources potentially available for harvest across all management regions is in Figure 2 in Chapter 1.

Straight of Juan De Fuca

The Strait of Juan de Fuca management region encompasses waters east of a line projected true north from Cape Flattery to the international boundary line; and those waters west and south of a line projected from Point Wilson to Partridge Point, Whidbey Island, then westerly to the vessel traffic service buoy "S", north of Dungeness Spit, then north to the vessel traffic service buoy "R", then due west to the international boundary line, then westerly along the international boundary line to a point where the international boundary line intersects the line projected from Observatory Point. This management region covers about 449,700 acres. The Strait of Juan de Fuca Region has 5,572 acres of commercially available geoduck tracts, estimated to contain 12,070,000 geoducks, weighing an estimated total of 21,271,000 pounds. The average density on commercial tracts in the Strait of Juan de Fuca management region is 0.06 geoducks per square foot. The average geoduck weight is 2.3 pounds (WDFW 2004).

North Sound

The North Sound management region encompasses waters east of Whidbey Island north of a line projected from Possession Point, Whidbey Island to Picnic Point on the mainland; south of the railroad bridges at Swinomish channel; and east of the Deception Pass bridge. Those waters west of Whidbey Island and north of a line projected from Partridge Point, Whidbey Island westerly to vessel traffic service buoy –S”, north of Dungeness Spit, then north to the vessel service buoy –R”, then due west to the international boundary line; and south of a line projected due east from the international boundary line to a point one nautical mile west of Pile Point, San Juan Island, then southeasterly along a line one nautical mile from the southern shores of San Juan Island and Lopez Island to Davidson Rock near Point Colville, then easterly to a point one nautical mile south of the buoy at Lawson Reef and then due east to Whidbey Island. This management region covers about 356,900 acres. The North Sound Region has 1,515 acres of commercially available geoduck tracts, estimated to contain 1,079,000 geoducks, weighing an estimated total of 4,254,000 pounds. The average density on commercial tracts in the North Sound management region is 0.032 geoducks per square foot. The average geoduck weight is 2.06 pounds (WDFW 2004).

Central Sound

The Central Sound management region encompasses waters north of a line projected from the ferry dock at Point Southworth to Brace Point, not including the waters of Hood Canal; northeasterly of a line projected from Olele Point to Foulweather Bluff; easterly of a line projected from Point Wilson to Partridge Point, Whidbey Island; and southerly of a line projected easterly from Possession Point, Whidbey Island to Picnic Point on the mainland. This management region covers about 231,700 acres. Central Sound has 8,968 acres of commercially available geoduck tracts, estimated to contain 27,040,000 geoducks, weighing an estimated total of 53,899,000 pounds. The average density on commercial tracts in the Central Sound management region is 0.09 geoducks per square foot. The average weight is 2.11 pounds (WDFW 2004).

Hood Canal

The Hood Canal management region encompasses waters south of a line projected from Olele Point to Foulweather bluff including the area described as Dabob Bay. This management region covers about 100,400 acres. The Hood Canal management region has 5,165 acres of commercially available geoduck tracts, estimated to contain 26,894,000 geoducks, weighing an estimated total of 47,019,000 pounds. The average density on commercial tracts in the Hood Canal management region is 0.11 geoducks per square foot. The average geoduck weight is 2.28 pounds (WDFW 2004).

South Sound

The South Sound management region encompasses waters south of a line projected from the ferry dock at Point Southworth to Brace Point, except waters of Hood Canal. This management region covers about 172,100 acres. The South Sound Region has 8,688 acres of commercially available geoduck tracts, estimated to contain 42,554,000 geoducks, weighing an estimated total of 91,472,000 pounds. The average density on commercial tracts in the South Sound management region is 0.12 geoducks per square foot. The average geoduck weight is 2.29 pounds (WDFW 2004).

San Juan Islands

The San Juan Islands management region encompasses waters north of a line projected due east from the international boundary line to a point one nautical mile west of Pile Point, San Juan Island, then southeasterly along a line one nautical mile from the southern shores of San Juan Island and Lopez Island to Davidson Rock near Point Colville, then easterly to a point one nautical mile south of the buoy at Lawson Reef and then due east to Whidbey Island; and north of the railroad bridge at Swinomish Channel; and west of the Deception Pass bridge; and south and east of the international boundary line. This management region covers about 518,100 acres. The San Juan Islands management region has geoduck beds identified, but most have not been surveyed and do not have biomass estimates (These are referred to as X-beds.) No commercial harvest is currently allowed in the San Juan management region, but it is included in this HCP because harvest will occur there at some point in the future.

GEODUCK TRACTS AND THE GEODUCK ATLAS

A geoduck tract is any subtidal area with well-defined boundaries which has been surveyed and found to contain geoducks of commercial quantity and quality. The tract boundaries are artificial and not tied solely to biological criteria. Geoduck tracts have been identified by WDFW, DNR, and the Tribes within each of the six management regions across the extent of the inventoried resource shown in Figure 2. The total acreage of surveyed tracts (i.e., the entire extent of the surveyed resource) fluctuates some, but is about 30,000 acres. Future surveys could identify additional commercial tracts. The total acreage fluctuates because newly discovered beds are added, or the status of an existing tract is changed. The commercial status of a tract can change if a tract is rendered unharvestable by pollution, a tract gets fished down to where it is put into recovery status, or geoduck densities are too low for a viable commercial fishery.

The State of Washington Geoduck Atlas is a tract-specific compilation and update of information on geoduck tracts based on annual dive surveys performed by WDFW. For each tract, the Geoduck Atlas states the estimated tract size in acres (from GIS data), estimated number of geoducks and biomass (in pounds), average geoduck density (number of geoducks per square foot) and average weight (in pounds) of geoducks on the tract.

The Geoduck Atlas also documents other features or conditions of the tract noted during the survey such as the presence of eelgrass, known water quality issues, the presence of herring spawning areas and other information important in assessing the suitability of the tract for commercial harvest. The Geoduck Atlas is updated each year by WDFW (accessible online at http://www.wdfw.wa.gov/fish/shelfish/geoduck/index.htm).

There are nearly 400 individual geoduck tracts identified (384 in the 2004 Geoduck Atlas). Sometimes large areas are divided into several tracts. Data from the 2004 Geoduck Atlas show individual tracts ranging in size from 4 acres to 1197 acres, but most (more than 60 percent) are less than 200 acres in size and only 18 tracts are 300 acres or bigger.

Surveys conducted for assessing tracts for inclusion in the Geoduck Atlas are only performed within a narrow bathymetric band. Shoreward, the boundary is at the –18 ft line (corrected to the mean lower low water [MLLW] level). Seaward, surveys stop at the – 70 ft depth, adjusted to MLLW, because this is the limit at which divers can most efficiently survey the resource using compressed air SCUBA and the Navy dive table. Geoducks occur across a broader range, both deeper and shallower, than the current commercial tract depth limits.

UPPER AND LOWER SUBTIDAL HARVEST BOUNDARIES

Commercial harvest is limited to areas that have been surveyed, and is confined to suitable subtidal tracts located within a narrow bathymetric band. Shoreward, the harvest tract boundary is at the –18 ft line (corrected to the mean-lower-low water [MLLW] level) or deeper. Harvest boats must stay 200 yards (600 feet) seaward from the line of ordinary high tide, but divers can venture further shoreward, within the constraints of their dive equipment, but cannot harvest shoreward of the –18 foot boundary. The shoreward boundary acts to protect geoducks closer to shore, eelgrass beds, and other nearshore habitats and their inhabitants (e.g., juvenile fish). Seaward, no harvest occurs deeper than –70 feet. As with survey boundary, the seaward, deep-water boundary is the limit at which harvest divers can efficiently operate for workable periods.

The –18 foot shoreward boundary is not absolute. The shoreward boundary is adjusted deeper to avoid eelgrass (for example), to eliminate rocky areas from the tract, to avoid conflicts with areas such as aquatic lands adjoining state parks, or for other reasons.

The –70 foot depth boundary is stated in WAC 220-52-019(11). This rule was recently changed (effective September 2006) to allow the –70 foot boundary to be corrected to MLLW. Previously, the –70 foot depth contour that establishes this boundary was uncorrected, meaning it was dependent on the tidal cycle; it would fluctuate with the tide up to a distance of 4.5 feet. The changed rule clearly identifies a fixed boundary for harvest tracts that is consistent with the boundary of surveyed areas. Some existing harvest agreements are still operating under the previous rule language because it is specified in shoreline permits issued to DNR for geoduck harvest. The shoreline permits are good for five years. Once they expire and new ones are obtained, harvest agreements will be issued with language reflecting the updated rule. Not all counties require DNR to obtain shoreline permits. Only those tracts where shoreline permits are required, and have been issued with restricted shoreline permit language will be under the old rule.

COMMERCIAL HARVEST

Commercial harvest occurs year-round on a small portion of the subtidal geoduck tracts identified jointly by WDFW, DNR, Dept. of Health, and the Tribes as able to support commercial harvest. Harvest areas are rotated within regions according to harvest agreements between the state and tribes. Commercial harvest is managed so that it occurs within one management region at a time, and usually on one tract at a time. However situations can arise that cause harvest to occur in more than one management region at a time. This is driven by circumstances outside DNR's control, such as PSP occurrences forcing closure of a tract. In order to keep harvesters fishing, some boats may be moved to a tract in another region. This is a temporary situation and not desirable from a management and compliance enforcement standpoint, partly because two compliance boats must be maintained and fully staffed at two different locations.

Harvest sometimes occurs from more than one tract but only when the tracts are close enough to each other to allow DNR compliance staff to oversee both harvest operations.

Commercial harvest occurs in those tracts which are shown to have geoducks in commercial quantities (normally more than 0.04 geoducks per ft^2), contain market-quality geoducks, present no practical difficulties for harvest, and do not conflict with existing uses such as ferry routes. The tracts also must be certified by the Washington Department of Health as meeting state and national health standards. This information is gathered annually via surveys and is summarized in the Geoduck Atlas.

Currently, tracts that are identified as commercial are in nearshore substrate adjacent to nine counties (Clallam, Island, Jefferson, King, Kitsap, Mason, Pierce, Snohomish and Thurston). Surveys may result in additional tracts being designated commercial. Future surveys or changes in tract status could result in some currently identified commercial tracts being removed from the list. Based on changes in the status of commercial harvest tracts and the number of identified commercial tracts, the actual amount of harvest varies and is limited by the equilibrium harvest rate to assure a sustainable fishery.

Prior to harvest activities, DNR marks the boundary limits delineating the tract. Shore markers and buoys are used. Harvest areas define the boundaries for the purposes of administering and enforcing harvesting agreements (see Section 3-1.2 below). Tract boundaries are established to exclude important habitats such as eelgrass beds and herring spawning areas.

CHARACTERISTICS OF GEODUCK HABITAT AND TRACTS

Commercial harvest activities occur mostly in mud-sand and sand substrate because this is where geoducks tend to have higher average density and better market quality. A particular tract might contain rocky areas, but these are either eliminated from the harvest area, or are avoided by harvesters because they are not conducive to harvest. Geoduck clams occur in low densities or are absent from these habitats.

3-1.2 Geoduck Fishery Management

The commercial geoduck fishery is co-managed by state and tribal entities and there is joint responsibility for the scientific oversight of the fishery. Washington Department of Fish and Wildlife and the tribes perform surveys to support the scientific oversight of the fishery. WDFW sets the sustainable level of harvest each year. Based on data gathered during pre-harvest surveys, the state and tribes agree on stipulations for harvest boundaries and conditions to protect fish and wildlife habitat.

INTERAGENCY AGREEMENT – WDFW AND DNR

A lot of the preliminary work that goes into assessing a geoduck tract as being suitable for commercial harvest is performed by WDFW and the information is provided to DNR. WDFW performs studies related to the fishery and biological survey work including geoduck population density estimates. An interagency agreement specifies the funding and expectations for field surveys, management studies, collection of biological data, and analytical work that is needed to support the management of the commercial fishery (Appendix D). This is a biennial, contractual agreement between the two agencies. Funding for WDFW's survey work is provided by DNR (from revenue generated by the geoduck harvest program) under these interagency agreements. The dollar amount dedicated to these contracts has increased for the last three biennia (Table 3.1).

Table 3.1. Dollar amount of biennial contracts with WDFW.

Biennium	Amount of Contract Agreement
2001-2003	$276,000
2003-2005	$300,000
2005-2007	$371,816

PRE-HARVEST ENVIRONMENTAL ASSESSMENTS

Tract-specific Environmental Assessments (EAs) are performed and documented on all tracts proposed for harvest. The assessments describe specific tract boundaries, geoduck densities, and information on substrate, water quality, and biota on the tract (Example in Appendix E).

The EA is compiled and written by staff at WDFW and incorporates input from researchers; Federal, state (DNR, WDFW, Dept. of Health, Dept. of Ecology), and county governments; and the participating Tribes. The process of soliciting input consists of sending a scoping e-mail requesting comments to WDFW specialists (e.g., marine fish biologist, habitat biologist, bald eagle biologist, WDFW's threatened and endangered species biologist), county biologists, Tribes and others. The mailing list is modified based on the location of the tract so that appropriate people for that area are contacted. The e-mail briefly describes the tract, pre-harvest survey results and special conditions (such as the presence of eelgrass), and the dates of proposed harvest. A general vicinity map showing the tract location is attached as well. Potential threats to important species or their habitat are identified through this review and language added to the EA to address them. For example, a 0.25 mile bald eagle nest buffer was recommended in the vicinity of the Siebert Creek tract in the Strait of Juan de Fuca Region and the recommended buffer included and mapped in the EA for that tract. In addition to input solicited through the e-mail scoping, the NMFS Northwest Region's marine mammal biologist is contacted to solicit any concerns related to marine mammals.

Data from the pre-harvest surveys and language addressing concerns and recommendations received as a result of scoping are added to the EA. The EA also contains background information on the site and defines the harvest conditions and harvestable area for the tract. In addition to establishing limits for the biomass of geoduck to be harvested and restrictions on time, place, and manner of harvest; the EA serves as a baseline for identifying harvest effects and potential long-term impacts.

A Global Positioning System (GPS) is used to plot survey data, depth contours, encroaching shoreline structures, and tract boundaries.

The EA lists the most common and obvious aquatic flora and fauna observed during surveys including invertebrates, fish, eelgrass and algae. It also notes the birds and marine mammals that are observed, or may occur in the harvest area. It identifies features such as herring spawning and holding areas, and sand lance and surf smelt occurrences, and displays the information on maps in relation to the potential harvest tract. The EA notes the locations of eelgrass in relation to the tract and identifies harvest restrictions necessary to protect eelgrass or other important species and habitats. It identifies what measures will be needed for management of that tract, such as timing restrictions to avoid herring spawning, and boundary restrictions to avoid spawning areas and eelgrass beds.

STATE ENVIRONMENTAL POLICY ACT - SEPA

DNR's administration of the geoduck fishery must follow the legal requirements under the State Environmental Policy Act (SEPA) (RCW 43.21C and WAC 197-11), as well as DNR's Policies and Procedures rules (WAC 332-41).

After completion of the pre-harvest sampling and surveys and the Environmental Assessment for a tract, each proposed auction of geoduck harvest quotas on that tract undergoes an established SEPA process. DNR must also receive all required state and local permits before the harvest quotas can be offered. Local permitting requirements vary by county.

Each time DNR prepares to auction geoduck harvest quotas on specific tracts, the agency issues a DS (Determination of Significance) and adopts the Final SEIS and the 2001 Fishery Management Plan under the DS. In doing this, DNR can incorporate all of the mitigation from the Final SEIS and the 2001 Fishery Management Plan into harvest activities associated with the quotas for a given tract, reducing any potential significant adverse impacts to below a level of significance. Issuing a DS as opposed to issuing a determination of <u>non</u>-significance is the procedure that allows DNR to reference and incorporate mitigation from the Final SEIS and 2001 Fishery Management Plan.

Notification of an upcoming auction of harvest quotas for a tract and the SEPA documentation is sent primarily to the appropriate Tribes and local governments in the area. State and federal agencies with management or regulatory authority in the area where harvest will occur are also notified. The SEPA documentation provided consists of:

a **cover memo** advising interested parties of DNR's lead agency status, the determination of significance and adoption of an existing environmental document (the SEIS);

a **threshold determination** that also states the determination of significance and adoption of an existing environmental document (the Final SEIS), identifies where the SEIS is available for interested parties to review, and provides contact information; and

the **Environmental Assessments** for the tracts where harvest quotas will be offered.

These documents are also posted on DNR's external website.

It takes two to seven years to set up a tract, perform all the surveys and assessments, and obtain permits to qualify a geoduck tract for harvest.

During the period that a tract is under contract for harvest, the Environmental Assessment is reviewed by WDFW and DNR prior to each harvest period or as specific situations arise that require documentation or a change in harvest parameters.

POST-HARVEST SURVEYS

Tracts that are eligible for post-harvest surveys are identified jointly by WDFW and DNR. To be eligible the tract must be fished down to a minimum level of at least 65% of the pre-harvest biomass estimate. Tracts eligible for post-harvest surveys are placed in recovery status and may not be fished again until pre-fishing geoduck densities are achieved, as determined through post-harvest surveys. The intent of post-harvest surveys is to measure the recovery of the geoduck population but, as with the pre-harvest surveys, divers also note the most obvious and common animals and plants that are encountered along the surveyed transects. The same methodology and the same intensity of survey are performed during pre-and post-harvest surveys, with a few exceptions (Appendix D). In addition to an initial post-harvest survey of a tract, a series of additional surveys are performed to determine rates of geoduck recovery.

HARVESTING AGREEMENTS

Washington DNR auctions the right to harvest geoducks from state owned aquatic lands. Quotas of harvest pounds are awarded to ―purchaser" companies that are the highest responsible bidders at the auctions. About four auctions are held each year. The quotas are managed under harvesting agreements between DNR and purchaser companies (Appendix B) which are legally-binding contracts.

The terms under which successful bidders are required to operate are incorporated in the legally binding harvesting agreement and in specific state laws and regulations. It is through the harvesting agreement that DNR regulates geoduck harvest. A harvesting agreement is typically awarded for two to four months for a certain amount (quota in pounds) of geoducks allowed to be harvested. Washington DNR has the ability, through authority of the harvesting agreement, to terminate harvest at any time at the agency's discretion and can implement a closure within a day.

The harvesting agreement establishes the harvest area boundaries and identifies harvest ceilings, measured in pounds. It also establishes the duration of harvest and specifies harvest times (days and hours of operations).

Through the harvesting agreement, DNR can change the harvest dates or duration of harvest and can increase or decrease the harvest ceiling for a harvest area at any time during the harvest agreement period.

The harvesting agreement also sets conditions for vessel use, the number of vessels, noise restrictions, number of divers, and other aspects of harvest activities (Appendix B).

Site-specific restrictions or harvest considerations identified in the Environmental Assessment are incorporated into the harvesting agreement, although these are often dealt with prior to this through the site selection and boundaries established for the tract and harvest timing. Specific, unique considerations for a tract can be included in the harvesting agreement, beyond those already addressed in the EA or state law.

Commercial geoduck harvest is carried out by dive harvesters, licensed by WDFW, who are hired by the purchaser companies.

PLAN OF OPERATIONS

The harvesting agreement requires submission of a Plan of Operations by the successful bidder. DNR requires the Plan of Operations to include:

(1) Source and identity of divers, vessel operators, tenders, packers, shippers, harvest vessels, and other harvest equipment.

(2) Legal relationship between purchaser, divers, vessel operators, and tenders;

(3) The identity of any other subcontractors Purchaser will use in engaging work under the contract;

(4) Location and moorage site of vessel(s); and

(5) The identity of all vehicles used to transport harvested geoducks from the approved off load site; and

(6) Steps purchaser will take to ensure compliance with this contract by purchaser, Purchaser's employees, and subcontractors.

3-2 Activities Covered by Permit

3-2.1 Timing

Commercial geoduck harvest administered by DNR occurs year-round. Harvest is allowed Monday through Friday, from 8:00 a.m. to 4:30 p.m. and does not occur on State holidays or weekends. Each harvester operates during the period specified in their harvesting agreement (generally 2-4 months). It takes several years, and even up to seven years, to complete harvest on one commercial geoduck tract over the course of several harvest cycles. About 70 percent of the geoduck biomass is removed then the tract is allowed to recover to the pre-harvest biomass.

3-2.2 Access to Commercial Tracts – Vessels

Commercial geoduck tracts are accessed via boat. The boats range from 25 to 70 feet long and are anchored during harvest activities. Harvest boats anchor and sit with idling engines for most of the day. A boat might re-anchor two to three times a day as it repositions on the tract being harvested. Boats cannot enter the tract boundary prior to the harvest start time each day and they are not legally allowed to stay on the tracts after the daily harvest.

Onboard compressors provide air for the divers via hoses about 300 feet long. Onboard pumps deliver pressurized water for the water jet nozzles used to remove the geoducks.

Dive boats can, and usually do, maintain two divers in the water at a time. A third person (tender) stays on board to monitor equipment and to bring harvested geoducks onboard. The tender and divers stay in constant verbal contact using a surface-to-diver communication system.

Through contract management, DNR limits the number of boats actively harvesting at one time and place. Typically eight to ten boats are in operation at one time.

Harvesting agreements require vessels to operate at surface noise levels less than 50 decibels measured at 200 yards (600 feet) from the source; a level less than the state standard.

DNR'S COMPLIANCE BOAT

DNR maintains a commercial dive team whose primary responsibility is the daily on-water management, enforcement and harvesting agreement compliance of the tract harvest. Dive team members are skilled in scuba and surfaced-supplied diving techniques, investigative procedures and boat handling. DNR's compliance staff has a boat on the tract at all times during harvest. The compliance boat contains spill containment materials and can respond to fuel spills and other emergencies.

In addition to ensuring that all harvest restrictions, state fishery laws and regulations, and harvesting agreement conditions are followed, DNR maintains oversight of the condition and operation of harvest vessels.

See Fishery Enforcement activities, Section 3-4 below.

3-2.3 Harvest Methods and Equipment

Geoducks are harvested individually by divers using hand operated water jets. The water jet is a pipe about 18 to 24 inches long with a nozzle on the end which releases water at a pressure of about 40 to 60 psi – about the same pressure as that from a standard garden hose. The size of the nozzle on the water jets is limited to a maximum inside tip diameter of 5/8 inch (by WDFW via WAC 220-52-019(2a)). The water jet is controlled by the diver. It is inserted in the substrate next to the exposed geoduck siphon or in the hole left when the siphon is retracted. By discharging pressurized water around the clam the sediment is loosened and the clam is removed by hand.

Each diver carries a mesh bag to collect the harvested geoducks. The bag holds about 180 pounds, or 50-80 clams. Divers periodically surface to unload their bags.

A diver can harvest about 800 geoducks per day on a high-density commercial tract with good digging conditions.

Intakes for supplying water to the onboard pumps are positioned about 10 to 20 feet below the water surface. Intake openings are 4-6 inches in diameter and are screened to prevent debris from stalling the pump. The pump delivers pressurized water to the water jet.

After the geoducks are brought onboard they are weighed and fish receiving tickets (issued by WDFW) are filled out in the presence of, and authenticated by, DNR compliance staff. After being unloaded at a pre-approved marina or boat ramp, the geoducks are transported to a wholesaler or directly to market.

3-2.4 Harvest

The geoduck fishery is an efficient fishery in the locations where it occurs because one specific area is very intensively fished and also intensively managed.

Tracts selected for harvest are generally concentrated in a single geographic area to make enforcement easier, allow efficiency in survey efforts, and to more easily identify and address local concerns.

The fishery operates year-round, but harvest activities on a particular tract do not occur year-round because harvest is intentionally rotated around the different regions. In addition, water quality deterioration or PSP occurrence can cause termination or suspension of harvest on a specific tract. Harvest stops when the tract has been ―fished down” to the thresholds identified in annual management plans; generally about 30 percent of the estimated pre-harvest tract density. Tribal sharing agreements can limit the biomass taken from a given tract. Harvest on a particular tract can be suspended or terminated for other reasons as well.

3-2.5 Extent of Harvest and Limits for the HCP

Prior harvest can be used to understand the fishery rotation from year to year and the extent of harvest activities (Table 3.2).

Table 3.2. Annual harvest by state fishery.

Mgmt. Region	Tract Name	Pounds harvested[1]	Tract size (acres)	Area harvested (acres)[2]
2001				
Strait of Juan de Fuca	Jamestown 1	128,240	331	27
	Protection Island	136,994	256	13
Central Sound	Olele Point	383,047	225	43
South Sound	Pt. Heyer	582	137	.05
	Mahnckes 2-4	393,922	149	16
	Treble Point	62,619	40	4
	Sandy Pt./Big slough	161,108	185	11
Hood Canal	Hood Head E	66,298	33	3
	Hood Head S	66,300	40	3
	Sisters/Shine	397,204	459	51
2001 Total		**1,796,314**	**1855**	**171.05**
2002				

Mgmt. Region	Tract Name	Pounds harvested[1]	Tract size (acres)	Area harvested (acres)[2]
Strait of Juan de Fuca	Jamestown 1	164,227	331	34
	Protection Island	156,351	256	17
Central Sound	Olele Point	268,751	225	43
	Austin	268,845	94	35
	Double Bluff	232,940	73	27
South Sound	Mahnckes 2-4	385,439	149	19
	Sandy Pt./Big slough	117,750	185	9
Hood Canal	Hood Head S	94,529	40	5
	Sisters/Shine	421,822	459	54
2002 Total		**2,110,654**	**1812**	**243**
2003				
Strait of Juan de Fuca	Jamestown 1	160,155	331	42
	Protection Island	123,853	256	15
Central Sound	Austin	242,355	94	51
	Double Bluff	226,714	73	42
South Sound	Mahnckes 2-4	220,029	149	14
	Sandy Pt./Big slough	423,430	185	35
Hood Canal	Hood Head S	42,716	40	2
	Sisters/Shine	494,514	459	81
2003 Total		**1,933,766**	**1732**	**282**
2004				
Strait of Juan de Fuca	Freshwater Bay	282,789	510	58
Central Sound	Skiff Point	143,221	126	17
	Murden Cove	71,692	222	13
South Sound	Point Heyer	470,342	137	54
	Mahnckes 2-4	462,904	149	49
	Sandy Pt. Big slough	186,530	185	21
Hood Canal	Hood Head S	97,191	40	7
	Lofall	422,705	170	73

Mgmt. Region	Tract Name	Pounds harvested[1]	Tract size (acres)	Area harvested (acres)[2]
2004 Total		**2,137,374**	**1539**	**292**
2005				
Strait of Juan de Fuca	Freshwater Bay	226,731	510	54
Central Sound	Port Madison	683,728	311	83
	Skiff Point	122,966	126	14
	Murden Cove	93,292	222	20
South Sound	Point Heyer	34,894	137	12
	Mahnckes 2-4	82,027	149	10
	Sandy Pt. Big slough	314,405	185	45
Hood Canal	Hood Head S.	153,431	40	16
	Vinland	412,765	100	16
	Hamma Hamma	1740	14	0.7
North Sound	Point Partridge	26,320	586	9
2005 Total		**2,152,299**	**2380**	**279.7**

[1] Includes test harvest and PSP testing.
[2] A calculated estimate, using the number of geoducks harvested and the average density of geoducks on the tract.

Based on the 2001 – 2005 data above, in one year harvest typically occurs on eight to twelve tracts with a combined acreage of 1732-2380 acres (Table 3.2). This harvest acreage is between 5.8 and 7.9 percent of the 30,000 acres of inventoried geoduck tract.

Harvest does not occur across an entire tract in one year; instead harvest activities focus on smaller areas within the tract. For example, in Table 3.2, 128,240 pounds of geoduck were harvested from the Jamestown 1 tract in 2001. The average weight of individual geoducks on this tract is 2.2 pounds (from WDFW survey data), so a calculated 58,291 geoducks were harvested from the tract in 2001 (128,240 ÷2.2). The density of geoducks on this tract is .05 geoducks per ft^2 (from WDFW survey data). Assuming an even distribution of geoducks across the tract, an area of 1,165,818 ft^2 (or 27 acres) would have theoretically been harvested to remove the 58,291 geoducks (58,291÷.05).

The above calculation assumes an even distribution of geoducks across the entire tract. In reality, geoducks are commonly concentrated in patches, and the actual area where harvest occurs is primarily in these patches; an area smaller than that shown in the last column of Table 3.2., but more widely distributed across the tract. The area harvested on each tract is likely somewhere between the acreages in the last two columns of Table 3.2. Note that harvesters return to the same tracts for several years; harvest does not occur on entirely new tracts each year.

When harvest quotas are offered in the San Juan management region, the total acres across which harvest occurs will increase because that region will be assigned a total allowable catch (see Section 3-3 below). The scope of harvest will be similar to that in the other regions.

The biomass harvested each year fluctuates but remains within the amount allowed to sustain the geoduck resource. The management of the fishery at conservative, sustainable biomass levels limits the amount of harvest allowed each year and limits DNR's ability to expand the fishery.

ACREAGE LIMITS

For the purposes of this HCP, DNR is proposing a 6000 acre maximum tract acreage from which harvest would occur annually, considering the 50-year timeframe for this HCP. Harvest from this maximum acreage would be spread across the five management regions and may eventually include tract acres in the San Juan management region. In any one year, the harvest would not occur from tracts in one management region but would be divided between management regions similar to past years (Table 3.2). The area from which geoducks are harvested annually will not exceed 1500 acres in any one management region. This 6000 acre maximum is the combined tract sizes on which harvest activity would occur; as described above the actual amount of tract area experiencing harvest would be less than the 6000 acre total.

The 6000 acre maximum was arrived at by considering the sum total of the two largest tracts in each management region (Table 3.3). Should harvest in one year occur on these tracts, the total acreage would be 6286. In practice, this would not occur because in any one year a given tract may be non-commercial because of low geoduck densities, pollution, land use conflicts or for other reasons. The logistics or need to harvest from this large of an area in one year also precludes this scenario in reality. However this exercise is useful in establishing a maximum upper limit of tract acres from which harvest would occur for the purposes of this HCP, and is plausible given the 50-year timeframe of the HCP.

Table 3.3. Two largest tracts in each management region.

Region	Size (acres)	Tract Number	Tract Name
Strait of Juan de Fuca	1197	00300	Siebert Creek
	728	00350	Dungeness spit
Central Sound	723	07000	Battle Point North
	700	04100	Port Townsend
South Sound	461	17400	Salom Point
	310	17700	Windy Point
Hood Canal	459	20300	Sisters/Shine
	421	21450	Warrenville
North Sound	586	03100	Point Partridge

	301	03900	Randall Point
Total – all currently harvested regions	**5886**		
San Juan *	200	NA	NA
	200	NA	NA
Total – all regions	**6286**		

* The San Juan management region is a different situation because even though geoduck beds have been identified, commercial tracts and geoduck biomass have not been quantified. Over the course of the 50-year span of this HCP, harvest could occur here. Based on the currently identified extent of geoduck beds in that region compared to that of the other regions (Figures 1 and 2), an estimate for this exercise of maximum acres is two tracts of 200 acres each.

3-2.6 Geoduck Research and Sampling

In addition to the sampling done to ensure water quality and shellfish safety prior to and during harvest, sampling occurs throughout the year for a variety of research efforts including stock assessment, geoduck aging and geoduck genetics. Samples are collected throughout the six management regions within the depths utilized for commercial harvest. Health-related sampling is done within commercial tracts as is most research sampling. When performed or managed by DNR, these activities will follow the same restrictions as those for commercial harvest.

3-2.7 Other Practices

SOUTHERN RESIDENT ORCA

In order to comply with the Marine Mammal Protection Act, DNR has developed a ―diver recall" system capable of getting all divers out of the water when orcas are sighted on the tract being harvested. DNR divers and harvesters remain out of the water until all marine mammals have left the area. Vessel engines remain switched off until that time.

3-3 Determining TAC and Managing Geoduck Tracts

An annual harvest quota for geoduck clams is calculated for each management region by multiplying the current regional commercial biomass estimate by a sustainable harvest rate (2.7 percent). The sustainable harvest rate is derived from a deterministic age-based equilibrium model (Bradbury and Tagart 2000) and a risk-adverse (F40) fishing strategy selected by geoduck managers. In Washington, the annual quota has been termed ―Total Allowable Catch, or TAC. The TAC is calculated by WDFW.

Total population biomass is the sum of all known wild stock geoducks measured in pounds. *Commercially available biomass* is the estimated poundage available for commercial harvest and is estimated from survey data (see Calculating Harvest, Section 3-3.1 below). Tracts closed due to sediment or water quality impairments, are *not* included in the commercial biomass; neither are those areas or tracts where densities of geoducks have not been quantified (X-beds). Recovery beds (those in recovery from past harvest) are included.

Tracts that have been fished down to about 30 percent of the pre-fishing density and placed into recovery status are not fished again until a new survey demonstrates that the average geoduck tract density has reached or exceeded the previous pre-fishing density. At this point the tract is considered ―recovered" and again made available for commercial harvest.

Based on an equilibrium yield model (see Section 3-3.1 below), currently 2.7 percent of the commercial biomass in each of the five management regions is allocated for total fishing effort each year. (The San Juan management region currently does not have identified commercial biomass.) This is the TAC and it is split equally between the state and tribes, so the State's share of the TAC is half of the 2.7 percent, or 1.35 percent of the commercial biomass. In order to protect the resource further, the State reduces its share by 2 percent to allow for the potential of unreported harvest mortalities.

After taking the 2 percent reduction, DNR makes the remaining 98 percent of the State's share of the annual TAC for each management region available for harvest opportunity at auction each year, i.e., the State auctions 1.32 percent of the commercial biomass.

Closures of tracts for health reasons, market conditions, weather concerns, time constraints and delays in obtaining shoreline permits can result in underharvest of the TAC. Unharvested portions from one year's TAC are not carried forward or added to the next year's TAC.

By management agreement, overharvest of a party's share of the TAC will result in a reduction of the following year's TAC for that party.

3-3.1 Calculating Harvest Amounts

Commercial biomass for a tract is the product of geoduck density, weight and tract area estimates. Geoduck density in a tract is estimated by establishing belt transects in the tract, and counting the number of siphons seen by divers along the transects. Geoduck counts are corrected with a daily ‗siphon show' factor that adjusts for the variability in actual siphons visible compared to the total number of geoducks. The tract weight estimate is made by removing and weighing ten geoducks from every sixth survey transect and pooling the samples to calculate an average geoduck weight. The tract area estimate is made using NOAA water depth contours between –18 and –70 feet (corrected to MLLW) and subtracting areas that cannot be harvested due to health, ecological, statutory, substrate or conflicting use constraints. ArcGIS is used to estimate tract area. (Water surface area is used as a proxy for benthic surface area.)

REGIONAL HARVEST CALCULATIONS

Regional commercial biomass estimates are the sum of all commercially harvestable tracts surveyed within one management region. Tract biomass estimates are adjusted up or down. Harvestable biomass is added when a tract is surveyed and additional biomass is found. Biomass is subtracted after geoduck harvest has occurred or a survey indicates reduced biomass. Biomass is either added or subtracted when a tract's health classification has been changed by the Department of Health, depending on whether the status is changed to approved, conditionally approved, restricted, or prohibited.

EQUILIBRIUM YIELD MODEL

Washington's geoduck fishery uses an age-based model with a F40 % fishing strategy to provide an equilibrium harvest rate. A predictive mathematical yield model forecasts the effect of various harvest rates on wild stock geoduck populations (Bradbury and Tagart, 2000). This model relies on estimates of growth, natural mortality, sexual maturity, harvest selectivity and other life history parameters. Based on the current model, an equilibrium rate of 2.7 percent was calculated and agreed to by both State and Tribal managers in 1997. The 2.7 percent harvest rate is predicted to preserve 40 percent of the un-fished spawning biomass of wild stock geoduck populations (Bradbury et al. 2000).

3-4 Fishery Enforcement Activities

Commercial tracts selected for harvest are concentrated in a single geographic area of each management region to facilitate fishery enforcement. DNR's commercial dive team is present on the tracts undergoing harvest each day that geoduck harvest operations are being conducted. DNR has the authority to cancel a harvest day if weather conditions present a safety hazard or for other reasons.

At least two compliance staff, one of whom is an enforcement officer, are present on the compliance vessel, on the tract being harvested. This ensures compliance with the specified harvest conditions and restrictions. They have a number of responsibilities which include:

- setting and checking tract boundaries and marker buoys;
- identifying and documenting the dive harvest vessels and onboard harvest divers and tenders;
- documenting the vessel harvest location with GPS coordinates;
- collecting weekly samples of geoduck for testing by Dept. of Health to ensure the product is safe for human consumption and assisting Dept. of Health in routinely scheduled water sampling activities;
- conducting random vessel inspections to ensure no unreported catch is onboard and to assess diving safety and vessel safety conditions including any potential discharges of hazardous materials such as fuel or hydraulic fluids;
- performing investigative dives and video camera drops to monitor harvest activity and ensure sound environmental practices are being followed, ensure harvest is within tract boundaries, and verify that no unreported harvest mortality is occurring;
- authenticating weigh-out of harvested geoduck at the end of each day;

- monitoring noise levels by using a sound meter and taking sound readings at 200 yards from vessels, and monitoring harvest vessel distances from shore using an electronic distance measuring device;
- identifying and removing environmental hazards such as derelict fishing nets or other fishing gear that may be present on a tract and constitute a threat to divers and marine fauna;
- utilizing a diver recall system and engine-off policy for emergency situations and marine mammal presence/protection;
- operating onboard communications systems with the shore and responding to questions or concerns from the public related to geoduck harvest activities; and,
- working cooperatively with WDFW enforcement to investigate reports of illegal harvest and WDFW biologists to collect information for research and fishery management purposes.

Vessel inspections occur at random. If the number of inspections was to be averaged it would be about 1 per day. In practice, one vessel could be inspected or four inspected on any given day. The same vessel could be inspected several times in a row. Inspections are noted in daily compliance logs maintained by DNR. These inspections are carried out continually during the course of the fishery.

The main intent of vessel inspections is to check for unreported geoducks but the general condition of the boat and its operating equipment, as well as the equipment used to conduct harvest operations is noted as well (E.g., vessel-diver communications, nozzle sizes, scales for weighing product, etc.).

Compliance dives are conducted randomly at a frequency of about one or two dives per week or in some cases dives occur two or three times per week. Dives are performed on tracts after harvesters have worked on them and also in areas that are actively being harvested. Underwater video camera viewing also occurs but gives a more limited view of the tract and harvest activities. The type of underwater inspection done (free dives, tethered dives, video camera drop) depends on the number of DNR compliance staff working that day, weather conditions, tract location and other variables.

Noise level checks are done on an as needed basis. In harvest areas off shore of shoreline homes, more noise level checks are done than when harvest occurs in more remote areas. Situations have occurred where background noise (e.g., from waves hitting the compliance boat, upland noises, wind hitting the microphone used to measure noise levels) is loud enough to interfere with the ability to get a reading on the noise coming from a particular harvest boat.

4. Potential Biological Impacts and Take Assessment

4-1 Direct and Indirect Effects

Geoduck harvest activities, and thus related effects, are localized, meaning that at one time, harvest activities are occurring on one tract, or sometimes on more than one tract within one management region. Effects are limited to the tract area and its immediate vicinity. Geoduck harvest activities could potentially directly disturb individuals of the covered species. Substrate and water are temporarily affected by disturbance of bottom sediments and suspension of fine sediments during geoduck harvest. Other benthic organisms (besides geoducks) within harvest tracts may be inadvertently removed and damaged during harvest and their abundance temporarily reduced within the tract boundary. The use of motorized boats and mechanized equipment create a risk of introductions of toxic materials to the water which could impact individuals of the covered species, and damage habitat, should a spill occur. The noise and general activity of harvest can also potentially disturb the covered species.

4-1.1 Surface Effects

VESSELS

Harvest vessels and DNR compliance vessels are on the water during harvest operations. Their movement and presence could potentially disturb birds and marine mammals. Vessels pose a risk of fuel spills or spills of other hazardous materials that could damage habitat or kill individuals, eggs, or larvae. These risks are reduced through the following means.

Fuel spill and similar risks are managed through DNR compliance staff which require harvest vessels in danger of capsizing, or with obvious leaks of toxic or hazardous materials to move out of the harvest area and return to the docks for necessary repairs before they can return to the harvest tract.

Harvesters are required, in the harvesting agreement (Appendix B) to comply with all federal, state, and local laws and regulations concerning the use and disposal of hazardous, toxic or harmful substances. They are also required to notify the DNR of any release of hazardous, toxic or harmful substances.

Harvesters are required to provide DNR the right to enter and inspect any harvest vessel operating under the harvesting agreement. Since 2003, all harvest vessels are required to carry pollution liability insurance to provide funds in the event of a spill.

A Vessel Spill Contingency Plan (Appendix F) provides guidance to DNR compliance staff in the event of a spill and instructs them to immediately report observed oil sheens or slicks to Washington State Department of Ecology and the United States Coast Guard.

Noise

Noise from boat operations and dive support equipment could disturb birds and marine mammals. Geoduck harvest operations generate noise from three sources: the vessel engine, the pump or compressor engines powering the water jets and diver air supply, and the two-way diver communication system. Communication between the vessel and divers is electronic, via their umbilical. Engine noise increases when boats reposition on the tract.

On-site measurements found maximum surface noise levels of 61 to 58 dBA at a distance of 100 feet where auxiliary equipment was housed on deck and 55 to 53 dBA where equipment was housed below deck (Table 4.1).

Sound intensity levels drop off rapidly in air. The inverse square law of sound behavior says that, in situations where sound is from a stationary or point source with negligible obstacles or boundaries on the sound, it will decrease 6 decibels with each doubling of distance from the source. Using this law and the above measured noise levels, noise levels at other distances can be calculated (Table 4.1).

Table 4.1. Measured and calculated noise levels above water at various distances.

Distance (ft)	Predicted surface noise levels (dBA)	
	Equipment on deck	Equipment below deck
100	61-58 (measured)	55-53 (measured)
200	55-52 *	49-47 *
400	49-46 *	43-41 *
800	43-40 *	37-35 *

*calculated

Noise levels are enforced at less than 50 decibels measured at a distance of 200 yards (600 feet) from each vessel. Calculated levels in Table 4.1 above indicate noise from geoduck boats will usually be below this level. Effects from noise are reduced through these limits imposed on harvest vessels.

Noise levels are measured by compliance staff. Vessels found to be out of compliance are not allowed to participate in harvest activities until violations are remedied. Noise levels from harvest activities might cause individuals of the covered species to avoid the harvest tract and immediate vicinity but are not expected to be great enough to result in impacts beyond this.

4-1.2 Benthic Environment Effects

Harvest activities, particularly the use of water jets when harvesting, and to a lesser degree vessel anchoring, diver movement and the dragging of hoses and collection bags, temporarily disturb bottom sediments and unintentionally remove and damage organisms on and in the substrate in the vicinity of the harvest, and may temporarily reduce their abundance. Suspension of fine sediments temporarily causes turbidity. These effects are not expected to be great enough to impact the covered species or their habitat.

The disturbance to the substrate and subsequent turbidity caused by resuspended fine sediment is reduced through the use of selective, hand held harvest equipment that only disturbs the immediate harvest vicinity (dig hole). Disturbance is limited to the proportionally small area that is harvested each year (1732 – 2380 acres), compared to the extent of the known commercial resource that has been inventoried between depth contours of –18 and –70 (about 30,000 acres).

VESSEL ANCHORAGE

Vessel anchorage may cause bottom scour and disturb vegetation, if present, and benthic organisms. These effects are limited to the swing radius of the weighted portion of vessel's anchor line (usually a heavy chain near the anchor itself). Effects to the bottom substrate would be temporary; based on comparisons of plants and animals before and after harvest, these areas recover through recolonization from surrounding areas. Effects from anchoring on eelgrass are avoided by the establishment of nearshore depth restrictions of –18 feet MLLW and 2-foot vertical harvest buffers around eelgrass beds.

HARVEST ACTIVITIES

Extracting geoducks mixes surface sediments with material found deeper in the geoduck hole. Harvest activities also temporarily suspend sediment causing localized turbidity within or near the harvest tract. Coarser sediments tend to fall out of suspension quickly, while fine particles may remain suspended in the water column until they are re-deposited away from the hole. As the suspended sediments settle they are redistributed in the vicinity of the harvest activities and may form a thin layer on the seafloor. The fate of particles put into suspension depends on particle size and water currents. The harvest activity does not introduce new sediment into the environment from external sources.

The use of hand-held harvesting equipment limits the area disturbed and therefore sediment disturbance and turbidity to the area where geoducks are extracted.

Benthic Fauna

Soft-bodied animals may be inadvertently damaged and displaced from within the substrate by the water jets and those brought to the surface are exposed to predation by fish, crab, and other predators and scavengers. Tubeworms may be broken apart, while very small animals may be suspended and carried away by currents.

The majority of infauna reside within the top 12 inches of the benthos and are likely to be directly affected by both mobilization of, and temporary changes in, the granular matrix of the sediments in harvest areas (Coull 1988; Somerfield et al. 1995). However, unlike larger scale disturbances that may have prolonged consequences (Morton 1977; van Dalfsen et al. 2000), small-scale disturbances of seabed sediments and morphology are likely to result in short-term effects on the benthic community.

Because harvest only affects a portion of the geoduck tract, recolonization of most marine organisms from surrounding sources within and adjacent to the tract is expected to occur in a short time. For comparison, monitoring of a small maintenance dredging operation found that the infauna re-adjusted to pre-dredging conditions within 28 days in the dredged area (McCaully et al. 1977). Based on studies of benthic recolonization related to dredging and sediment cap placements, the substrate on geoduck tracts is expected to be quickly recolonized after harvest activities (McCaully et al. 1977; Richardson et al. 1977; Romberg et al. 1995; Wilson and Romberg 1995) and the fauna are expected to be similar to the existing nearby benthic community. Geoduck harvest methods are less impactive than dredging, so the recolonization is expected to be similar, or occur faster than that indicated in studies involving dredging.

More invasive methods for harvesting other bivalves have documented temporary impacts to the surrounding communities. Kaiser et al. (1996) found that the infaunal community was restored within 7 months after suction harvesting Manila clams in coarse sediments and Spencer et al. (1998) found that the benthic community was restored within 9 to 12 months after suction harvesting in fine muddy sand substrate. Coen (1995) found that harvesting clams using a mechanical hydraulic dredge causes some mortality of infaunal and epifaunal organisms directly in its path. However, the community effect was found to be short term because many of the small benthic organisms regenerate rapidly, recolonize quickly and have high fecundity.

The effects of geoduck harvest methods on the abundance and diversity of animals associated with the substrate were assessed by Goodwin (1978). He reported that total biomass of the infauna in study plots in Hood Canal (excluding geoducks) seven months after geoduck harvest showed no statistically significant changes over that of pre-harvest levels. Assessing changes attributable to harvest was complicated by the patchy distribution and natural variability in abundance of benthic animals. In this study, seasonal variation may have been an uncontrolled factor. Pre-harvest samples were collected in November, 1975 and the post-harvest samples were collected in the summer of 1976. Increases seen in the numbers and weights of benthic animals were likely attributable to natural seasonal variability. Goodwin noted that: 1) Increases in the benthos were not as pronounced in the treatment plot as those in the control plot, and 2) geoduck harvest did not create dramatic decreases in standing crops of the major benthic organisms for which data were collected.

Breen and Shields (1983) also looked at benthic fauna in their study of geoduck harvest effects at five sites off Vancouver Island, British Columbia. They collected core samples from control and treatment sites and separated out infaunal organisms. Some species increased in abundance after the harvest treatment, and some decreased. Changes were not statistically significant. A greater diversity of species was seen in the more recently disturbed plot. Only one animal taxon (Harpacticoid copepods) was significantly affected and its presence increased significantly following geoduck harvest. The authors noted that the harvest treatments used in this study were more destructive than those used during commercial geoduck harvests because their treatment attempted to remove every geoduck.

Substrate Alterations

Goodwin (1978) conducted a study in northern Hood Canal to determine (in part) the effects of geoduck harvest on substrate particle size. Overall, sediment particle size distribution appeared to be minimally affected by geoduck harvest; Goodwin (1978) found no statistical difference in the average median sediment grain size between core samples from test plots (where harvest occurred) and those from control plots. The average percentage of silt and clay in the core samples from test and control cores was also not significantly different.

Breen and Shields (1983) also assessed the effects of geoduck harvest on sediment composition. They found no difference in sediment structure, as measured by particle size, in samples taken at three plots; one an undisturbed control and two that had previously been completely harvested. The authors noted that the harvest treatments used in this study were more destructive than those used during commercial geoduck harvests because their treatment attempted to remove every geoduck.

Harvest Holes

Harvesting geoducks temporarily leaves behind a series of depressions, or holes where the clams are extracted, sediments displaced, and fine particles suspended. The number of depressions created across a harvested area in a tract depends on the density of geoducks. The fate of these depressions, in terms of the time to refill, depends on the substrate composition and tidal currents. The time for them to refill can range from several days to 5-7 months (Goodwin 1978).

Most of the material removed during the harvesting of a geoduck ends up falling back into the hole or forming berms around the holes. The berms eventually erode back into the harvest holes as a result of grain settling, water current, wave energy and animal activity (Goodwin 1978).

A decrease in the percentage of fines and coarse sediments was measured by Goodwin (1978) in the holes after harvest, compared to adjacent, undisturbed sites. Fines suspended by the water jet harvest did not re-settle in the depression made by harvest.

The average dimensions of the harvest holes measured immediately after harvest by Goodwin (1978) were 14.7 inches wide and 3.2 inches deep. The depth to which disturbance occurred in removing the geoduck was 18 inches (averaged). Goodwin calculated an average hole volume of about 0.32 ft^3, or about 2 ½ gallons of material displaced.

Turbidity

Harvesting geoducks results in temporary, localized increases in turbidity levels. The level of turbidity depends on the type of substrate that harvest is occurring in. Water currents also play a role in turbidity, affecting the time for dispersal and distance of suspended material.

Heavier particles (sand) will settle faster than finer ones (silt or mud). Turbidity plumes could last for hours, or days and could result in short-term (hours to days) reduction in habitat quality for some benthic species, as well as smothering, or burying primary producers (diatoms, aquatic vegetation) and consumers (epibenthic organisms) as the material settles back to the bottom.

Short and Walton (1992) examined total suspended solids (TSS) in plumes generated by geoduck harvest, in the field and in modeled experiments. They found that at low current speeds, most material put into suspension settles within the harvest area.

Studies by Tarr (1977) of plumes down current from a hydraulic clam harvester found no significant effect on dissolved oxygen, organic and inorganic phosphates, suspended solids, or turbidity beyond 450 feet. The major effect noted was the suspension of fine material, which increased turbidity down-current 300 feet by an average of 1 mg/L above the background range of 8 to 25 mg/L. While research indicates that increased turbidity may increase mortality and decrease growth rates of bivalves (Table 4.2), the increases attributable to Washington's commercial geoduck harvest appear to be well below effect thresholds summarized in Table 4.2.

Table 4.2 - Impacts of increased turbidity on bivalves.

Species	Impact	Reference
Quahog clam (*Mercenaria mercenaria)* eggs	Increased abnormal development above 750 mg/L	Davis (1960)
Mercenaria mercenaria larvae	No effect on growth at 750 mg/L; increased growth below 750 mg/L	Davis (1960)
Mercenaria mercenaria juvenile	Growth reduced at 44 mg/L; no effect at 25 mg/L	Bricelj et al. (1984)
Eastern Oyster (*Crassostrea virginica)* eggs	25 percent mortality of eggs at 250 mg/L	Loosanoff and Davis (1963)
	Adverse effects at 188 mg/L	Davis and Hidu (1969)
Crassostrea virginica larvae	Decreased growth at levels above 705 mg/L	Loosanoff and Davis (1963)
Mediterranean mussel *(Mytilus galloprovincialis)* larvae	Increased growth up to 500 mg/L; decreased growth at high concentrations	Seaman et al. (1991)

Sediment Deposition

Sediment suspended by water jets is dispersed down-current in the vicinity of harvest activity and eventually settles back out of the water column in calm areas and may form a thin film on the seafloor. The fate of sediments disturbed by harvest will vary depending on the substrate composition of the particular harvest tract, and current direction and speed.

Short and Walton (1992) estimated that the average cumulative thickness of all grain sizes suspended during a normal commercial geoduck harvest settling on one acre would be 0.16 inches, while Goodwin (1978) estimated deposition for fines at 0.08 inches. By comparison, Brundage (1960) measured natural sedimentation deposition rates of .67 inches/year in the Nisqually River delta in south Puget Sound.

Short and Walton (1992) estimated that if all grain sizes put in suspension by commercial geoduck harvest were to settle on the harvested tract (a conservative scenario) the deposition would range from 7.9 to 8.83 kg/m^2/year. This is within the natural background range 2.6 to 12.0 kg/m^2/year for Puget Sound as a whole (Lavelle et al. 1986).

Short and Walton (1992) tracked and quantified suspended sediment down-current from geoduck harvest in the Nisqually Reach tract, off the Nisqually River delta. They also developed a numerical particle tracking model, calibrated with field data, to augment observational data. Using the model, they assessed the transport and fate of suspended sediment under various conditions within the range of conditions typically encountered on commercial geoduck harvest tracts. Even when scaled upward to approximate the harvesting intensity that occurs on one area in a year, the cumulative thickness of material deposited was calculated to be 0.16 inches.

The average settled sediment thickness at different current speeds was found to be extremely small for the study simulations (25 holes dug in 20 minutes), measuring in thousandths of an inch. Long-term cumulative sedimentation effects scaled to typical annual harvest were also small. Their conclusion was that deposition of suspended material would be inconsequentially small, even when extrapolated over a year.

Short and Walton (1992) also demonstrated that even under worst case conditions of direct onshore transport , the resulting thickness of material deposited in the intertidal zone, per hour of harvesting, is extremely small (thousandths of an inch). They demonstrated that deposition of fine sediment on beaches is unlikely to occur because of the presence of wave energy. Short and Walton (1992) used their model to calculate the potential for sediment suspended by geoduck harvest to accumulate onshore. This model estimated that harvest of 75 geoducks 656 feet from shore could result in a maximum of 0.0004 cm of material accumulating on shore. Many beaches along Puget Sound are composed of sand or gravel, suggesting that typical wave and current conditions do not allow the deposition and retention of fines.

4-1.3 Summary

The transport and deposition of sediment put into suspension by harvest activities will have minimal impacts on the physical environment within the tract and adjacent areas. The amount of sediment resuspended by harvest activities is negligible and not expected to impact the covered species or their habitats. Substrate disturbance, subsequent sediment suspension and eventual deposition, and impacts to fauna on the tracts cause temporary, local (confined to the tract and immediate vicinity) effects. The effects are measurably small on the tract and nearly immeasurable further away. No significant effects on dissolved oxygen, organic and inorganic phosphates, suspended solids, or turbidity are expected.

EFFECTS OF GEODUCK REMOVAL

It has been suggested that geoducks act to filter suspended particulate matter from the water, providing a perceived benefit to local environmental conditions. In some coastal systems, dense bivalve populations exert a strong influence on suspended particulate matter including phytoplankton, zooplankton, and detritus by clearing particles from the surrounding water (Dame 1996). Transformation and translocation of matter by bivalves also appears to exert a controlling influence on nitrogen concentrations in some coastal regions (Dame et al. 1991) and can provide a means of retaining nutrients, while the removal of bivalves reduces the rate of nutrient cycling (Jordan and Valiela 1982). A strong indication that bivalve filter feeders are able to control suspended particulate matter in some coastal systems comes from documented ecosystem changes that occurred after large biomass variations in natural and cultured bivalve populations. Population explosions of introduced bivalve species in San Francisco Bay and dramatic reductions in oyster populations in Chesapeake Bay have also been implicated as the cause of large changes in phytoplankton biomass and production experienced in these systems (Alpine and Cloern 1992; Newell 1988; Nichols 1985; Nichols et al. 1990; Ulanowicz and Tuttle

1992). However, a loss of biological filtering capacity due to the removal of geoducks from Puget Sound are localized and likely insignificant because of low harvest rates within a geographic area and the small proportion of the geoduck population that is actually harvested. As an example, geoduck filtration rates were estimated for DNR in a laboratory experiment in 2004 by Taylor Shellfish Farms of Shelton, Washington. Filtration rates under laboratory conditions ranged from 72 to 240 liters per day (20 to 63 gallons), per geoduck. Using these rough estimates, it was calculated that the geoducks harvested by the state in Hood Canal would filter only 0.4 percent of Hood Canal's waters each year (Washington Department of Natural Resources 2004).

4-1.4 Scope and Intensity of Effects

Presently, harvest activities and associated effects occur on a relatively small portion of the commercial tracts each year. For example, from 2001 – 2005 geoducks were harvested from individual tracts ranging in size from 14 to 459 acres (Table 3.2). The largest tract listed in the 2004 Geoduck Atlas is 1197 acres. Annually, based on 2001 – 2005 data, geoducks are harvested from a total of about 1732 – 2380 acres of commercial tracts, spread out across the five regions that currently have commercial tracts identified. This is between 5.8 and 9.4 percent of the total commercial tract acreage of about 30,000 acres. The actual area experiencing harvest activities is smaller than the sum of the tract acreages (See Section 3-2.5).

At the maximum acreage level proposed for this HCP, harvest would occur annually from tracts totaling 6000 acres spread across the five regions that currently have commercial tracts identified, and the San Juan management region. This is 20% of the total commercial tract acreage of about 30,000 acres. The actual area from which geoducks would be harvested would be smaller than the 6000 acres (See Section 3-2.5).

The number of boats participating in the State-administered portion of the geoduck fishery at one time ranges between eight and ten.

When DNR offers harvest quotas in the San Juan region, the total acres across which harvest occurs will increase because that region will be assigned a TAC. This is already included in the 6000 acre total tract acreage.

4-2 Impacts to Covered Species

Inadvertent and infrequent encounters between the covered species and geoduck harvest activities could temporarily disrupt normal feeding, roosting and other behaviors. This would occur locally, in the immediate vicinity of the harvest operations. Known sensitive habitats, primarily fish spawning habitats but also bird nesting sites, are avoided by harvest managers so that impacts from harvest activities are reduced or completely avoided.

There are predator-prey interactions between the covered species, and also between the covered species and other forage fish species. Habitat for forage fish species, especially spawning habitat, is generally closer to shore than nearshore boundaries of geoduck tracts. Known spawning areas are avoided so that impacts to forage fish are reduced or eliminated.

It should not be assumed that the described impacts could potentially occur from harvest on each and every tract. For example there are not eagle nests near every tract, nor are there herring spawning areas, or eelgrass beds near every tract.

Potential impacts to covered species are actively researched and assessed prior to harvest, to avoid and eliminate potential impacts.

4-2.1 Birds

Boat movement and anchored boats could temporarily alter movements of individual birds in the vicinity of harvest activities. Harvest activities occur in the vicinity of forage fish species use by the covered bird species, and forage fish habitat. Impacts to forage fish, should they cause a decrease in abundance, could affect the covered bird species.

BALD EAGLE

Geoduck harvest, which occurs year-round, may be coincident with bald eagle foraging and nesting periods. The presence and operation of boats could temporarily disrupt foraging by individual eagles, at the specific locations where harvest was occurring. Moving vessels could disrupt foraging activity and stationary boats could cause displacement of individual eagles. These effects would be temporary and limited to the area near the harvest tract. Because eagles are opportunistic feeders that prey on a variety of species, and obtain food in a number of ways (hunting live prey, scavenging, and pirating food) it is unlikely that inadvertent disturbance by harvest activities would have an impact on them.

Watson et al. (1995) investigated responses of bald eagles within nesting territories to geoduck harvest activities in Puget Sound in two separate years and found that nesting bald eagles showed little indication of disturbance from boats involved in the geoduck fishery. They concluded that harvest activities were unlikely to result in long-term adverse effects to eagle productivity, but could result in short-term changes in eagle behavior.

In the study areas, all nests were located less than 984 feet from the Sound. Because harvest is not allowed on weekends, Watson et al. (1995) were able to study eagle responses in the presence and absence of harvest activity. Other potential disturbances from recreational boating activity, pedestrian activity, aircraft activity, noise from other sources (construction, chainsaws, lawnmowers) and automobiles occurred in the study area as well but the authors surmised that comparisons of eagle behavior between non-harvest and harvest days reflected actual effects of geoduck harvest activities.

There was a slight trend of reduced foraging attempts by eagles on harvest days compared to non-harvest days but the difference was not significant. Eagles made about one less attempt to capture prey during 20 hours of observation time when geoduck harvest was occurring (Watson et al. 1995).

No correlation was found between foraging attempts and time of day on harvest days; foraging attempts were equitably distributed throughout the observation period on days when harvest was occurring.

Harvest activities did not appear to affect the spatial distribution of foraging attempts.

For all human activities identified in the study area, only 4 percent resulted in flushing of eagles and the geoduck harvest activity was an insignificant source of disturbance (1 of 34 flushes). The amount of time that boats were in transit from docks to harvest sites was small compared to the total time that boats were on the water and no eagles were seen responding to the moving boats.

Anchored harvest boats are most likely to change the behavior of nesting bald eagles when harvest occurs within core foraging areas, and during the most intense daily foraging period (before 10:00 am).

Harvest could potentially affect bald eagle forage fish species (see Sections 4-2.2 and 4-2.5 below) but this is not expected to cause reductions in overall prey abundance for bald eagle. Eagles eat a variety of prey types. Potential impacts to forage fish will be avoided and minimized.

Mechanisms are in place through the Environmental Review process and the delineation of tract boundaries to identify eagle nests and maintain distance from eagle nests near shores adjacent to tracts, reducing potential disturbance. Because of restrictions for other reasons, harvest boats will always be at least 200 yards (600 feet) from shore, so would be this distance or farther from any nearby eagle nest. Possible disturbance of eagles from harvest activity is limited to the area near the tract being harvested and is not spread across a large area.

CALIFORNIA BROWN PELICAN

Individual pelicans could be temporarily displaced from roosting and foraging areas should these overlap with geoduck harvest activities. This disturbance would be temporary and would only affect the occasional pelican, should it encounter harvest activities. Possible disturbance of pelicans is limited to the area near the tract being harvested and is not spread across a large area.

Harvest activities could potentially affect brown pelican forage fish species (see Section 4-2.2 and 4-2.5 below) but not to the extent that the abundance of forage fish would be reduced. Potential impacts to forage fish will be avoided and minimized.

MARBLED MURRELET

Individual murrelets could be temporarily displaced while foraging, should they overlap with geoduck harvest activities. This disturbance is expected to be temporary and only affect the occasional murrelet, should it encounter harvest activities. Possible disturbance of murrelets is limited to the area near the tract being harvested and not spread across a large area.

Harvest activities could potentially affect marbled murrelet forage fish species (see Sections 4-2.2 and 4-2.5 below) but not to the extent that the abundance of forage fish would be reduced. Potential impacts to forage fish will be avoided and minimized.

TUFTED PUFFIN

Individual puffins could be temporarily displaced while foraging, should they overlap with geoduck harvest activities. This disturbance is expected to be temporary and only affect the occasional puffin, should it encounter harvest activities. Possible disturbance of puffins is likely limited to the vicinity of two tracts near Protection Island, where a nesting colony exists.

Harvest activities on tracts in the vicinity of Protection Island could disturb nesting and foraging tufted puffins there. The 600-foot buffer around the island provides protection, and the closest harvestable geoduck tract is about 1320 feet (0.25 mile) offshore, with the shoreward harvest boundary for the tract set at –31 feet MLLW so disturbance of nesting birds is unlikely.

Mechanisms are in place through the established 600-foot buffer around Protection Island, and the Environmental Review process to identify puffin nesting colonies and maintain distance from them, reducing potential disturbance. Because nesting colony locations are known, they will be avoided.

Harvest activities could potentially affect tufted puffin forage fish species (see Sections 4-2.2 and 4-2.5 below) but not to the extent that the abundance of forage fish would be reduced. Potential impacts to forage fish will be avoided and minimized.

4-2.2 Fish

The covered fish species spend time as juveniles and adults in the nearshore and rely on this environment for food and cover, and spawning in the case of Pacific herring. Geoduck harvest activities occur in the vicinity of juvenile and adult fishes of all the covered fish species. Generally the fishes occupy nearshore waters and those waters shallower than the –18 foot shoreward boundary of geoduck tracts. This limits potential disturbance to fish from harvest activities. Generally, juveniles would be more vulnerable to effects from increased turbidity than migrating adults due to their dependence on nearshore environments.

Effects from harvest activities such as sediment suspension and turbidity that could potentially impact fish species would be temporary and localized, and would affect fish that moved into the vicinity of harvest activities. Possible disturbance of fish species is limited to the area near the tract being harvested and not spread across a large area.

Young fish generally occupy shallow areas where vegetation provides cover. Older juveniles and adults that could occur in deeper waters are more mobile and can avoid and move away from areas of increased turbidity. Should fish encounter harvest activities and associated suspended sediments they are not expected to be impacted because concentrations of suspended sediment are below levels that cause harm.

Fishes that live as adults in the open ocean are less likely to be disturbed by harvest activities because their distribution would only potentially overlap with harvest locations when they are migrating to or from the ocean.

The possibility of suspended material smothering prey and/or damaging eelgrass is reduced by the temporary, localized nature of harvest; use of selective harvest equipment; the low levels of sediment suspended and deposited; and buffers between harvest locations and important nearshore habitats.

The potential for harvest activities to impact the foraging and migrating behavior, and foraging opportunities of the covered fish species is negligible due to the low levels of sedimentation (100 mg/L at the densest portion of the plume) generated by geoduck harvest, the relatively small areas harvested, and restrictions on harvest in the nearshore areas used by juvenile fishes. The potential for suspended sediment to affect the physiology of the fishes is likewise low.

Injury to gills can occur from increased levels of suspended sediment. Short and Walton (1992) measured total suspended solid levels immediately surrounding the geoduck dig hole at 100 mg/L above background levels; well below the levels that caused damage. Lake and Hinch (1999) found that TSS >40,000 mg/L elicited a stress response that is correlated to gill damage in coho salmon, with mortalities of 20 percent at TSS concentrations of 100,000 mg/L. TSS concentrations >4,000 mg/L resulted in erosion of gill filament tips from both angular and rounded sediment (Nightingale and Simenstad 2001). In laboratory experiments, sockeye smolts exposed to suspended sediment levels of 14,400 mg/L caused a decrease in body moisture compared to a control group. However, plasma chloride levels, which indicated a reduction in osmoregulatory capacity of the smolts, never reached acute stress levels. In laboratory experiments, Gregory (1988) concluded that elevated turbidity levels > 200 mg/L have a negative effect on juvenile Chinook foraging rates.

PACIFIC HERRING

Juvenile and adult herring that encountered geoduck harvest activities would likely move away from the area. Spawning adults and spawning habitat are avoided through seasonal harvest closures and minimum depth restrictions.

There are commercial geoduck tracts adjacent to, or coincident with, areas where Pacific herring spawn. Geoduck harvest could disrupt spawning behavior and impact spawning habitat and deposited eggs. These impacts are avoided by adjusting tract boundaries to avoid herring spawning areas, establishing harvest depth buffers in the vicinity of documented herring spawning habitat, and imposing timing restrictions to avoid geoduck harvest during spawning times. Critical herring spawning times and locations will be avoided for documented herring stocks.

The Geoduck Atlas identifies which tracts occur adjacent to herring spawning areas as well as specifying fishing restrictions during herring spawning times. In addition, herring spawning or holding areas noted in tract-specific Environmental Assessments will lead to additional harvest restrictions.

Commercial geoduck harvest in tracts adjacent to herring spawning areas is restricted to waters deeper than –35 feet MLLW during spawning season and –25 feet during the remainder of the year. This avoids the 0 to –10 foot depths where most herring spawning occurs.

Deposited herring eggs could potentially by impacted by sediment settling out from harvest operations, but the likelihood of this is very low, based on available sediment studies (see Section 4-1.2).

The low level of sediment disturbance and harvest restrictions to avoid herring spawning areas, and seasonal restrictions during spawning periods act to reduce potential impacts on herring.

COASTAL CUTTHROAT TROUT

Impacts to coastal cutthroat would be in the form of disturbance if the fish encountered harvest activities. Disturbance would be localized, in the vicinity of harvest activities occurring on a given tract, and temporary. Potential interactions between this species and harvest activities are not likely because cutthroat prefer habitats not generally coincident with those in harvest tracts. Fish could avoid disturbing activities.

Cutthroat prey items include other fish species that are addressed here (salmon, sand lance, herring). Impacts to these species are avoided and minimized and are not expected to occur at a level where their abundance is reduced.

BULL TROUT

Impacts to bull trout would be in the form of disturbance if the fish encountered harvest activities. Disturbance would be localized, in the vicinity of harvest activities occurring on a given tract, and temporary. Potential interactions between this species and harvest activities are not likely because they generally inhabit areas closer to shore. Fish could avoid disturbing activities.

Bull trout prey items include other fish species that are addressed here (salmon, surf smelt, sand lance, herring). Impacts to these species are avoided and minimized and are not expected to occur at a level where their abundance is reduced.

STEELHEAD TROUT

Impacts to steelhead would be in the form of disturbance if the fish encountered harvest activities. Disturbance would be localized, in the vicinity of harvest activities occurring on a given tract, and temporary. Potential interactions between this species and harvest activities are not likely because of their limited use of nearshore environments. Fish could avoid disturbing activities.

Steelhead prey items include other fish species that are addressed here (sand lance). Impacts to these species are avoided and minimized and are not expected to occur at a level where their abundance is reduced.

CHINOOK SALMON

Impacts to Chinook salmon would be in the form of disturbance if the fish encountered harvest activities. Disturbance would be localized, in the vicinity of harvest activities occurring on a given tract, and temporary. Potential interactions between juveniles and harvest activities are not likely because they generally inhabit or emigrate in areas closer to shore. Fish could avoid disturbing activities.

Chinook salmon prey items include other fish species that are addressed here (surf smelt, sand lance, herring). Impacts to these species are avoided and minimized and are not expected to occur at a level where their abundance is reduced.

Vegetated nearshore areas used by Chinook salmon are avoided during geoduck harvest and would not be affected.

CHUM SALMON

Impacts to chum salmon would be in the form of disturbance if the fish encountered harvest activities. Disturbance would be localized, in the vicinity of harvest activities occurring on a given tract, and temporary. Potential interactions between juveniles and harvest activities are not likely because they generally inhabit or emigrate in areas closer to shore. Fish could avoid disturbing activities.

Salo et al. (1980) studied effects of suspended sediments on juvenile chum salmon from dredging at the U.S. Navy‘s Bangor facility in Hood Canal. About 224,000 cubic yards of bottom sediments were dredged. They found that suspended solids in the dredge area were not lethal and did not increase the incidence of disease. There was evidence of avoidance of suspended solids by outmigrating salmon. Juvenile chum are also considered turbidity tolerant compared to other fishes due to their reliance on nearshore habitat, which typically have high natural turbidity levels (Nightingale and Simenstad, 2001).

Chum salmon prey items include other fish species that are addressed here. Impacts to these species are avoided and minimized and are not expected to occur at a level where their abundance is reduced.

Vegetated nearshore areas used by chum salmon are avoided during geoduck harvest and would not be affected.

COHO SALMON

Impacts to coho salmon would be in the form of disturbance if the fish encountered harvest activities. Disturbance would be localized, in the vicinity of harvest activities occurring on a given tract, and temporary. Fish could avoid disturbing activities.

Coho salmon prey items include other species that are addressed here (salmon species, surf smelt, sand lance, herring). Impacts to these species are avoided and minimized and are not expected to occur at a level where their abundance is reduced.

Vegetated nearshore areas used by coho salmon are avoided during geoduck harvest and would not be affected.

PINK SALMON

Impacts to pink salmon would be in the form of disturbance if the fish encountered harvest activities. Disturbance would be localized, in the vicinity of harvest activities occurring on a given tract, and temporary. Fish could avoid disturbing activities.

Pink salmon prey items include other species that are addressed here (sand lance, herring). Impacts to these species are avoided and minimized and are not expected to occur at a level where their abundance is reduced.

Vegetated nearshore areas are avoided during geoduck harvest and would not be affected.

4-2.3 Marine Mammals

SOUTHERN RESIDENT ORCAS

Impacts are not expected to orcas because of the low likelihood for interaction between the species and harvest activities. Possible interaction with orcas is limited to the area near the tract being harvested. If orcas encountered harvest activities they would likely continue their activities.

Though the geoduck fishery is not specifically mentioned, it falls within the “Dive, hand/mechanical collection” fishery group in the NMFS final List of Fisheries for 2005, as required by the Marine Mammal Protection Act (FR Vol. 71 No. 162. 2006). This fishery group has a Category III designation under the Marine Mammal Authorization Program for Commercial Fisheries. Category III fisheries are those that have no more than a “remote” likelihood of a take of marine mammals, defined as “highly unlikely that any marine mammal will be incidentally taken by a randomly selected vessel in the fishery in a 20-day period” (50 CFR 229.3(b)(3)).

Harvest activities could potentially affect the prey base of southern resident orcas, which is generally accepted to be mostly salmon but could included other fish species. Effects to orca forage species would be those described above for the salmon species or below for forage fish. Geoduck harvest is not expected to impact these forage species to the point where it would cause a decrease in the orca prey base because of avoidance and minimization measures for the forage species and their habitat.

Sounds emanating from engines and air compressors on geoduck harvest vessels may impair the ability of marine mammals to communicate and echolocate. Harvest vessels can produce sound at levels comparable to slow moving vessels. Slow moving vessels are likely to be audible to orcas at distances of 0.6 miles (1 km), cause behavioral reactions at distances of 164 feet (50 m), and result in temporary hearing loss at distances of 65 feet (20 m) from the vessels (Richardson et al. 1995). Temporary hearing loss and noticeable behavioral changes are unlikely to result from harvest support activities because the vessels are stationary with engines idling during harvest.

Orcas have been observed during harvest operations. In order to comply with the Marine Mammal Protection Act, DNR has implemented a “diver recall” system capable of getting all divers out of the water when marine mammals are sighted on the tract being harvested. Implementing the “diver recall” system will lessen the potential for interactions between people and orcas by reducing noise (boat engines are shut off) and having divers out of the water.

4-2.4 Invertebrates

PINTO ABALONE

No impacts will occur to pinto abalone or its habitat because it occupies rocky substrate that would not be targeted for geoduck harvest.

OLYMPIA OYSTER

Temporary degradation of water quality in the form of suspended sediment could occur in the vicinity of oysters. Effects from geoduck harvest activities are not expected to impact Olympia oysters because of the limited, localized areas across which harvest occurs. Although Olympia oysters may theoretically exist at depths where commercial geoduck harvest occurs in Puget Sound, it likely to be a rare occurrence based on current information and observations.

4-2.5 Forage Species Impacts

A number of nearshore species that occur in the vicinity of geoduck harvest areas are prey resources for the covered species. This includes surf smelt, sand lance, Pacific herring, salmon, and certain invertebrates. Pacific herring and salmon are discussed separately above. Effects from geoduck harvest would be those described above and will not occur at a level where the abundance of these species would be reduced. Impacts to forage species are reduced because harvest activities do not overlap spatially with spawning habitats. Generally sand lance and surf smelt spawn on beaches and high in the intertidal zone, not within subtidal areas where harvest activities occur.

PACIFIC SAND LANCE

Impacts to sand lance would be in the form of disturbance when adult fish are encountered during harvest activities or if harvesters inadvertently removed buried fish from the substrate. Disturbance would be localized, in and around the area of harvest activities occurring on a given tract. Spawning areas and areas used for burrowing by sand lance are closer to shore than geoduck harvest tracts, and are often in areas near freshwater inputs, so do not generally overlap with harvest tracts. In the water column, sand lance can move away from disturbances created by harvest activities. Buried sand lance would not move away until disturbed by digging where they were buried, or near to locations where they were buried. Important nearshore areas used by sand lance are avoided during geoduck harvest and would not be affected.

WDFW biologists note the occurrence of adult and juvenile sand lance seen during the tract surveys. Sand lance can apparently detect the presence of divers, as they have been observed leaving the substrate and swimming away when divers approach (pers. comm. WDFW 2005). In 355 surveyed transects from 2001-2006 in the Strait of Juan de Fuca region, sand lance were noted in 9 transects; in 129 surveyed transects in the North Sound region, they were noted in 2 transects. Sand lance were not observed in the other regions during surveys (Appendix C, note caveats to this data).

Turbidity and deposited sediment could potentially impact sand lance larvae and eggs. This is reduced by the localized nature of the harvest, through the use of the least disruptive harvest method available resulting in a small amount of sediment suspended and redeposited, and by the distance between harvest activities and shallower spawning habitats. The amount of sediment suspended and deposited is insignificant and not expected to impact larvae and eggs.

SURF SMELT

Impacts to surf smelt spawning habitat would not occur because they spawn in higher intertidal areas and beaches that do not overlap with geoduck harvest areas. In the open water, mobile juveniles and adults could avoid disturbances from harvest activities.

Turbidity and deposited sediment could potentially impact larvae and eggs. This is reduced by the localized nature of the harvest, through the use of the least disruptive harvest method available resulting in a small amount of sediment suspended and redeposited, and by the distance between harvest activities and shallower habitats. The amount of sediment suspended and deposited is insignificant and not expected to impact larvae and eggs.

4-3 Cumulative Impacts

There are sixteen treaty tribes that also harvest geoducks. Each Tribe is responsible for managing its own geoduck fishery including the fishery's schedule, monitoring, and enforcement. Through annual state-Tribal geoduck harvest plans, the Tribes have obligated themselves to set and follow environmentally based provisions to conserve elements of the geoduck's natural environment. For instance, the Tribes have agreed to impose a two-foot vertical buffer around eelgrass to protect this habitat. The participating Tribes also consented to comply with the Department of Health's restrictions imposed for public health safety. However, because the Tribes are sovereign entities, they are not bound by existing Federal, state, city or county laws in the exercise of their treaty fishing rights.

Geoduck tracts proposed for harvest are jointly selected by the treaty tribes, WDFW, and DNR. Depending on the particular management agreement negotiated between the State and the tribes that harvest in a management region, some tracts may be fished by both state and tribal operations during the year. In other cases, harvest occurs on separate tracts. The treaty tribes harvest an amount of geoducks consistent with half of the TAC annually.

The tribal harvest cumulatively contributes to the effects described above because it occurs in the same way, but sometimes in different areas.

5. Conservation Strategy

DNR's conservation strategy consists of integrating specific avoidance and minimization measures into management of the geoduck fishery. Conservation measures will be carried out through DNR's administration of the geoduck wild stock fishery as specified in the objectives and strategies below and as described in Chapter 3.

5-1 Goal for Conservation Purposes

DNR's goal is to avoid direct impacts to covered species, and minimize and avoid possible effects to the habitat for covered species. To achieve this goal, DNR has developed the following objectives and strategies.

5-1.1 Objectives and Strategies

1. Avoid disturbing nesting bald eagles and reduce or eliminate the possibility of disturbing foraging bald eagles during nesting periods.

   Strategies:

   a) DNR will adjust harvesting times and shoreward tract boundaries as needed when harvest is proposed in the vicinity of bald eagle nests. Setback distances from nests will vary on a site-specific basis but harvest boats will always be at least 600 feet from shorelines.

   b) Individual tracts will be assessed to determine the need to adjust the tract boundary or timing of harvest in relation to eagle nests and nesting periods. DNR will obtain information from WDFW staff to determine locations of eagle nests, the need for setbacks from eagle nests, setback distances, and adjustments to harvest timing.

2. Avoid disturbing tufted puffins at nesting locations and reduce or eliminate the possibility of disturbing foraging tufted puffins during nesting periods.

   Strategies:

   a) DNR will adjust the shoreward tract boundary when harvest is proposed in the vicinity of puffin nesting colonies. Established setbacks for National Bird Sanctuaries such as those on Protection Island will be recognized and no harvest activity will occur within these setback areas. Harvest boats will always be at least 600 feet from shorelines.

b) Prior to harvesting from tracts in the vicinity of National Wildlife Refuges, National Bird Sanctuaries (e.g., Protection Island and Smith Island), or other discovered puffin nesting colonies, DNR will coordinate with appropriate USFWS staff to verify setback distances and address other concerns. This will occur each time these tracts are harvested so that new information and science as to nesting locations can be considered in establishing setbacks prior to harvest activity on the tract.

3. Reduce or eliminate the possibility of disturbing Southern Resident orcas.

Strategy:

a) DNR will avoid potential interactions between orcas, people, and harvest activities by invoking the ―diver recall" system to get divers out of the water when orcas are sighted near the tract being harvested. DNR divers and harvesters will remain out of the water, and vessel engines will be turned off and will remain off until all orcas have left the area.

4. Minimize possible disruptions to the covered species from noise related to geoduck harvest.

Strategy:

a) DNR will reduce the likelihood of disturbing species vulnerable to surface noise by limiting surface noise levels to 50 decibels at a distance of 200 yards (600 feet) from each vessel.

5. Protect the nearshore prey base of species covered in this HCP. Protect nearshore habitats that support forage fish, thereby protecting this source of food for the covered fish species, bird species, and orcas.

Strategy:

a) DNR will protect eelgrass beds adjacent to geoduck harvest tracts by establishing a 2-foot vertical or 180-foot horizontal (on very gradual slopes) buffer between geoduck tracts and the deepest occurrence of eelgrass.

b) DNR will protect herring spawning habitat and macroalgae habitat that may provide cover for other fish, and avoid disturbing herring during spawning times by establishing seasonal shoreward harvest boundaries. On tracts adjacent to documented herring spawning areas (eelgrass, macroalgae, or other substrate), the shoreward harvest boundary will be restricted to waters deeper than –35 feet MLLW during spawning season and deeper than –25 feet during the remainder of the year.

c) Within one year after obtaining the Incidental Take Permits, DNR will contact appropriate WDFW and Tribal biologists and arrange a meeting for the purposes of assessing and reaffirming that the above buffers are adequate to protect nearshore environments, eelgrass, and herring spawning areas. Results and recommendations from the meeting will be reported to the Services at annual meetings.

6. Minimize impacts to covered species caused by disturbances to benthic sediment and benthic flora and fauna, and caused by turbidity.

Strategy:

a) DNR will limit the area impacted by harvest activities by limiting harvest to designated tracts and enforcing the conditions stated in harvesting agreements for the tracts.

b) DNR will protect nearshore habitats by locating the closest shoreward harvest boundary at or deeper than the –18 foot MLLW water depth contour on all tracts.

c) DNR will restrict the harvest method to the removal of individual geoducks using hand-operated water jets as stipulated in WAC 220-52-019(2a).

d) DNR will limit annual harvest to the State's half of a TAC of 2.7 percent of the commercial biomass in each region, which is 2 to 3 million pounds. The total tract area from which annual harvest occurs will be no more than 6000 acres and will not exceed 1500 acres in any one management region.

7. Protect the covered species from direct mortality associated with toxic spills; protect habitats from habitat damage associated with toxic spills.

Strategy:

a) DNR will employ specific measures (see Section 5-2.5 below) to reduce the risk of a spill, and to lessen the effects of a spill, should one occur.

5-2 Mechanisms to Meet the Objectives and Strategies

Washington DNR makes the following commitments in order to achieve the conservation goal, objectives, and strategies stated in Section 5-1 above. The mechanisms to implement the objectives and strategies exist within DNR's geoduck fishery management structure. This section attempts to display the strategies from the above section in the context of how the fishery program is managed.

5-2.1 Administration

All strategies from Section 5-1 will be met to by administering the Geoduck Fishery HCP. Washington DNR will continue to use contractual harvesting agreements (described in Section 3-1.2, example at Appendix B) to conduct the fishery within the legal requirements and to stipulate harvest parameters that implement the HCP.

Washington DNR has the ability to condition harvesting agreements on a site-specific basis for each harvest tract. Some harvest parameters are stipulated in Washington law and rule.

SITE-SPECIFIC ENVIRONMENTAL ASSESSMENTS

DNR will avoid and minimize potential harvest-related effects by employing protective measures when establishing tract boundaries and during harvest activities. Tract boundaries and protective measures are determined through tract-specific Environmental Assessments (See Section 3-1.2 and example at Appendix E).

DNR will continue to provide funds for biennial interagency agreements with WDFW (described in Section 3-1.2, example at Appendix D) that require pre- and post-harvest tract surveys and Environmental Assessments of tracts to be performed by WDFW in support of management of the geoduck fishery. This allows species and habitat concerns to be identified and documented on a tract-specific basis so that the objectives and strategies in Section 5-1 can be met.

PRE- AND POST HARVEST SURVEYS

DNR will continue to provide funds for biennial interagency agreements with WDFW (described in Section 3-1.2, example at Appendix D) that require pre- and post-harvest tract surveys to be performed by WDFW in support of management of the geoduck fishery. This allows collection of data on the most common and obvious animals and plants encountered along the surveyed transects before a tract is harvested and after the tract has been fished down.

5-2.2 Harvest Levels

Strategy 6e will be met by managing harvest levels. DNR will limit effects on the substrate, benthic organisms, and local water quality (turbidity) to the areas where harvest occurs on discrete tracts, and will limit the potential for impacts to covered species by maintaining harvest within certain levels.

DNR will auction harvest quotas within a range consistent with past harvest levels and within the State‘s half of the calculated TAC of 2.7 percent of commercial biomass in each management region. A calculated sustainable yield will dictate the specific amount (biomass) of geoducks to be offered for harvest. Annual harvested biomass will be in the range of 2-3 million pounds. The sum of the tract area in acres from which harvest occurs will likely be similar to that shown in Table 3.2, but will not exceed 6000 in any year.

5-2.3 Harvest Methods

Strategy 6d will be met by enforcing legal harvest methods. DNR will minimize disturbance to the substrate and associated flora and fauna, and keep turbidity to a minimum by restricting the harvest method to the removal of individual geoducks using hand-operated water jets as stipulated in WAC 220-52-019(2a). This selective harvest method creates the lowest levels of disturbance for this type of harvest (commercial, benthic, bivalves).

5-2.4 Harvest Activity Restrictions

All strategies, with the exception of 7a will be addressed through site-specific restrictions appropriate for a specific tract. The following general operating measures apply to all tracts. DNR will incorporate these into the harvest management of individual tracts. These measures will vary depending on the nature and situation of each tract and restrictions will be established based on tract-specific surveys documented in Environmental Assessments performed by WDFW under contract with DNR (See example at Appendix D and E). Harvest restrictions will be implemented by establishing tract boundaries and adding appropriate language to harvesting agreements. These restrictions include:

GENERAL OPERATING MEASURES

DNR will minimize the area impacted by harvest activities by permitting harvest only from tracts designated through contract by DNR.

DNR will minimize the area impacted by harvest activities by clearly marking tracts with easily identifiable stakes and/or buoys, and recording latitude and longitude positions on all markers.

TRACT BOUNDARY RESTRICTIONS

Nearshore buffers – DNR will protect nearshore habitats from geoduck harvest activities by locating the closest shoreward harvest boundary at or deeper than the –18 foot MLLW water depth contour. This protects nearshore habitats where younger juvenile salmonids and forage species are generally found and where forage fish species spawn. It also prevents disturbance of migrating adult salmonids.

Eelgrass buffers – DNR will avoid and protect eelgrass by establishing a 2-foot vertical or 180-foot horizontal (on very gradual slopes) buffer between geoduck tracts adjacent to eelgrass beds and the deepest occurrence of eelgrass.

This will protect habitat used by the covered fish species for refuge, and will protect habitat used for spawning and refuge by forage fish species important as prey to the covered species.

Herring spawning area buffer – DNR will protect herring spawning habitat and macroalgae habitat that may provide cover for other fish, and avoid disturbing herring during spawning times by establishing shoreward harvest boundaries. On tracts adjacent to documented herring spawning areas (eelgrass, macroalgae, or other substrate), the shoreward harvest boundary will be restricted to waters deeper than –35 feet MLLW during spawning season and deeper than –25 feet during the remainder of the year.

Within one year after obtaining the Incidental Take Permits, DNR will contact appropriate WDFW and Tribal biologists and arrange a meeting for the purposes of assessing and reaffirming that the above buffers are adequate to protect nearshore environments, eelgrass, and herring spawning areas.

OTHER RESTRICTIONS

Eagle nesting restrictions – DNR will avoid nesting eagles and reduce the possibility of disturbing nesting and foraging eagles by adjusting harvesting times and tract boundary setbacks, if needed, in the vicinity of eagle nests.

Setback distances from nests will vary on a site-specific basis but harvest boats will always be at least 600 feet from shore.

Individual tracts will be assessed to determine the need to adjust the tract boundary or timing of harvest in relation to eagle nests and nesting periods. DNR will obtain information from WDFW staff to determine the need for setbacks for eagle nests, setback distances, and adjustments to harvest timing.

Puffin nesting area restrictions – DNR will reduce the possibility of disturbing nesting and foraging tufted puffins by assessing the need to adjust the shoreward tract boundary to avoid disturbing birds at nesting colonies. Established setbacks for National Bird Sanctuaries such as those on Protection Island and other nesting locations will be recognized and no harvest activity will occur within these setback areas. Harvest boats will always be at least 600 feet from shore.

When performing Environmental Assessments for tracts in the vicinity of National Wildlife Refuges or National Bird Sanctuaries, or other areas that may be used for nesting by tufted puffins (e.g., Protection Island and Smith Island), DNR will coordinate with appropriate USFWS staff to verify setback distances and address other concerns. This will occur each time these tracts are harvested so that new information and science as to nesting locations can be considered in establishing setbacks.

Diver recall system - DNR will avoid potential interactions between orcas, people, and harvest activities by invoking the ―diver recall" system to get divers out of the water when orcas are sighted near the tract being harvested. DNR divers and harvesters will remain out of the water, and vessel engines will be turned off and will remain off until all orcas have left the area.

Noise restrictions – DNR will reduce the likelihood of disturbing species vulnerable to surface noise disruptions by limiting surface noise levels to 50 decibels at a distance of 200 yards (600 feet) from each vessel.

5-2.5 Fuel Spill Risk Management

Strategy 7a will be met by employing the following measures to reduce the risk of a spill, and to lessen the effects of a spill, should one occur:

- Fuel spills and similar risks will be managed by DNR compliance staff in cooperation with harvesters.

- Harvest vessels in danger of capsizing, or with obvious leaks of toxic or hazardous materials will be required to stay out of the harvest area and return to the docks for necessary repairs before they can return to the harvest tract.
- The harvesting agreement will require purchasers and their subcontractors to comply with all Federal, state, and local laws and regulations concerning the use and disposal of hazardous, toxic or harmful substances.
- Harvesters will be required to notify DNR of any release of hazardous, toxic or harmful substances.
- Harvest vessels will carry pollution liability insurance to provide funds in the event of a spill.
- A Vessel Spill Contingency Plan will provide guidance to DNR compliance staff in the event of a spill and instruct compliance staff to immediately report observed oil sheens or slicks to Washington State Department of Ecology and the United States Coast Guard.

5-2.6 Harvest Compliance

Washington DNR will provide assurance that harvest occurs in accordance with all protective and avoidance measures in the HCP by having compliance staff aboard vessels on harvest tracts each day that commercial geoduck harvest occurs. Compliance staff will maintain direct oversight of the fishery, and perform enforcement activities as described in Section 3-4. A DNR enforcement vessel will be on the tract or within visual distance of the tract daily (except for emergency and operational requirements). Enforcement staff will ensure that WDFW laws and regulations, DNR contract conditions, and the conservation measures in this HCP are followed. Results of this compliance monitoring will be reported to the Services at annual meetings (See Section 8-1).

5-3 Covered Species

5-3.1 Birds

BALD EAGLES

The assessment of tracts on a site-specific basis as to their location in relation to nesting eagles will allow avoidance and minimization measures to be incorporated into harvest management of the tract.

On tracts near eagle nests, disturbance of nesting and foraging eagles is reduced by maintaining distances of at least 600 feet between harvest boats and shorelines.

Harvesting on one or two tracts at a time reduces the likelihood of disturbing eagles. Only those in the vicinity of the tract being harvested would potentially be disturbed.

Potential disturbance of eagles due to noise from harvest vessels is minimized by the established noise restrictions and tract boundary setbacks from eagle nests.

Implementation of measures to avoid and minimize effects to eagles is assured through the daily presence of compliance staff on the tract monitoring harvest activities.

Other measures address potential effects to forage fish species (see Sections 5-3.2 and 5-3.5 below). These will reduce potential impacts to eagles resulting from reductions in their prey base because the abundance of forage species will not be reduced by geoduck harvest activities.

CALIFORNIA BROWN PELICAN

Harvesting on one or two tracts at a time reduces the likelihood of disturbing pelicans. Only those in the vicinity of the tract being harvested would potentially be disturbed.

Potential disturbance of pelicans due to noise from harvest vessels is minimized by the established noise restrictions.

Implementation of the above measures to avoid and minimize effects to pelicans is assured through the daily presence of compliance staff on the tract monitoring harvest activities.

Other measures address potential effects to forage fish species (see Sections 5-3.2 and 5-3.5 below). These will reduce potential impacts to pelicans resulting from reductions in their prey base because the abundance of forage species will not be reduced by geoduck harvest activities.

MARBLED MURRELET

Harvesting on one or two tracts at a time reduces the likelihood of disturbing murrelets. Only those in the vicinity of the tract being harvested would potentially be disturbed.

Potential disturbance of murrelets due to noise from harvest vessels is minimized by the established noise restrictions.

Implementation of the above measures to avoid and minimize effects to murrelets is assured through the daily presence of compliance staff on the tract monitoring harvest activities.

Other measures address potential effects to forage fish species (see Sections 5-3.2 and 5-3.5 below). These will reduce potential impacts to murrelets resulting from reductions in their prey base because the abundance of forage species will not be reduced by geoduck harvest activities.

TUFTED PUFFIN

The assessment of tracts on a site-specific basis as to their location in relation to puffin nesting colonies will allow avoidance and minimization measures to be incorporated into harvest management of the tract. The occurrence of tufted puffins nesting colonies will be noted when Environmental Assessments are prepared for harvest tracts. Presently, only two existing harvest tracts are in the vicinity of one known nesting colony but other colonies could be discovered.

Disturbance of nesting and foraging tufted puffins is avoided by maintaining distances of at least 600 feet between harvest boats and shorelines and following setback requirements of bird sanctuaries.

Harvesting on one or two tracts at a time reduces the likelihood of disturbing puffins. Only those in the vicinity of the tract being harvested would potentially be disturbed.

Potential disturbance of puffins due to noise from harvest vessels is minimized by the established noise restrictions.

Implementation of measures to avoid and minimize effects to tufted puffins is assured through the daily presence of compliance staff on the tract monitoring harvest activities.

Other measures address potential effects to forage fish species (see Sections 5-3.2 and 5-3.5 below). These will reduce potential impacts to puffins resulting from reductions in their prey base because the abundance of forage species will not be reduced by geoduck harvest activities.

5-3.2 Fish

PACIFIC HERRING

The assessment of tracts on a site-specific basis as to their location in relation to herring spawning areas will allow avoidance and minimization measures to be incorporated into harvest management of the tract.

Harvesting on one or two tracts at a time reduces the likelihood of disturbing a large number of herring. Only those in the vicinity of the tract being harvested would potentially be disturbed.

The removal of individual geoducks using hand-operated water jets will minimize disturbance to the substrate and associated fauna, and keep turbidity to a minimum. This will reduce associated impacts to herring in the vicinity.

Shoreward tract boundaries along the –18 foot MLLW depth contour protect shallow nearshore habitats used by herring for spawning and rearing. This habitat includes eelgrass, macroalgae, and other substrate.

Buffers around eelgrass and other herring spawning vegetation protect them from disturbance. Deeper water restrictions during spawning times (–35 feet) avoids disturbing herring during spawning times. Buffers of – 25 feet MLLW protect potential herring spawning habitat during other times of the year.

Implementation of measures to avoid and minimize effects to herring is assured through the daily presence of compliance staff on the tract monitoring harvest activities.

COASTAL CUTTHROAT TROUT

Harvesting on one or two tracts at a time reduces the likelihood of disturbing a large number of cutthroat trout. Only those in the vicinity of the tract being harvested would potentially be disturbed.

The removal of individual geoducks using hand-operated water jets will minimize disturbance to the substrate and associated fauna, and keep turbidity to a minimum. This will reduce associated impacts to coastal cutthroat in the vicinity.

Shoreward tract boundaries along the –18 foot MLLW depth contour protects shallow nearshore habitats used by coastal cutthroat trout for foraging and rearing. This habitat includes eelgrass, macroalgae, and other vegetation.

Buffers around eelgrass and other vegetation protect these potential cover and food sources for cutthroat trout.

Implementation of measures to avoid and minimize effects to coastal cutthroat is assured through the daily presence of compliance staff on the tract monitoring harvest activities.

Other measures address potential effects to forage fish species (below). These will reduce potential impacts to coastal cutthroat resulting from reductions in their prey base because the abundance of forage species will not be reduced by geoduck harvest activities.

BULL TROUT

Harvesting on one or two tracts at a time reduces the likelihood of disturbing a large number of bull trout. Only those in the vicinity of the tract being harvested would potentially be disturbed.

The removal of individual geoducks using hand-operated water jets will minimize disturbance to the substrate and associated flora and fauna, and keep turbidity to a minimum. This will reduce associated impacts to bull trout in the vicinity of the tract.

Shoreward tract boundaries along the –18 foot MLLW depth contour protect shallow nearshore habitats used by bull trout for foraging and rearing. This habitat includes eelgrass, macroalgae, and other vegetation.

Buffers around eelgrass and other vegetation protect these potential cover and food sources for bull trout.

Implementation of measures to avoid and minimize effects to bull trout is assured through the daily presence of compliance staff on the tract monitoring harvest activities.

Other measures address potential effects to forage fish species (below). These will reduce potential impacts to bull trout resulting from reductions in their prey base because the abundance of forage species will not be reduced by geoduck harvest activities.

STEELHEAD TROUT

Harvesting on one or two tracts at a time reduces the likelihood of disturbing a large number of steelhead trout. Only those in the vicinity of the tract being harvested would potentially be disturbed.

The removal of individual geoducks using hand-operated water jets will minimize disturbance to the substrate and associated flora and fauna, and keep turbidity to a minimum. This will reduce associated impacts to steelhead trout in the vicinity.

Shoreward tract boundaries along the –18 foot MLLW depth contour protect shallow nearshore habitats potentially used by steelhead trout for foraging and rearing. This habitat includes eelgrass, macroalgae, and other vegetation.

Buffers around eelgrass and other vegetation protect these potential cover and food sources for steelhead.

Implementation of measures to avoid and minimize effects to steelhead is assured through the daily presence of compliance staff on the tract monitoring harvest activities.

Other measures address potential effects to forage fish species (below). These will reduce potential impacts to steelhead resulting from reductions in their prey base because the abundance of forage species will not be reduced by geoduck harvest activities.

CHINOOK SALMON

Harvesting on one or two tracts at a time reduces the likelihood of disturbing a large number of Chinook salmon. Only those in the vicinity of the tract being harvested would potentially be disturbed.

The removal of individual geoducks using hand-operated water jets will minimize disturbance to the substrate and associated flora and fauna, and keep turbidity to a minimum. This will reduce associated impacts to Chinook salmon in the vicinity.

Shoreward tract boundaries along the –18 foot MLLW depth contour protect shallow nearshore habitats used by Chinook salmon for foraging and rearing. This habitat includes eelgrass, macroalgae, and other vegetation.

Buffers around eelgrass and other vegetation protect these potential cover and food sources.

Implementation of measures to avoid and minimize effects to Chinook salmon is assured through the daily presence of compliance staff on the tract monitoring harvest activities.

Other measures address potential effects to forage fish species (below). These will reduce potential impacts to Chinook salmon resulting from reductions in their prey base because the abundance of forage species will not be reduced by geoduck harvest activities.

CHUM SALMON

Harvesting on one or two tracts at a time reduces the likelihood of disturbing a large number of chum salmon. Only those in the vicinity of the tract being harvested would potentially be disturbed.

The removal of individual geoducks using hand-operated water jets will minimize disturbance to the substrate and associated flora and fauna, and keep turbidity to a minimum. This will reduce associated impacts to chum salmon in the vicinity.

Shoreward tract boundaries along the –18 foot MLLW depth contour protect shallow nearshore habitats used by chum salmon for foraging and rearing. This habitat includes eelgrass, macroalgae, and other vegetation.

Buffers around eelgrass and other vegetation protect these potential cover and food sources.

Implementation of measures to avoid and minimize effects to chum salmon is assured through the daily presence of compliance staff on the tract monitoring harvest activities.

Other measures address potential effects to forage fish species (below). These will reduce potential impacts to chum resulting from reductions in their prey base because the abundance of forage species will not be reduced by geoduck harvest activities.

COHO SALMON

Harvesting on one or two tracts at a time reduces the likelihood of disturbing a large number of coho salmon. Only those in the vicinity of the tract being harvested would potentially be disturbed.

The removal of individual geoducks using hand-operated water jets will minimize disturbance to the substrate and associated flora and fauna, and keep turbidity to a minimum. This will reduce associated impacts to coho salmon in the vicinity.

Shoreward tract boundaries along the –18 foot MLLW depth contour protect shallow nearshore habitats used by coho salmon for foraging and rearing. This habitat includes eelgrass, macroalgae, and other vegetation.

Buffers around eelgrass and other vegetation protect these potential cover and food sources.

Implementation of measures to avoid and minimize effects to coho salmon is assured through the daily presence of compliance staff on the tract monitoring harvest activities.

Other measures address potential effects to forage fish species (below). These will reduce potential impacts to coho salmon resulting from reductions in their prey base because the abundance of forage species will not be reduced by geoduck harvest activities.

PINK SALMON

Harvesting on one or two tracts at a time reduces the likelihood of disturbing a large number of pink salmon. Only those in the vicinity of the tract being harvested would potentially be disturbed.

The removal of individual geoducks using hand-operated water jets will minimize disturbance to the substrate and associated flora and fauna, and keep turbidity to a minimum. This will reduce associated impacts to pink salmon in the vicinity.

Shoreward tract boundaries along the –18 foot MLLW depth contour protect shallow nearshore habitats used by pink salmon for foraging and rearing. This habitat includes eelgrass, macroalgae, and other vegetation.

Buffers around eelgrass and other vegetation protect these potential cover and food sources.

Implementation of measures to avoid and minimize effects to pink salmon is assured through the daily presence of compliance staff on the tract monitoring harvest activities.

Other measures address potential effects to forage fish species (below). These will reduce potential impacts to pink salmon resulting from reductions in their prey base because the abundance of forage species will not be reduced by geoduck harvest activities.

5-3.3 Marine Mammals

SOUTHERN RESIDENT ORCAS

Potential interactions between orcas and harvest activities will be avoided by having divers out of the water and boat engines shut off when orcas are present.

Other measures address potential effects to forage fish species, including salmon. These measures will reduce potential impacts to orcas resulting from reductions in their prey base because the abundance of forage species will not be reduced by geoduck harvest activities.

5-3.4 Invertebrates

PINTO ABALONE

Because the rocky habitat used by pinto abalone does not overlap with that used by geoduck, no specific conservation measures are proposed.

OLYMPIA OYSTER

Geoduck harvest levels, locations, and methods reduce the potential for effects to Olympia oysters.

5-3.5 Forage Fish

PACIFIC HERRING (discussed above)

SALMON SPECIES (discussed above)

PACIFIC SAND LANCE

Shoreward tract boundaries along the –18 foot MLLW depth contour protect intertidal habitats used by sand lance, and spawning areas. This habitat includes eelgrass, macroalgae, other vegetation and beaches.

Buffers around eelgrass and other vegetation protect these potential cover and food sources.

Harvesting on one or two tracts at a time reduces the number of sand lance potentially disturbed. Only those in the vicinity of the tract being harvested would potentially be disturbed.

The removal of individual geoducks using selective, hand-operated water jets will minimize disturbance to buried sand lance and the substrate and associated flora and fauna. Turbidity is also kept to a minimum. This will reduce impacts to sand lance and their habitat in the harvest vicinity.

Implementation of measures to avoid and minimize effects to sand lance is assured through the daily presence of compliance staff on the tract monitoring harvest activities.

SURF SMELT

Shoreward tract boundaries along the –18 foot MLLW depth contour protect intertidal habitats used by surf smelt, and spawning areas. This habitat includes eelgrass, macroalgae, other vegetation and beaches.

Buffers around eelgrass and other vegetation protect these potential cover and food sources.

Harvesting on one or two tracts at a time reduces the number of surf smelt potentially disturbed. Only those in the vicinity of the tract being harvested would potentially be disturbed.

The removal of individual geoducks using selective, hand-operated water jets will minimize disturbance to the substrate and associated flora and fauna, and keep turbidity to a minimum. This will reduce associated impacts to surf smelt in the vicinity.

Implementation of measures to avoid and minimize effects to surf smelt lance is assured through the daily presence of compliance staff on the tract monitoring harvest activities.

5-4 Measures to Mitigate Unavoidable Impacts

The effects of DNR's commercial geoduck harvest are reduced through the above avoidance and minimization measures. Below are additional environmentally beneficial activities that are able to occur through revenue generated by the geoduck fishery:

- Cleanup and restoration of contaminated sediment in Puget Sound
- Inventory of nearshore aquatic habitat in Puget Sound
- Control of invasive *Spartina*
- Salmon enhancement projects
- WDFW and DNR aquatic enforcement work other than that related to the geoduck fishery
- Grants to local governments for the purchase, conservation and restoration of aquatic lands for public access and habitat restoration
- Establishing aquatic reserves
- Creating a programmatic HCP for state-owned aquatic lands

The money generated from the sale of geoduck harvest rights is split equally between two accounts— the Resource Management Cost Account-Aquatics (RMCA-Aquatics) and the Aquatic Lands Enhancement Account (ALEA). The RMCA-Aquatics account is used to fund DNR's management of state-owned aquatic lands, including management of the commercial geoduck fishery (See Chapter 6). Money from the ALEA account is used by a number of state agencies to fund management and protection of state aquatic resources.

Average geoduck revenue is around $6 million annually. The 2003-2005 Biennium breakdown of the distribution of funds was:

<u>WA Department of Natural Resources 58%:</u>

Geoduck fishery management, enforcement and research; aquatic land management; *Spartina* and invasive species control

WA Department of Fish and Wildlife 13%:

Geoduck fishery management, enforcement and research; salmon recovery; shellfish enhancement projects

WA State Interagency Committee for Outdoor Recreation 24%:

ALEA Public Access and habitat restoration grants (state, tribal and local governments); habitat acquisition and public access projects

WA Department of Agriculture 4%:

Spartina and invasive species control

WA State Parks 1%:

Boating safety

5-5 Monitoring

5-5.1 Compliance Monitoring

Monitoring the implementation of the requirements of this HCP is assured because DNR compliance staff will be on site each day that harvest is occurring, monitoring harvest activities. Avoidance and minimization measures for a particular tract that have been incorporated through tract boundary delineation and through specific harvest stipulations will be monitored for compliance. Daily monitoring and compliance enforcement will be performed by DNR compliance staff as described in Section 3-4.

Commercial tracts selected for harvest will be concentrated in a single geographic area to facilitate fishery enforcement. DNR‘s commercial dive team will be present on the tracts undergoing harvest each day that geoduck harvest operations are being conducted, and at least one enforcement officer will be present onboard the compliance vessel. They will perform a number of tasks which include:

- setting and checking tract boundaries and marker buoys;
- identifying and documenting the dive harvest vessels and onboard harvest divers and tenders;
- documenting the vessel harvest location with GPS coordinates;
- collecting weekly samples of geoduck for testing by the Dept. of Health to ensure the product is safe for human consumption and assisting the Dept.of Health in routinely scheduled water sampling activities;
- conducting random vessel inspections to ensure no unreported catch is onboard and to assess diving safety and vessel safety conditions including any potential discharges of hazardous materials such as fuel or hydraulic fluids;
- performing investigative dives and video camera drops to monitor harvest activity and ensure sound environmental practices are being followed, ensure harvest is within tract boundaries, and verify that no unreported harvest mortality is occurring;
- authenticating weigh-out of harvested geoduck at the end of each day;
- monitoring noise levels by using a sound meter and taking sound readings at 200 yards from vessels, and monitoring harvest vessel distances from shore using an electronic distance measuring device
- identifying and removing environmental hazards such as derelict fishing nets or other fishing gear that may be present on a tract and constitute a threat to divers and marine fauna;
- utilizing a diver recall system and engine-off policy for emergency situations and marine mammal presence/protection;
- operating onboard communications systems with the shore and responding to questions or concerns from the public related to geoduck harvest activities; and,
- working cooperatively with WDFW enforcement to investigate reports of illegal harvest and WDFW biologists to collect information for research and fishery management purposes.

Vessel inspections, underwater monitoring and noise monitoring will occur as described in Section 3-4.

5-5.2 Eelgrass Surveys

DNR will contract with WDFW for eelgrass surveys through interagency agreements (See Section 3-1.2 and example at Appendix D). These surveys will be done as part of pre-fishing surveys. The entire shoreward boundary will be examined in the vicinity of the –16-foot (MLLW) water depth contour.

If eelgrass is discovered, surveyors will define the deepest seaward extension of eelgrass. The shoreward boundary of the harvest tract will then be established two vertical feet deeper than the deepest and most seaward occurrence of rooted eelgrass, or 180 horizontal feet on very gradual slopes.

5-5.3 Geoduck Resource Surveys

DNR will contract with WDFW for geoduck resource surveys through interagency agreements (Section 3-1.2 and example at Appendix D). These pre-fishing surveys will establish belt transects and will systematically collect data on the tract area between the –18 to –70 foot (MLLW) water depth contour.

Data collected will include geoduck counts, water depth, GPS position, substrate types, and associated macroscopic flora and fauna (Example of flora and fauna data at Appendix C).

5-5.4 Bald Eagles

While on the water during harvest times, DNR compliance staff will note the presence of bald eagle nests within site distance of the tract being harvested. They will note if the nest is occupied and if eagles appear to leave the nest in response to harvest activities.

5-5.5 Tufted Puffins

While on the water during harvest times on tracts offshore of puffin nesting areas, DNR compliance staff will note any occurrences of tufted puffins. They will note if the birds appear to change their behavior in response to harvest activities.

5-5.6 Other Covered Species

While on the water during harvest times DNR compliance staff will note the presence of other species covered in this HCP.

5-5.7 Reporting

DNR will submit reports on the above monitoring items to the Services at yearly meetings (see Section 8.1)

6. Funding

6-1 Sources of Funding and Plan Costs

DNR commits to funding the proposed HCP conservation strategy. The source of funds to implement this HCP will come from revenue generated by the commercial geoduck fishery that is appropriated and allotted to the geoduck fishery program from the RMCA-Aquatics account.

The commercial geoduck fishery generates revenue through the public auction of harvest quotas. The amount fluctuates, but is in the range of $6-10 million annually. Beyond funding the management of the fishery, this revenue pays for other aspects of the management and protection of state-owned aquatic lands and resources. Half the revenue goes to programs and projects paid for by the Aquatic Lands Enhancement Account (ALEA) (see Section 5-4). The other half goes into the RMCA-Aquatics account.

The geoduck fishery has been able to generate revenue to support the management of the fishery, scientific studies related to geoduck harvest, and provide funds for other programs and activities. The annual amount of revenue dedicated to management of the geoduck fishery fluctuates, but in recent years has been between $850,000 and $1.2 million (Table 6.1). Funding of the HCP is assured because the conservation measures will be integrated into the fishery through existing management mechanisms, and essentially already are.

Table 6.1. Amount budgeted for management of the geoduck wild stock fishery.

Biennium	Fiscal Year *	Annual Amount
2001-2003	2002	$ 846,260
	2003	870,600
2003-2005	2004	1,080,500
	2005	1,107,100
2005-2007	2006	1,160,700
	2007	1,193,100

* Fiscal years for Washington State government begin on July 1 and end on June 30. For example, FY 2006 runs July 1, 2005 through June 30, 2006.

Implementation of this HCP and its Conservation Objectives and Strategies (Section 5-1) will be funded through the annual RMCA-Aquatics allotment to DNR for management of the geoduck fishery program. No additional funds are anticipated to be needed to implement the HCP because mechanisms are in place within the existing management structure to implement the plan. Specific costs of implementing the objectives and strategies in the HCP cannot be separated from the costs of managing the geoduck fishery.

ADMINISTRATION OF THE FISHERY PROGRAM

Administering the program includes holding auctions for harvest quotas at a level consistent with that described in Section 5-2.2. It includes establishing contractual harvest agreements with purchasers that incorporate necessary restrictions to meet HCP requirements.

BIENNIAL INTERAGENCY AGREEMENTS WITH WDFW.

These agreements are described in Sections 3-1.2, 5-2.1 and Appendix D. Through these agreements, tract-specific Environmental Assessments, eelgrass surveys and tract resource inventories will be carried out by WDFW through funding from DNR.

DNR will fund the interagency agreements that require Environmental Assessments, eelgrass surveys and tract resource inventories to be performed. This will contribute to implementation of Objectives 1, 2, 5, and 6c.

HARVEST METHODS

See Section 5-2.3. No new funding is needed to continue using the harvest method established in WAC 220-52-019(2a). Using the established legal harvest method meets Objective 6d.

HARVEST ACTIVITY RESTRICTIONS

See Section 5-2.4. DNR will fund management of the fishery, which includes establishing general operating restrictions, establishing tract boundaries, avoidance measures for eagles, tufted puffins, and orcas, and noise restrictions. Restrictions needed to meet the requirements of the HCP will be incorporated into the management of individual tracts. This will allow implementation of the Conservation Objectives in the HCP

FUEL SPILL RISK MANAGEMENT

See Section 5-2.5. These practices will occur within the existing funded program.

DNR will fund general administration of the fishery, including funding for compliance staff that will manage fuel spill risk on the tracts. This provides the means to implement Objective 7 of the HCP.

HARVEST COMPLIANCE

See Section 5-2.6. DNR‘s compliance staff and their duties are funded as part of the geoduck fishery program. DNR will fund compliance staff so that the Objectives in the HCP are implemented daily during harvest operations.

7. Alternatives

7-1 Alternative 1. Discontinue Harvest

This alternative would consist of the state discontinuing harvest of its share of geoduck resources. This would eliminate potential take of covered species associated with the State's participation in the fishery. This alternative would not affect the Treaty Tribes' rights to harvest up to 50 percent of the geoduck TAC nor would it affect tracts harvested by the Treaty Tribes. The tribes could also pursue the unharvested portion through legal venues.

This alternative was not selected because it is not an economically viable alternative for DNR, nor does it support certain aspects of long-term environmental protection of aquatic lands. Revenue from geoduck harvest quotas funds the management of state-owned aquatic land, and funds programs that protect, conserve and restore aquatic habitat statewide and increase and improve public access to the waterfront. These funds also enable the study and control of invasive species and the cleanup of contaminated sediments. Opportunities to conduct biological surveys and research as part of the geoduck fishery management process would not occur, because they are also funded through geoduck harvest quotas. Information about geoduck populations and associated species would not be collected.

7-2 Alternative 2. Different Harvest Methods

One alternative is the use of different harvest methods that are currently available in the clam harvest industry. This alternative was not selected because these methods are more disruptive to the substrate and are not considered to reduce the potential for environmental effects. Employing different harvest methods would require a change in law and additional permitting requirements. Such methods include mechanical suction dredges such as the hydraulic escalator harvester used for clam harvesting on the Atlantic coast, and hand-held suction devices. The hydraulic escalator harvester operates by loosening the sediment in its path down to the depth of the clam and separating the clam from the sediment, while the handheld suction harvester vacuums all the sediment from around the clam and the clam itself. A reduction in the level of take associated with either of these methods was not evaluated but they would result in more substrate disturbance and greater elevated turbidity levels than the water jets presently used for harvest, so would not meet the intent of a reduction in potential impacts.

No other alternatives are known that would result in a decreased level of potential take.

8. Plan Implementation, Changed and Unforeseen Circumstances

8-1 Plan Implementation

Washington DNR will implement this HCP through the agency‘s existing geoduck fishery management program housed in the Aquatics Division. Mechanisms to implement the HCP such as agreements with WDFW to perform surveys and write Environmental Assessments; legally-binding harvest agreements; and deployment of compliance staff and staff to establish tract boundaries are currently in place to ensure compliance with this HCP.

Washington DNR is not requesting an Implementing Agreement, and understands that it is responsible for implementing this HCP in accordance with the specifications for conservation strategies, monitoring, reporting, and funding described herein and will perform all obligations assigned to it in the Section 10 permit and the HCP.

8-1.1 Annual Appraisal with NMFS and USFWS

Washington DNR and the Services have agreed to a process of regular, annual meetings and reporting requirements to assess the implementation and effectiveness of the HCP. This will provide a forum for reporting on compliance with the HCP and for discussing appropriate adjustments to the conservation strategies and mechanisms.

ANNUAL MEETINGS

DNR will arrange annual meetings with the Services at which time DNR will disseminate reports and other information pertinent to implementing the HCP. The first such meeting will be scheduled for summer (between June and August) of 2008.

The geoduck harvest season runs from April 1st to March 31st each year; harvest management occurs in this timeframe. However data on the fishery are collected, analyzed, and reported for the calendar year. DNR will report on results from the previous calendar year, and will also report on the ongoing operations of the current harvest season.

ANNUAL REPORTING REQUIREMENTS

DNR will provide documentation of the following to the Services at the annual meetings:

- The biomass harvested the previous year. Annual harvest amounts (biomass measured in pounds) are not static but are determined by the State‘s half of the calculated 2.7 percent TAC of each region‘s commercial biomass. A range of 2-3 million pounds is expected to be harvested annually under the current 2.7 percent TAC and would not be considered to exceed the scope of this HCP.

- The tracts and tract sizes (acreage) from which geoducks were harvested the previous year.
- Compliance monitoring from the previous year. This is the daily tract monitoring performed by DNR compliance staff and documented in compliance logs. This will include notes taken in the field on occurrences of covered species observed in the vicinity of tracts during harvest.
- Anticipated current harvest season tracts to be harvested and harvest quotas to be offered.
- Copies of the Environmental Assessments for each tract from which harvest is occurring or proposed, for the current harvest season.
- Data collected during post-harvest tract surveys performed the previous year.
- Copies of the most recent region-specific harvest management plans.

DNR will provide and consider additional information pertinent to implementing this HCP, including:

- New information and new science, such as:
  - Recommended changes in eelgrass and herring spawning vegetation buffer distances based on input from WDFW and Tribal biologists as a result of meeting with them to reassess the buffers,
  - Results of new studies regarding benthic community structure and changes attributable to the geoduck fishery.
  - Climate change—Information indicating that climate change is detectable in Puget Sound and is manifesting in a way that potentially would change the way the geoduck fishery occurs.
  - Discovery of new tufted puffin nesting colonies.
- Proposed revisions and updates to the 2001 Commercial Geoduck Fishery Management Plan.
- Information that updates the geoduck atlas. For example increases in the acres of geoduck tracts determined to be commercial and available for harvest.
- With 30 days advance notice, DNR will provide the opportunity for site visits by Services staff to observe the fishery in action.
- DNR will use the annual meetings to keep the Services informed about intentions to harvest in the San Juan management region. DNR will inform the Services at least one year before offering harvest quotas in the San Juan management region and provide Environmental Assessments for the tracts from which harvest will occur in that Region.

Information on these topics and others pertinent to the fishery will be assessed with the Services at the annual meetings to ensure that the operating conservation strategies and mechanisms are still valid.

DNR will arrange additional meetings if reporting information affecting implementation of the HCP cannot be postponed until the next yearly meeting.

DNR and the Services will jointly determine a schedule for subsequent annual meetings and assess the need to meet annually.

8-2 No Surprises Policy

The purpose of the No Surprises policy (63 FR 8859) is to provide assurances to landowners such as Washington State that are participating in the ESA Section 10 HCP process. Specifically, the policy provides regulatory assurances to the holder of an Incidental Take Permit issued under Section 10(a) of the ESA that no additional land use restrictions or financial compensation will be required of the permit holder with respect to species covered by the permit, even if unforeseen circumstances arise after the permit is issued indicating that additional mitigation is needed for a species covered by the Incidental Take Permit.

Essentially, under this policy, DNR is assured that if unforeseen circumstances arise, the Services will not require the commitment of additional land or financial compensation or additional restrictions on the use of land or other natural resources beyond the level otherwise agreed to in this HCP, without the consent of DNR. The Services will honor these assurances as long as DNR is implementing the conservation strategy in this HCP and the Incidental Take Permits in good faith.

The No Surprises Policy provides economic and regulatory certainty to DNR regarding the overall cost of species conservation and mitigation, provided that the affected species are adequately covered by a properly functioning HCP, and DNR is properly implementing the HCP and complying with the terms and conditions of the Incidental Take Permits.

The No Surprises policy speaks to two types of events – “changed circumstances” and “unforeseen circumstances.” Each type of circumstance is handled differently under the No Surprises Policy and the HCP must address both types of events.

8-2.1 Changed Circumstances

Changed circumstances are those affecting a species or the geographic area covered by this HCP that can reasonably be anticipated and that were planned for by DNR and the Services during the course of developing this HCP. Changed circumstances are not uncommon and will not require changes to management of the geoduck fishery. DNR and the Services foresee the possibility that circumstances surrounding harvest and management of the wild stock geoduck resource could change during the term of this HCP. The Incidental Take Permits will authorize the incidental take of covered species under ordinary circumstances as well as changed circumstances, as long as DNR is operating in compliance with this HCP and the Incidental Take Permits. Washington DNR and the Services anticipate that circumstances could change during the term of the HCP, by reason of:

CLIMATE CHANGE

Compelling evidence of global climate change has been documented by a large body of research. The primary conclusion is that documented increases in globally averaged temperature in the past 30-50 years are largely due to increasing concentrations of greenhouse gases (mostly CO_2) in the atmosphere. In addition to increased air temperatures, climate change manifests in the form of melting glaciers, increases in sea levels, changes in hydrologic regimes, and other environmental trends and events. Mote et al. (2005) examined climate change implications specifically for Puget Sound, but recognized that the consequences to various features of the Sound could not be determined. Changes that Mote et al. found to be most likely were an increase in air temperature by at least 0.5 ^{o}F per decade, increases in water temperature, reduced summer freshwater inflow, increases in flood events, a sea level rise of at least 1.6 inches per decade, and changes in species composition in many ecosystems.

The environment of Puget Sound could conceivably be altered as a result of progressing climate change over the next 50 years, affecting the environment of the covered species, and the environment in which geoduck harvest occurs. This in turn could cause DNR to adjust fishery operations and could potentially result in operating outside the scope of this HCP and its conservation measures. Annually, at meetings with the Services, this scenario will be assessed to verify that the operating conservation plan is still valid (see Section 8.1 above). DNR, in consultation with the Services, will assess and modify the HCP‘s conservation strategies and mechanisms in order to continue meeting the goals and objectives of the conservation plan.

INCREASES IN COMMERCIAL TRACT ACREAGE

Continuing surveys and assessments of the geoduck resource, along with environmental influences may result in adjustments to the total tract acreage available for commercial harvest. Potential increases in the amount of commercial tract acreage are considered a changed circumstance. Annually, at meetings with the Services, DNR will report on any increases in the acres of geoduck tracts determined to be commercial and available for harvest. DNR, in consultation with the Services, will assess and modify the HCP‘s conservation strategies and mechanisms in order to continue meeting the goals and objectives of the conservation plan.

EXPANSION OF THE FISHERY

If annual harvest exceeds the 2-3 million pound range, it would likely be because a new yield model is adopted for management or the existing yield model is substantially re-parameterized, thus increasing the harvest rate above 2.7 percent, or because of a large increase in the commercially available biomass. If, in the future, DNR considers offering harvest quotas exceeding 3 million pounds per year because of an increase in the harvest rate or an increase in commercially available biomass, it would be addressed as a changed circumstance.

The desire to continue operating a sustainable fishery presently holds harvest levels within a certain range. If in the future DNR considers offering harvest quotas exceeding those within the present range they will contact the Services and assess potential additional impacts. DNR, in consultation with the Services, will assess and modify the HCP's conservation strategies and mechanisms in order to continue meeting the goals and objectives of the conservation plan.

HARVEST OUTSIDE –18 TO –70 FOOT BOUNDARIES

Currently, survey data to estimate geoduck biomass and determine the TAC are not collected outside the – 18 to – 70 foot boundaries. Expanding the survey boundaries, and thus the potential commercial harvest area is considered a changed circumstance. Should DNR want to expand harvestable areas to include those outside of the present boundaries, they will contact the Services and amend this HCP to address impacts and create additional, commensurate conservation measures if determined to be necessary. DNR, in consultation with the Services, will assess and modify the HCP's conservation strategies and mechanisms in order to continue meeting the goals and objectives of the conservation plan.

Harvesting deeper than –70 feet would require a change in WAC 220-52-019(11), which stipulates the –70 foot depth. Harvesting shallower than –18 feet MLLW would require a change to RCW 77.60.070, which stipulates this depth.

CHANGES IN THE STATUS OF COVERED SPECIES

The Services may list additional species under the ESA as threatened or endangered, or de-list species that are currently listed.

New Listings of Species Covered by the ITP

All species covered by this HCP have been addressed as though they are listed. The ITP covers several species that currently are not listed as threatened or endangered under the ESA. Subject to compliance with all other terms of this HCP, no additional conservation measures will be required should species be listed under the ESA that are addressed in the HCP and ITP.

New Listings of Species Not Covered by the ITP

If a species that is present or potentially present in the HCP area becomes listed under the ESA, the Services will determine if there is a potential for incidental take of the species from commercial geoduck harvest activities, as they are described in this HCP. If so, DNR will either implement measures to avoid incidental take of the species, or request the Services add the newly listed species to the ITP in accordance with the provisions in the HCP, and in compliance with the provisions of Section 10 of the ESA. If DNR chooses to pursue incidental take coverage for the species, they will amend this HCP or prepare a separate HCP. All parties (DNR, USFWS, NMFS) will enter into discussions to develop the necessary measures to meet ESA Section 10(a) requirements for incidental take coverage.

8-2.2 Unforeseen Circumstances

Unforeseen circumstances would be those affecting a species or the geographic area covered by this HCP that were not, or could not reasonably have been anticipated by DNR and the Services at the time of developing and negotiating this HCP, *and* that result in a substantial and adverse change in the status of a covered species. The burden of demonstrating that unforeseen circumstances exist falls to the Services.

If additional conservation and mitigation measures are required in response to an unforeseen event during the life of the HCP, the Services may require additional measures from DNR where the HCP is being properly implemented. These measures would be limited to modifications within the HCP area or to the conservation plan for the species, maintaining the original terms of the HCP to the maximum extent possible.

The Services would not require commitments of additional land, additional funds, or additional restrictions on the use of the land or resources beyond the level agreed on for the species in the HCP, without the consent of DNR.

Unforeseen circumstances include:

CHANGES IN THE LAWS OR RULES GOVERNING THE FISHERY

In addition to those stipulating harvest depths, some of the measures presented in this HCP exist as laws in the Revised Code of Washington and as rules in the Washington Administrative Code. Should a change be proposed to the laws or rules governing harvest, DNR, in consultation with the Services, will assess and modify the HCP's conservation strategies and mechanisms in order to continue meeting the goals and objectives of the conservation plan.

9. References

Alpine, S.E. and J.E. Cloern. 1992. Trophic interactions and direct physical effects control phytoplankton biomass and production in an estuary. Limnol. Oceanogr. 37: 946-955.

Angell, T. and K.C. Balcomb III. 1982. Marine birds and mammals of Puget Sound. Washington Sea Grant Program. University of Washington Press. Seattle, WA

Baker, P. 1995. Review of ecology and fishery of the Olympia oyster, *Ostrea lurida* with annotated bibliography. Journal of Shellfish Research (14) 2: 501-518.

Baker, P., N. Terwilliger, and N. Richmond. 1999. In Press. Re-establishment of a native oyster, following a natural local extinction. Proc. 1st Natl. Conf. Marine Bioinvasions, MIT Press, Cambridge, MA.

Bargman, G. 2001. WDFW studies causes of Cherry Point herring decline. Fish and Wildlife Science, an Online Science Magazine. Accessed November 1, 2004: http://wdfw.wa.gov/science/articles/herring/

Bax, N.J. 1982. Seasonal and annual variations in the movement of juvenile chum salmon through Hood Canal, Washington. In: Brannon, E.L., and E.O. Salo (eds.), Proceedings of the salmon and trout migratory behavior symposium, June 3-5, 1981, Seattle, Washington. University of Washington, School of Fisheries, Seattle, WA

Bax, N.J. 1983. Early marine mortality of marked juvenile chum salmon (*Oncorhynchus keta*) released into Hood Canal, Puget Sound, Washington, in 1980. Can. J. Fish. Aquat. Sci. 40:426-435.

Bax, N.J., E.O. Salo, and B.P. Snyder, C.A. Simenstad, and W.J. Kinney. 1978. Salmonid outmigration studies in Hood Canal. Final Report, Phase VI. FRI-UW-7819. University of Washington, Fisheries Research Institute, Seattle, WA

Bernard, F.R. 1983. Catalogue of the living Bivalvia of the eastern Pacific Ocean. Canadian Special Publication in Fishery and Aquatic Sciences.

Blackmon, D., T. Wyllie-Echeverria, and D. Shafer. 2006. The role of seagrasses and kelps in marine fish support. Wetlands Regulatory Assistance Program. ERDC TN-WRAP-06-1. February 2006.

Bradbury, A, B Sizemore, D. Rothaus, and M. Ulrich. 2000. Stock assessment of subtidal geoduck clams (*Panopea abrupta*) in Washington. Washington Dept of Fish and Wildlife, Marine Resources Unit, Fish Management Division, Fish Program. 52p.

Bradbury, A. and J.V. Tagart. 2000. Modeling geoduck, *Panopea abrupta* (Conrad, 1849) population dynamics. II. Natural mortality and equilibrium yield. J. Shellfish Res. 19:63-70.

Breed-Willeke, G.M. and D.R. Hancock. 1980. Growth and reproduction of subtidal and intertidal populations of the gaper clam *Tresus capax* (Gould) from Yaquina Bay, Oregon. Proc. Natl. Shellfish Assoc. 70:1-13.

Breen, P.A. and T.L. Shields. 1983. Age and size structure in five populations of geoduck clams (*Panopea generosa*) in British Columbia. Can. Tech. Rep. Fish. Aquat. Sci. No. 1169. 62 p.

Breese, W.P. 1953. Rearing of the native Pacific oyster larvae, under controlled laboratory conditions. MS thesis, Oregon State College, Corvallis, Oregon.

Brennan, J.S., K.F. Higgins, J.R. Cordell, and V.A. Stamatiou. 2004. Juvenile salmonid composition, timing, distribution, and diet in marine nearshore waters of Central Puget Sound in 2001-2002. King County Department of Natural Resources and Parks, Seattle, WA. 164 pp.

Bricelj, V.M., R. E. Malouf, and C.de Quillfeldt. 1984. Growth of juvenile *Mercenaria mercenaria* and the effect of resuspended bottom sediments. Mar. Biol. 167-173.

Brodeur, R.D. 1990. A synthesis of the food habits and feeding ecology of salmonids in marine waters of the North Pacific. FRI-UW-9016. University of Washington, Fisheries Research Institute. Seattle, WA

Brundage, W.L. Jr. 1960. Recent sediments of the Nisqually River delta, Puget Sound, Washington. Masters Thesis. University of Washington. Seattle, WA

Busby, P.J., T.C. Wainwright, G.J. Bryant, L.J. Lierheimer, R.S. Waples, F.W. Waknitz, and I.V. Lagomarsino. 1996. Status review of west coast steelhead from Washington, Idaho, Oregon, and California. U.S. Dep. Commerce. NOAA Technical Memorandum NMFS-NWFSC-27. 261 pp. http://www.nwfsc.noaa.gov/assets/25/4245_06172004_122523_steelhead.pdf

Campbell, A., N. Bourne, and W. Carolsfeld. 1990. Growth and size at maturity of the Pacific gaper *Tresus Nuttallii* (Conrad 1837) in southern British Columbia. J. Shellfish Res. 9:273-278.

Coen L. D. 1995. A review of the potential impacts of mechanical harvesting on subtidal and intertidal shellfish resources. South Carolina Department of Natural Resources Marine Resources Research Institute. 12 January 1995. 46 pp. plus appendices.

Couch, D., and T.J. Hassler. 1989. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific Northwest)--Olympia oyster. U.S. Fish Wildl. Serv. Biol. Rep. 82(11.124). U.S. Army Corps of Engineers, TR EL-82-4. 8 pp.

Coull B.C. 1988. Ecology of the marine meiofauna. In: Introduction to the Study of Meiofauna. R.P Higgins and H. Theil (eds). Smithsonian Institute Press. Washington, DC

Dame, R.F. 1996. Ecology of marine bivalves: An ecosystem approach. CRC Press, Boca Raton, FL

Dame, R.F., N. Dankers, T. Prins, H. Jongsma and A. Smaal. 1991. The influence of mussel beds on nutrients in the western Wadden Sea and Eastern Scheldt estuaries. Estuaries 14: 130-138.

Davis, H.C. 1960. Effects of turbidity-producing materials in sea water on eggs and larvae of the clam [*Venus* (*Mercenaria*) *mercenaria*]. Biol. Bull. 118:48-54.

Davis, H.C. and H.H. Hidu. 1969. Effects of turbidity-producing substances in sea water on eggs and larvae of three genera of bivalve mollusks. Veliger 11:316-323.

Dowty, P., B. Reeves, H. Berry,S. Wyllie-Echeverria, T. Mumford, A. Sewell, P. Milos and R. Wright. 2005. Puget Sound submerged vegetation monitoring project 2003-2004 monitoring report. Nearshore Habitat Program, Aquatic Resources Division, Washington Department of Natural Resources, Olympia.

Emmett, R.L., and M.H. Schiewe (editors) 1997. Estuarine and ocean survival of Northeastern Pacific salmon: Proceedings of the workshop. U.S. Department of Commerce, NOAA Tech. Memo. NMFS-NWFSC-29. 313 p. http://www.nwfsc.noaa.gov/assets/25/4037_06172004_121750_tm29.pdf

Emmett, R.L., S.L. Stone, S.A. Hinton, and M.E. Monaco. 1991. Distribution and abundance of fishes and invertebrates in west coast estuaries, Volume II: species life history summaries. ELMR Rep. No. 8. NOAA/NOS Strategic Environmental Assessments Division, Rockville, MD 329 p.

Fresh, K.L., R.D. Cardwell, and R.R. Koons. 1981. Food habits of Pacific salmon, baitfish and their potential competitors and predators in the marine waters of Washington, August 1978 to September 1979. State of Wash. Dept. Fish. Progr. Rep. No. 145. Olympia.

Goetz, F. and E. Jeanes. 2004. Bull trout in the nearshore – preliminary draft. US Army Corps of Engineers, Seattle District. Seattle, WA

Goodwin, L. 1978. Some effects of subtidal geoduck (*Panopea generosa*) harvest on a small experimental plot in Puget Sound, WA. Washington Department of Fish and Wildlife. Olympia. Progress Report No. 66. 21 pp.

Goodwin, C.L., and B.C. Pease. 1987. The distribution of geoduck (*Panopea abrupta*) size, density, and quality in relation to habitat characteristics such as geographic area, water depth, sediment type and associated flora and fauna in Puget Sound, Washington. Washington Department of Fisheries. Technical Report 102. Olympia, WA

Goodwin, C.L. and B.C. Pease. 1989. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific Northwest) –Pacific geoduck clam. U.S. Fish. Wildl.Serv. Biol. Rep. 82(11.120). U.S. Army Corps of Engineers, TR EL-82-4. 14 pp.

Goodwin, C.L., and B.C. Pease. 1991. Geoduck (*Panopea abrupta* (Conrad, 1849), size, density, and quality as related to various environmental parameters in Puget Sound, Washington. J. Shellfish Res. 10:65-77.

Goodwin, C.L. and W. Shaul. 1978. Some effects of the mechanical escalator shellfish harvester on a subtidal clam bed in Puget Sound, Washington. State of Washington, Department of Fisheries. Olympia. Progress report No. 53. 21 pp.

Gregory, R.S. 1988. Effects of turbidity on benthic foraging and predation risk in juvenile Chinook salmon. P. 65-73. *In:* C.A. Simenstad (ed.). Effects of dredging on anadromous Pacific Coast fishes. Workshop proceedings, September 8-9, 1998. Washington Sea Grant Program. University of Washington, Seattle.

Groot, C. and L. Margolis (eds). 1991. Pacific salmon life histories. University of British Columbia Press. Vancouver.

Hard, J. J., R. G. Kope, W. S. Grant, F. W. Waknitz, L. T. Parker and R. S. Waples. 1996. Status review of pink salmon from Washington, Oregon and California. US Department of Commerce. NOAA Tech. Memo. NMFS-NWFSC-25. Seattle, WA

Heimlich-Boran, J. R. 1986. Fishery correlations with the occurrence of killer whales in greater Puget Sound. Pages 113-131 *in* B. C. Kirkevold and J. S. Lockard, editors. Behavioral biology of killer whales. Alan R. Liss, New York, New York.

Heimlich-Boran, J. R. 1988. Behavioral ecology of killer whales (*Orcinus orca*) in the Pacific Northwest.Canadian Journal of Zoology 66:565-578.

Hemminga, M.A. and C.M. Duarte. 2000. Seagrass ecology. Cambridge University Press. United Kingdom.

Hertlein, L.G. 1959. Notes on California oysters. Veliger 2:5-10

Hickman, T., and R.F. Raleigh. 1982. Habitat suitability index models: Cutthroat trout. FWS/OBS-82/10.5. US Fish and Wildlife Service.

Hoffmann, A., A. Bradbury, and C.L. Goodwin. 2000. Modeling geoduck, *Panopea abrupta* (Conrad, 1894) population dynamics. J. Shellfish Res. 19:57-62.

Jauquet, J. 2003. The occurrence of diet items in coastal cutthroat trout collected in south Puget Sound, 1999-2002. Washington Department of Fish and Wildlife. Proceedings: 2003 Georgia Basin/Puget Sound Research Conference.

Johnson, O. W., M. H. Ruckelshaus, W. S. Grant, F. W. Waknitz, A.M. Garrett, G. J. Bryant, K. Neely, and J. J. Hard. 1999. Status review of coastal cutthroat trout from Washington, Oregon, and California. NOAA Technical Memorandum NMFS-NWFSC-37. US Department of Commerce, NOAA Fisheries. Seattle, WA

Jordan, T.E. and I. Valiela. 1982. A nitrogen budget of the ribbed mussel, *Geukensis demissa*, and its significance in the nitrogen flow in a New England salt marsh. Limnol. Oceanogr. 27: 75-90.

Kaiser, M.J., D.B. Edwards, and B.E. Spencer. 1996. Infaunal community changes as a result of commercial clam cultivation and harvesting. Aquatic Living Resources 9:57-63.

Kraemer, C. 1994. Some observations on the life history and behavior of the native char, Dolly Varden (*Salvelinus malma*) and bull trout (*Salvelinus confluentus*) of the North Puget Sound Region. Wash. Department of Wildlife. Draft.

Krahn, M.M., M.J. Ford, W.F. Perrin, P.R. Wade, R.P. Angliss, M.B. Hanson, B.L. Taylor, G.M. Ylitalo, M.E. Dahlheim, J.E. Stein, and R.S. Waples. 2004. 2004 status review of southern resident killer whales (*Orcinus orca*) under the Endangered Species Act. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-62.

Lake, R.G. and Scott G. Hinch. 1999 Acute effects of suspended sediment angularity on juvenile coho salmon (Oncorhy*nchus kisutch*) Can. J. Fish. Aquat. Sci. 56(5): 862-867.

Lavelle, J.W., G.J. Massoth, and E.A. Crecelius. 1986. Accumulation rates of recent sediments in Puget Sound, Washington. Marine Geology 72:59-70.

Lemberg, N., M. O'Toole, D. Penttila and K. Stick. 1997. 1996 Forage fish stock status report. Washington Department of Fish and Wildlife Stock Status Report 98-1. Olympia.

Loosanoff, V.L., and H.C. Davis. 1963. Rearing bivalve molluscs. Adv. Mar. Biol. Acad. Press, London, 1:136.

Mavros, B. and J. Brennan. 2001. Nearshore beach seining for juvenile Chinook (*Oncorhynchus tshawytscha*) and other salmonids in King County intertidal and shallow subtidal zones. King County Department of Natural Resources.

McCaully, J.F., R.A. Parr, and D.R. Hancock. 1977. Benthic infauna and maintenance dredging: A case study. Pergamon Press, Water Research II:233-242.

McCrae, J. 1994. Oregon developmental species. Pacific herring (*Clupea Pallasi*). Oregon Department of Fish and Wildlife. Salem, OR

McShane, C., et al. 2004. Evaluation report for the 5-year status review of the marbled murrelet in Washington, Oregon, and California. Unpublished report. EDAW, Inc. Seattle, WA. Prepared for the U.S. Fish and Wildlife Service, Region 1. Portland, OR.

Morton J.W. 1977. Ecological effects of dredging and dredge spoil disposal: A literature review. Technical Paper 94. United States Department of the Interior, Fish and Wildlife Service. Washington, DC

Mote, P.W., A.K. Snover, L. Whitely Binder, A.F. Hamlet, and N.J. Mantua, 2005: Uncertain future: Climate change and its effects on Puget Sound - Foundation Document. Climate Impacts Group, Center for Science in the Earth System, Joint Institute for the Study of the Atmosphere and Oceans, University of Washington. 37 pages.

Myers, J.M., R.G. Kope, G.J. Bryant, D. Teel, L.J., Lierheimer, T.C. Wainwright, W.S. Grand, F.W. Waknitz, K. Neely, S.T. Lindley, and R.S. Waples. 1998. Status review of Chinook salmon from Washington, Idaho, Oregon, and California. NOAA Tech. Memo. NMFS-NWFSC-35. U.S. Dept. Commerce, NOAA Fisheries.

National Marine Fisheries Service. 2004. Draft environmental impact statement. Puget Sound Chinook harvest resource management plan. Prepared by NMFS with assistance from Puget Sound Treaty Tribes and WDFW. Seattle, WA. April 2004.

NatureServe. 2003a. NatureServe Explorer: An online encyclopedia of life; Version 1.8. Bald Eagle. NatureServe, Arlington, Virginia. Accessed November 2, 2004: http://www.natureserve.org/explorer

NatureServe. 2003b. NatureServe Explorer: An online encyclopedia of life; Version 1.8. Tufted Puffin. NatureServe, Arlington, Virginia. Accessed November 2, 2004: http://www.natureserve.org/explorer

NatureServe. 2006. NatureServe Explorer: An online encyclopedia of life [web application]. Version 6.0. Brown Pelican. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: October 31, 2006).

Newell, R.I.E. 1988. Ecological changes in Chesapeake Bay: Are they the results of over harvesting the American oyster, *Crassostrea virginica*? Chesapeake Res. Consor. Pub. 129: 536-546.

Nichol, L.M. and D.M. Shackleton. 1996. Seasonal movements and foraging behaviour of northern resident killer whales in British Columbia. Canadian Journal of Zoology 74: 983.

Nichols, F.H. 1985. Increased Benthic Grazing: An alternative explanation for low phytoplankton biomass in northern San Francisco Bay during the 1976-1977 drought. Estuarine, Coastal, and Shelf Sciences. 21: 379-388.

Nichols, F.H., J.K. Thompson and L.E. Schemel. 1990. Remarkable invasion of San Francisco Bay (California, USA) by the Asian clam *Potamocorbula amurensis II*. Displacement of a former community. Mar. Ecol. Prog. Ser. 66: 95-101.

Nightingale, B., and C. Simenstad. 2001. Dredging activities: Marine issues. White paper. Aquatic habitat guidelines: An integrated approach to marine, freshwater, and riparian habitat protection and restoration. Washington Department of Fish and Wildlife. Olympia.

NOAA. 2004. National Marine Fisheries Service, Office of Protected Resources. Species of concern and candidate species: Pinto abalone. April 13, 2004.

Partridge, V, K. Welch, S. Aasen, and M. Dutch. 2005. Temporal monitoring of Puget Sound sediments: Results of the Puget Sound ambient monitoring program, 1989-2000. Washington Department of Ecology Environmental Assessment Program Publication No. 05-03-016. Olympia, Washington 267 pp.

Penttila, D. 1978. Studies of the surf smelt (*Hypomesus pretiosus*) in Puget Sound. Technical Report No. 42. State of Washington, Department of Fisheries. Olympia. 47 pp.

Phillips, R.C. 1984. The ecology of eelgrass meadows in the Pacific Northwest: a community profile. FWS/OBS-84/24, US Fish and Wildlife Service. Washington, DC

Piatt, J. and A. Kitaysky. 2002. Tufted Puffin (*Fratercula cirrhata*). *In*: The birds of North America, No. 708 (A. Poole and F. Gill, eds.). Philadelphia, PA.

Posey, M. 1986. Changes in a benthic community associated with dense beds of a burrowing deposit feeder, *Callianassa californiensis.*Mar.Ecol. Prog. Serv., 31:15-22.

Posey, M., B. Dumbauld, and D. Armstrong.1991. Effects of a burrowing mud shrimp, *Upogebia pugettensis* (Dana), on abundance of macro-fauna. J. Exp.Mar. Biol. Ecol. 148:283-294.

Quinn, T. 2005. The behavior and ecology of Pacific salmon and trout. University of Washington Press. Seattle.

Ranson, Gilbert. 1951. Les Huitres, Biolgie-Culture. Lechevalier, Paris.

Redman, S., D. Myers, and D. Averill. 2005. Regional nearshore and marine aspects of salmon recovery in Puget Sound. Delivered for inclusion in the Regional Salmon Recovery Plan, Shared Strategy for Puget Sound. June 28, 2005.

Richardson, M.D., A.G. Carey, Jr., and W.A. Colgate. 1977. Aquatic disposal field investigations Columbia River site, Oregon. Appendix C: The effects of dredged material disposal on benthic assemblages. U.S. Army Corps of Engineers Waterways Experiment Station, Dredged Material Research Program Technical Report D-77-30, Vicksburg, Mississippi.

Richardson, W.J., C.R. Greene, Jr., C.I. Malme, and D.H. Thomson. 1995. Marine mammals and noise. Academic Press. San Diego, CA

Romberg, P., C. Homan, and D. Wilson. 1995. Monitoring at two sediment caps in Elliott Bay. Pages 289-299 in Puget Sound Research _95: Proceedings. Puget Sound Water Quality Authority, Olympia, Washington.

Salo, E.O., N.J. Bax, T.E. Prinslow, C.J. Whitmus, B.P. Snyder, and C.A. Simenstad. 1980. The effects of construction of naval facilities on the outmigration of juvenile salmonids from Hood Canal, Washington. Final Rep. FRI-UW-8006. University of Washington, Fisheries Research Institute. Seattle. 159 pp.

Seaman, M.N.L., E. His, M. Kaskin, and T. Reins. 1991. Influence of turbulence and turbidity on growth and survival of laboratory-reared bivalve larvae. ICES C.M., K:56.

Selleck, J., H. Berry, and P. Dowty. 2005. Depth profiles of *Zostera marina* throughout the greater Puget Sound: Results From 2002-2004 monitoring data. Nearshore Habitat Program. Aquatic Resources Division Washington Department of Natural Resources. Olympia.

Shepard, M. 1981. Status and review of the knowledge pertaining to the estuarine habitat requirements and life history of chum and Chinook salmon juveniles in Puget Sound. Final Report. University of Washington, Washington Cooperative Fishery Research Unit, College of Fisheries. Seattle, WA

Short, K. S. and R. Walton. 1992. The transport and fate of suspended sediment plumes associated with commercial geoduck harvesting - Final Report. Washington Department of Natural Resources. Olympia.

Simenstad. C.A.. 1998. Appendix A: Estuarine landscape impacts on Hood Canal and Strait of Juan De Fuca chum salmon and recommended actions. Report prepared for the Point No Point Treaty Council.

Simenstad, C.A., W.J. Kinney, S.S. Parker, E.O. Salo, J.R. Cordell, and H. Buechner. 1980. Prey community structure and trophic ecology of outmigrating juvenile chum and pink salmon in Hood Canal, Washington. A Synthesis of ThreeYears' Studies, 1977-1979. FRI-UW-8026. Fish. Res. Institute. University of Washington, Seattle. 113 pp.

Simenstad, C.A., K.L. Fresh and E.O. Salo. 1982. The role of Puget Sound and Washington coastal estuaries in the life history of Pacific Salmon: An unappreciated function. In: Estuarine comparisons. V. S. Kennedy, editor. Academic Press. New York, New York.

Simenstad, C.A., J.R. Cordell, R.C. Wissmar, K.L. Fresh, S. Schroder, M. Carr, G. Sanborn and M. Burg. 1988. Assemblage structure, microhabitat distribution, and food web linkages of epibenthic crustaceans in Padilla Bay National Estuarine Research Reserve, Washington. NOAA Tech. Rep. Ser. OCRM/MEMD, FRI-UW-8813, University of Washington, Fisheries Research Institute. Seattle, WA

Somerfield, P.J., Rees, H.L. and Warwick, R.M., 1995. Interrelationships in community structure between shallow-water marine meiofauna and macrofauna in relation to dredgings disposal. Mar. Ecol. Prog. Ser., 127: 103-112.

Speich, S.M. and T.R. Wahl. 1989. Catalog of Washington seabird colonies. U.S. Fish and Wildlife Service Biological Report 88(6). Washington, DC

Speich, S.M. and T.R. Wahl. 1995. Marbled murrelet populations of Washington – marine habitat preferences and variability of occurrence. In: Ecology and conservation of the Marbled Murrelet. C.J. Ralph, G.L. Hunt Jr., M.G. Raphael, and J.F. Piatt, editors. USDA Forest Service. Forest Service General Technical Report PSW-152. Washington DC.

Spencer, B.E., M.J. Kaiser, and D.B. Edwards. 1998. Intertidal clam harvesting: Benthic community change and recovery. Aquaculture Research 29 (6): 429

Stinson, D.W., J.W. Watson, and K.R. McAllister. 2001. Washington State status report for the bald eagle. Washington Department of Fish and Wildlife. Olympia. 92 pp.

Strickland, R.M. 1983. The fertile fjord. Plankton in Puget Sound. Washington Sea Grant Program. University of Washington Press. Seattle.

Tarr, M. 1977. Some effects of hydraulic clam harvesting on water quality in Kilisut Harbor, Port Susan, and Agate Pass, Washington. Washing. Dept. Fish. Progress Rept. 22. Olympia.

Thom, R.M., J.W. Armstrong, C.P. Staude, K.K. Chew, and R.E. Norris. 1976. A survey of the attached marine flora at five beaches in the Seattle Washington area. Syesis 9: 267-275.

Thom, R.M., L. Antrim, A. Borde, W. Gardiner, D. Shreffler, P. Farley. 1998. Puget Sound's eelgrass meadows: Factors contributing to depth distribution and spatial patchiness. Proceedings, Puget Sound Research 1998. Puget Sound Water Quality Action Team. Olympia WA.

Thorpe, J.E. 1994. Salmonid fishes and the estuarine environment. Estuaries 17(1A):76-93.

Toft, J., C. Simenstad, J. Cordell, and L. Stamatiou. 2004. Fish distribution, abundance, and behavior at nearshore habitats along City of Seattle marine shorelines, with an emphasis on juvenile salmonids. University of Washington School of Aquatic & Fishery Science. Located at http://www.fish.washington.edu/Publications/pdfs/0401.pdf. August 10, 2004.

Tynan T. 1997. Life history characterization of summer chum salmon populations in the Hood Canal and eastern Strait of Juan De Fuca regions. Volume I. Technical Report H97-06. Washington Department of Fish and Wildlife. Olympia. 99 pp.

Ulanowicz, R.E. and J.H. Tuttle. 1992. The trophic consequences of oyster stock rehabilitation in Chesapeake Bay. Estuaries 15: 298-306.

USFWS. 1996. Endangered species habitat conservation planning handbook. U.S. Fish and Wildlife Service and National Marine Fisheries Service. November 1996.

van Dalfsen J.A., K. Essink, M.H. Toxvig, J. Birklund, J. Romero and M. Manzanera. 2000. Differential response of macrozoobenthos to marine sand extraction in the North Sea and the western Mediterranean. ICES Journal of Marine Science 57: 1439–1445.

Washington Department of Fish and Wildlife. 1997a. Washington State forage fish: Pacific herring. Accessed November 1, 2004: http://wdfw.wa.gov/fish/forage/herring.htm

Washington Department of Fish and Wildlife. 1997b. Washington State forage fish: sand lance. Accessed November 2, 2004: http://www.wdfw.wa.gov/fish/forage/lance.htm

Washington Department of Fish and Wildlife. 1997c. Washington State forage fish: surf smelt. Accessed November 2, 2004: http://www.wdfw.wa.gov/fish/forage/smelt.htm

Washington Department of Fish and Wildlife. 2000. Critical spawning habitat for herring, surf smelt, sand lance, and rock sole in Puget Sound, Washington. Fish Program. Olynpia. 151 pp.

Washington Department of Fish and Wildlife. 2004. Geoduck Atlas: Atlas of major geoduck tracts of Puget Sound. Marine Resources Unit. Olympia, Washington. http://wdfw.wa.gov/fish/shelfish/geoduck/index.htm

Washington Department of Natural Resources and Washington Department of Fish and Wildlife. 2001. Final supplemental environmental impact statement (SEIS) for the State of Washington commercial geoduck fishery. Washington Department of Natural Resources, Aquatic Resources Program. Olympia.

Washington Department of Natural Resources. 2001. State of Washington commercial geoduck fishery management plan. Washington Department of Natural Resources, Aquatic Resources Program. Olympia. 18 pp.

Washington Department of Natural Resources. 2004. Calculation of the filteration rate of state commercial harvest of geoduck in Hood Canal. Aquatic Resources Program, Olympia.

Watson J.W. and D.J. Pierce. 1998. Ecology of bald eagles in western Washington with an emphasis on the effects of human activity. Final report. Washington Department of Fish and Wildlife. Olympia.

Watson, J.W., D. Mundy, J.S. Begley, and D. J. Pierce. 1995. Responses of nesting bald eagles to the harvest of geoduck clams (*Panopea abrupta*). Final Report. Washington Department of Fish and Wildlife. Olympia. 23 pp.

Weitkamp, D.E. 2000. Estuarine habitat used by young salmon. An annotated bibliography. Review draft. Parametrix, Kirkland, WA.

Weitkamp, L.A., T.C. Wainwright, G.J. Bryant, G.B. Milner, D.J. Teel, R.G. Kope, and R.S. Waples. 1995. Status review of coho salmon from Washington, Oregon, and California. NOAA Technical Memorandum NMFS-NWFSC-24. National Marine Fisheries Service Northwest Fisheries Science Center. Seattle, WA

West, J.E. 1997. Protection and restoration of marine life in the inland waters of Washington State. Puget Sound/Georgia Basin environmental report series. No. 6. May 1997, reprinted June 2004.

Wiles, G. J. 2004. Washington State status report for the killer whale. Washington Department of Fish and Wildlife. Olympia. March 2004. 120 pp.

Williams, G.D. and Thom, R.M. 2001. Marine and estuarine shoreline modification issues. Washington Department of Fish and Wildlife. Olympia.

Williams, G.D., R.M. Thom, J.E. Starkes, J.S. Brennan (Ed.), and others. 2001. Reconnaissance assessment of the state of the nearshore ecosystem: Eastern shore of central Puget Sound, including Vashon and Maury Islands (WRIAs 8 and 9). King County Department of Natural Resources, Seattle, WA

Wilson, D., and P. Romberg. 1995. Elliott Bay/Duwamish Restoration Program: Pier 53-55 sediment cap and enhanced natural recovery area remediation project, 1993 data. Prepared for the Elliott Bay/Duwamish Restoration Program Panel by the King County Department of Metropolitan Services, Seattle, WA.

Wydoski, R. S. and R. L. Whitney. 2003. Inland fishes of Washington. Second Edition. American Fisheries Society and University of Washington Press. Seattle, WA