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PROGRAMMATIC BIOLOGICAL EVALUATION OF POTENTIAL IMPACTS OF INTERIDAL GEODUCK CULTURE FACILITIES TO ENDANGERED SPECIES AND ESSENTIAL FISH HABITAT

TAYLOR SHELLFISH, SEATTLE SHELLFISH, AND CHELSEA FARMS CULTURE FACILITIES

Prepared for:

TAYLOR SHELLFISH
Shelton, Washington

SEATTLE SHELLFISH
Olympia, Washington

CHELSEA FARMS
Olympia, Washington

Prepared by:

ENTRIX, INC.
Olympia, WA

Project No. 3093802

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Prepared for:

TAYLOR SHELLFISH
Shelton, Washington

SEATTLE SHELLFISH
Olympia, Washington

CHELSEA FARMS
Olympia, Washington

Prepared by:
Cody Fleece
Darin Waller
Jeff Fisher
Jeff Vanderpham
Greg Reub

ENTRIX, INC.
148 Rogers Street, Suite 1
Olympia, Washington 98502

Project No. 3093802

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1.0 INTRODUCTION

This Biological Evaluation (BE) is a programmatic evaluation of the potential impacts to threatened and endangered species from the existing and envisioned intertidal culture of geoduck clams (*Panope generosa*) in Puget Sound including Hood Canal. The evaluation is based on intertidal culture as practiced by a consortium of growers that currently includes Taylor Shellfish (Shelton, WA), Seattle Shellfish (Olympia, WA), and Chelsea Farms (Olympia WA). This document also addresses potential effects from the proposed actions on *essential fish habitat* (EFH), as defined in Section 16 U.S.C. 1802(10) of the Magnuson Fisheries Conservation Act. EFH includes the water, substrate and habitat necessary for certain managed marine and anadromous fish populations to spawn, breed, feed, or grow to maturity. South Puget Sound, including the Project Area, provides potential EFH for many marine species of fish and for the Evolutionary Significant Unit (ESU) of Puget Sound chinook salmon. The BE has been prepared in accordance with the US Army Corps of Engineers (USACOE) publication CENWS-OD-RG, *Draft Guidance for Preparation of a Biological Evaluation (BE) or Biological Assessment (BA)* dated March 29, 2000 and CENWS-OD-RG, *Additional Information Necessary for Endangered Species Act Review*, also dated March 29, 2000. In addition, sections pertaining to Essential Fish Habitat were prepared in accordance with The National Marine Fisheries Service publication, *Guidance for Integration Magnuson – Stevens Fishery Conservation and Management Act EFH consultations with Endangered Species Act Section 7 Consultations*, dated January 2001(NOAA 2004). Species listed under the Endangered Species Act (ESA) are subject to the regulatory oversight and protection of the United States Fish and Wildlife Service (USFWS) as well as the National Oceanic and Atmospheric Administration – National Marine Fisheries Service (NOAA-Fisheries). Species that are currently ESA listed by USFWS and NOAA Fisheries are considered in this BE (Table 1-1).

Pursuant to Section 7 of the ESA, the listings require consultations with NOAA-Fisheries and the USFWS when federal agencies make permit decisions that may affect these species.

Table 1-1. ESA-listed species potentially found within the action area.

Common Name	Scientific Name	ESA State Status	ESA Federal Status
	BIRDS		
Bald Eagle	*Haliaeetus leucocephalus*	T	T
Marbled Murrelet	*Brachyramphus marmoratus marmoratus*	T	T
	FISH		
Bull Trout	*Salvelinus confluentus*	C	T
Chinook Salmon	*Oncorhynchus tshawytscha*	C	T
Hood Canal Chum Salmon	*Oncorhynchus keta*	C	T

T = Threatened
E = Endangered
C = Species of Concern

2.0 PROJECT DESCRIPTION

2.1 PROJECT AND ACTION AREAS

"Project Areas" are considered any area that is directly affected by construction from the proposed action, and includes any permanent or temporary structures created by the project action. "Project Actions", for the purposes of this document, are defined as those activities associated with the intertidal culture of geoduck clams. Maps illustrating the distribution of Project Areas throughout the southern end of Puget Sound and Hood Canal are provided in Figure 2-1. All areas outside the immediate Project Area that may be affected by the Project Actions can be considered within the "Action Area" circle of the project. In practice, a two-mile radius around the project is often considered the "Action Area," however, this project is exclusively aquatic, and effects on upland habitat will not occur. The two-mile radius therefore incorporates a much greater area than is actually affected by the Project Actions. Considering the 2-mile radius, however, the Action Area for the Project Areas incorporates areas of industrial use, residential use, Puget Sound lowland forest (fringing the ordinary high water line), and portions of the Puget Sound.

2.2 GEODUCK LIFE HISTORY

The geoduck clam (geoduck) is among the largest of the burrowing clams and is known to occur in near-shore marine environments from California to Alaska. They are especially abundant in Washington and may be found from the intertidal zone to depths of 360 feet (WDNR 2001). Individuals in Puget Sound are known to live as long as 130 years (Goodwin and Shaul 1984). Geoducks may live for several decades however, maximum size and weight are generally achieved within 15 to 25 years (WDNR 2001). Adult geoducks as large as 7.2 pounds have been documented in Puget Sound (Goodwin and Pease 1991) although individuals as large as 14 pounds have been documented elsewhere. Geoducks occur in sand, silt, and gravel substrates and may burrow as deep as two to three feet below the surface. They extend a contractile siphon up through the sediment to the surface which is used to filter food particles from the water column that include phytoplankton and bacteria.

Geoducks typically spawn between April and June and produce planktonic larvae that drift with the current. They are, on average, sexually mature by the third year of life. Spawning in laboratory situations appears to be triggered by food availability and rising water temperature (Goodwin and Pease 1989). Females are capable of releasing as many as 20 million eggs in a single burst (Goodwin and Pease 1989). The planktonic-larval stage lasts from two to six weeks. In the postlarvae stage individuals settle to the bottom and begin to burrow into the sediment. Spines appear on the growing edge of the postlarvae shell, the siphon increases in size, and adult features become more pronounced. As the metamorphosis continues from postlarvae to juvenile, the siphon becomes more fully developed and the clams burrow deeper into the sediment. Geoducks are especially vulnerable to predation at the postlarvae and juvenile stage. Predators may

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Figure 2-1 **Distribution of Project Areas throughout the southern end of Puget Sound and Hood Canal**

include the sunflower star (*Pycnopodia helianthoides*), red rock crab (*Cancer productus*), the graceful crab (*C. gracilis*) and others such as diving ducks.

Prior to commercial subtidal harvests in 1970, the Washington Department of Fisheries (WDF) and the Washington Department of Natural Resoruces (WDNR) estimated that the standing stock for geoduck clams approached 127,000 tons (WDF and WDNR 1985 as reported in Goodwin and Pease 1989). In 2001, WDNR and the Washington Department of Fish and Wildlife (WDNR and WDFW 2001b) estimated that the statewide standing stock was approximately 337,000 tons. It should be noted that geographic area and the methods for calculating biomass for the 1970 and 2001 estimates were not the same and therefore the estimates are not directly comparable. Insufficient information exists to accurately compare current population levels to "pre-harvest" levels. Other stock assessment metrics, such as the frequency distribution of individuals in various age classes, indicate that the populations are recruiting new individuals and are, on the whole, healthy (Bob Sizemore, WDFW personal communication)

2.3 OPERATIONS

The consortium growers have a total of approximately 106 acres of intertidal habitat over 37 sites which are distributed throughout the southern end of Puget Sound (Table 2-1). The area (footprint) of the individual sites ranges between 0.25 and 25 acres. Photos depicting the various stages of intertidal geoduck culture can be found in Appendix A.

Consortium growers cultivate adult geoduck clams in shellfish hatcheries for spawning. Spawning is stimulated by adjusting ambient conditions (i.e., food availability and temperature). The larvae are reared through metamorphosis in tanks. Following metamorphosis, the juveniles are placed in nurseries until they reach suitable size (5-15mm) for planting (seed), at which time they are transferred to intertidal culture sites (Project Areas). Under current operations, the seed from the hatchery is planted in the same region from which the broodstock was harvested. Washington State Department of Fish and Wildlife has identified geoduck management regions in Puget Sound including: 1) the South Sound, 2) the Central Sound, 3) Hood Canal, 4) North Sound, and 5) the San Juan Islands, and 6) the Strait of Juan de Fuca (Bob Sizemore, WDFW personal communication). Geoduck seeds are typically loaded onto barges and delivered to planting beds.

Table 2-1. **Geoduck culture locations and approximate sizes operated by the consortium of growers in the Southern Puget Sound.**

Site Name	Owner	Approximate Area (acres)
	Chelsea Farms	25
Sandy Point	Seattle Shellfish	21
Whitman Cove	Seattle Shellfish	4
Spencer Cove	Seattle Shellfish	20
Jackowski	Seattle Shellfish	0.5
Arcadia Point	Seattle Shellfish	3.5
Allen	Seattle Shellfish	0.25
Hunter Point	Seattle Shellfish	10.5
Tinglin (Wilson Point)	Seattle Shellfish	4
Westgard/Nelson	Seattle Shellfish	1
Block	Taylor Shellfish	0.8
JC	Taylor Shellfish	1
Thordike	Taylor Shellfish	1
Barbara Taylor	Taylor Shellfish	1
Foss	Taylor Shellfish	12
Plein	Taylor Shellfish	2.5
Butson	Taylor Shellfish	0.6
Tice	Taylor Shellfish	0.5
Webster	Taylor Shellfish	0.4
Bent	Taylor Shellfish	0.91
McFelly	Taylor Shellfish	3.3
Smith	Taylor Shellfish	0.5
Hervey	Taylor Shellfish	1.25
Raushert	Taylor Shellfish	0.5
Mazanti	Taylor Shellfish	1
Sommers	Taylor Shellfish	4
Sandberg	Taylor Shellfish	1
Steel	Taylor Shellfish	1.25
Johnson	Taylor Shellfish	0.25
Lev	Taylor Shellfish	1.25
Rau	Taylor Shellfish	1
Walker	Taylor Shellfish	2
Winkelman	Taylor Shellfish	0.5
Kimbel	Taylor Shellfish	0.14
Senff	Taylor Shellfish	0.5
Austin	Taylor Shellfish	0.25
Leonard	Taylor Shellfish	0.35
Manke	Taylor Shellfish	1.75

Harvest records indicate that individual geoducks weigh between 1.5 and 2.0 pounds at harvest time. Harvests typically occur five to seven year after planting. Harvested areas produce an average of 1.8 geoducks per square foot.

Planting generally occurs at low-low tide and geoducks are typically planted between –2 and +3 feet (MLLW) level. PVC tubes are "wiggled" into the planting beds and sediment disturbance from this activity is minimal. Geoducks are placed in PVC tubes and enclosed with netting or other protective devices to discourage predators. The tubes also create a "mini-tidepool" which protects the seeds from desiccation at low tide. As many as 3 to 7 seed clams may be planted in a single tube. The tubes are generally 8 to 12 inches in length and 2 to 6 inches in diameter. The spacing between planted tubes ranges between 12 to 18 inches. Approximately three inches of PVC tube remains exposed above the substrate. The largest sites may be planted over the course of several years resulting in numerous geoduck age classes. Beds are not planted during the winter because water temperatures are too low for optimum growth and winter storms often bury the tubes resulting in unacceptable mortality rates for the young clams. Summertime air temperatures in excess of 75 degrees Fahrenheit may also cause excessive mortality. In such cases, planting is halted until temperatures return to acceptable levels. The PVC tubes are removed after the young clams have buried themselves to a depth sufficient to avoid predators and desiccation, generally about 14 inches. This action usually occurs after one or two growing seasons, depending on the site's conditions.

The length of time to harvest may range between four and seven years depending on planting density, substrate quality, tidal elevation, and product demand. Geoduck clams weigh approximately two pounds at harvest time and may be harvested throughout the year. Clams may be harvested from above the water line at low tide, or by divers below the water line during high tide. Harvest on dry land at low tide is the preferred and most commonly used method. Although used infrequently, harvest from below the water line at high tide is also evaluated in this document. Both harvesting methods utilize water jets to liquify the sediment in which the geoduck is buried. Once the sediment is loosened, the geoduck can be removed by hand. The water jet nozzle is about 18 inches long with an inside diameter of 5/8" or less and may produce water pressures approaching 10-15 pounds per square inch. Nozzles are inserted next to the geoduck siphon or in the hole left by the retracted siphon. Harvesters may use up to 50 gallons of water per minute when liquifying the sediment. Water is generally supplied to the jets via pumps mounted on small boats anchored offshore. The boats are generally enclosed within plastic tarps in order to minimize noise disturbances resulting from operation of the pumps. In areas where many homes are located in close proximity to the harvest site, pumps may be enclosed in wooden sheds to further reduce potential noise disturbances. Intakes for the pumps are screened with 2.38 mm wire mesh to avoid entrainment of fish or large particles that may damage the pumps. Harvested clams are temporarily stored in crates while work is in progress. At the conclusion of each workday they are loaded onto a boat and transported to processing facilities. Other clam species are infrequently encountered while harvesting geoducks. Clams with market value (e.g., cockles) are also removed from the site.

Intertidal harvest from above the water line at low tide

The harvest of geoduck clams from above the water line at low tide is a relatively new practice that emerged in conjunction with intertidal culture. This harvest method utilizes a hydraulic jet and coincides with tidal cycles and may occur during daylight hours or at night. In excess of 100 geoducks per hour may be harvested with this method. When geoducks are harvested with water jets at low tide, the immediate area surrounding a planted geoduck is liquified, which allows the buried geoduck to be removed by hand. After removal, the geoducks are temporarily stored in nearby crates.

The hydraulic jet harvest method used above the water line typically causes the formation of small shallow holes across the bed. The areas immediately surrounding the holes are slightly softer than the undisturbed beach. The radius of the harvest hole is roughly 2 to 3 feet in diameter and the liquefied area extends 2 to 3 feet below the surface. Following harvest, the beach level may be lowered about 1-2 inches. However, beach topography typically returns to its former state within one to two tide cycles. The substrate in recently harvested sites is sufficiently stable that the sites may be replanted within two days of harvest. Overland flow caused by water used for harvesting may transport suspended sediments over the exposed intertidal to the water column. This surface water runoff can produce a noticeable sediment plume in the immediate vicinity of the harvest area.

Intertidal harvest from below the water line at high tide

The techniques used for geoduck harvest below the water line are essentially the same as those used from above the water line, except harvesting is conducted by scuba diving. This harvest methodology has been used for decades in the sub-tidal geoduck fishery. A single diver may harvest several hundred geoducks in the course of a day. The principal difference is that when harvesting from below the water line, bottom disturbances result in sediment transport that directly occurs within the water column. Intertidal harvest from below the water line is a method that is infrequently utilized by consortium growers because harvest from above the water line is easier and more cost effective.

3.0 DESCRIPTION OF FEDERALLY LISTED AND MANAGED SPECIES AND HABITAT

3.1 ESSENTIAL FISH HABITAT ASSESSMENT AND USE

The Magnuson-Stevens Fishery Conservation and Management Act (MSA), as amended by the Sustainable Fisheries Act of 1996 (Public Law 104-267), requires Federal agencies to consult with NOAA-Fisheries on activities that may adversely affect Essential Fish Habitat (EFH) for any fish that are covered under a Fishery Management Plan (FMP). Essential Fish Habitat is any habitat (including both water and substrate) that is required by fish for spawning, breeding, feeding, or growth to maturity. The objective of this EFH assessment is to describe potential adverse effects to designated EFH for federally-managed fisheries species within the proposed action areas.

The Fishery Management Councils who are responsible for implementing FMPs have combined the over four hundred individual EFH for each species and life history stages of managed fish into "composite" EFHs. Four composite EFHs can be described within the Puget Sound: (1) non-rocky shelf, (2) estuarine waters, (3) rocky shelf, and (4) all waters of Puget Sound. Intertidal geoduck culture areas throughout the Puget Sound share similar habitat features, tidal influences, and elevation. These locations meet the MSA designation as "estuarine waters". The EFH for this designation is defined as, "those waters, substrates and associated biological communities within bays and estuaries of Puget Sound, from MHHW (the average high tide line) or extent of upriver saltwater intrusion to the respective outer boundaries for each bay or estuary as defined in 33 CFR 80.1 (Coast Guard lines of demarcation)" (NOAA 2003). Table 3-1 lists the species and their life-history stages that are covered by this composite EFH.

Table 3-1 also lists the species of fish that are most likely to make use of EFH in the project areas. These assumptions are based on reconnaissance surveys of the project locations and knowledge of species preferences. While all of these fish could theoretically occur within any of the project areas, many species are highly unlikely to occur (e.g. bocaccio and sablefish). Surveys of the project areas show the substrate habitat consists largely of flat and featureless mud/silt plane (below MLLW). Many of the fish with EFH present within Puget Sound estuarine waters can be discounted within the project areas due to lack of structure and/or insufficient depth. Many species (e.g. most rockfish (*Sebastes sp.*) and lings (*Ophiodon elongatus*)) prefer habitat with some sort of structure or cover such as kelp, a wall, or rock outcrop. Others such as pacific whiting (*Merluccius productus*) prefer deeper habitat than what is available at the project areas.

Table 3-1. **Species of fishes and life-history stages with designated EFH in the estuarine waters of Puget Sound, (? = uncertain), and EFH present within the action areas.**

Species	Spawning/ Mating	Juvenile	Larvae	Eggs/ Parturition	*EFH Present in Action Area?*
Spiny Dogfish *Squalus acanthias*	X	X		X	X
California Skate *Raja. inornata*					X
Ratfish *Hydrolagus colliei*				X	
Lingcod *Ophiodon elongatus*	X	X	X	X	
Cabezon *Scorpaenichthys marmoratus*	X	X	?	X	
Kelp Greenling *Hexagrammos decagrammus*	X	X	X	X	
Pacific Cod *Gadus macrocephalus*	X	X	X	X	X
Pacific Whiting (Hake) *Merluccius productus*		X			
Sablefish *Anoplopoma fimbria*		X			
Bocaccio *Sebastes. paucispinis*	?	X	X		
Brown Rockfish *S. auriculatus*	?	?	X		
Copper Rockfish *S. caurinus*		X	?		
Quillback Rockfish *S. maliger*		X	?		
English Sole *Parophrys vetulus*	X	X	X	X	X
Pacific Sanddab *Citharichthys sordidus*		X	X	X	X
Rex Sole *Glyptocephalus zachirus*	X	X		X	X
Starry Flounder *Platichthys stellatus*	X	X	X	X	X
Chinook Salmon *Oncorhychus tshawytscha*		X			
Coho Salmon *O. kisutch*		X			
Puget Sound Pink Salmon *O. gorbuscha*		X			
Northern Anchovy *Engraulis mordax*	X	X	X	X	
Pacific Sardine *Sardinops sagax*					
Pacific Mackerel *Scomber japonicus*					
Market Squid *Loligo opalescens*					

Source, NOAA-Fisheries webpage;
http://www.nwr.noaa.gov/1habcon/habweb/efh/ps_estuarine.pdf

3.2 FEDERALLY LISTED FISH SPECIES - BULL TROUT, CHINOOK SALMON, AND CHUM SALMON

3.2.1 Bull Trout (*Salvelinus confluentus*)

The distinct population segment (DPS) of the Columbia River bull trout was federally listed as threatened by the USFWS on June 10, 1998 (63 FR 31647). This listing includes all waters of the watershed from the mouth of the Columbia River to the Canadian border. The fragmented nature of the population within this watershed is the primary basis for the broad listing of this char species (WDFW 1998). Critical habitat designations for bull trout were proposed in June of 2004. Much of Hood Canal and portions of Puget Sound extending northward from the Nisqually River have been identified as critical habitat. It is anticipated that a final rule will be submitted for publication in the Federal Register by June 15, 2005.

Bull trout display a high degree of environmental sensitivity during all life stages and have more specific habitat requirements than other salmonids (Rieman and McIntyre 1993). Newly hatched bull trout emerge from their gravel beds in the spring. After emergence, bull trout are known to exhibit four distinct life history patterns based on differences in migration preference. Resident bull trout spend their entire lives within the same stretch of headwater streams. These fish are slow to mature (seven to eight years) and rarely reach sizes greater than 14 inches in length. The remaining life history alternatives include: fluvial fish that migrate within the river system; adfluvial fish that migrate between river and lake habitats; and anadromous or ocean going fish. These migrating fish typically spend two years within or near their natal waters before they migrate to their feeding grounds (Goetz 1989, WDFW 1998). The only life history strategy considered in this programmatic BE is the anadromous bull trout, as bull trout exhibiting other life history patterns would not be affected. Sea run bull trout in North Puget Sound are known to pioneer and travel long distances from their natal stream in order to forage in the nearshore environment of Puget Sound (Fred Goetz, pers. com. 2003).

Within South Sound, the Nisqually River might support a population of bull trout. Jim Barr (Nisqually Tribe) observed an individual collected in 98/99 during chinook egg take in a hatchery (Jeff Chan, USFWS pers. com 2003). The nearest stream or river that have resident populations of bull trout is the Puyallup River, which empties into Commencement Bay in Tacoma Washington (StreamNet 2003). The Nisqually River is used on occasion by pioneering fish from a natal population in the Puyallup River. The core population of Bull Trout in the Puyallup basin, is depressed so the chances of even seeing a pioneering or foraging anadromous bull trout in marine waters would be very slim (Jeff Chan, USFWS pers com 2003). Kurt Fresh (NMFS) observed an individual charr (probably a bull trout) in Dewolf Bight in South Sound in 1978 (Jeff Chan, USFWS pers. com. 2003). There is no published documentation available supporting or refuting that bull trout may use South Puget Sound in the action area defined in this BE. No adult bull trout were observed during habitat surveys completed to support this BE.

3.2.2 Chinook Salmon (*Oncorhynchus tshawytscha*)

The Puget Sound Evolutionarily Significant Unit (ESU) of chinook salmon was listed as threatened by National Marine Fisheries Service (now NOAA-Fisheries) on March 24th 1999 (64 FR 14308). This ESU includes all naturally spawned populations of chinook salmon from rivers and streams flowing into Puget Sound including the Straits of Juan De Fuca from the Elwha River, eastward, including rivers and streams flowing into Hood Canal, South Sound, North Sound and the Strait of Georgia in Washington. This ESU also includes hatchery stocks from Kendall Creek (spring run), North Fork Stillaguamish River (summer run), White River (spring run), Dungeness River (spring run) and Elwha River (fall run). However, the critical habitat designation for this ESU of chinook salmon has been vacated by the U.S. District Court for Washington DC at the request of NOAA-Fisheries.

The Puget Sound chinook salmon ESU is considered to be ocean-type chinook salmon, meaning that they outmigrate as sub-yearlings during the summer and fall after emergence, spending little time in their natal streams and rivers (Mathews and Waples 1991; Waples et al. 1991; Myers et al. 1998). After two to five years in the ocean, these chinook salmon begin migrations back to their spawning grounds. Listed chinook salmon can be present in the action area on a limited basis during the ocean phase and juvenile outmigration phase of their life-history, however, no salmonids of any species were recorded during surveys (see section 4.0).

3.2.3 Chum Salmon (*Oncorhynchus keta*)

In 1997, the National Marine Fisheries Service (now NOAA-Fisheries) published a review of chum salmon stocks in the Puget Sound Region (Johnson et al.1997). NMFS concluded that populations in the Puget Sound/Georgia Straits ESU were stable or increasing in numbers. However, the Hood Canal summer-run ESU was considered at risk and was formally listed as threatened in March of 1999. Populations in the Puget Sound/Georgia Straits ESU may occur in streams throughout Puget Sound ranging from the Elwha River to the Strait of Juan de Fuca. It was determined, based on review of genetic, ecological and life history data that the Hood Canal summer-run populations constituted a separate ESU. The Hood Canal summer chum salmon ESU is comprised of sixteen historically quasi-independent populations, of which nine presumably still exist. Most of the extirpated populations occur on the eastern side of Hood Canal, and some of the seven putatively extinct stocks are the focus of extensive supplementation programs underway in the ESU (WDFW and PNPTT 2000 and 2001).

Most chum in the Puget Sound area exhibit spawning migrations in October and November and are thus considered "fall run" fish. In contrast, Hood Canal chum are summer run and migrations may begin as early as August. Spawning for winter runs may end as late as March. Emerging fry may spend only a few weeks in their natal streams before migrating out to estuaries (Meehan and Bjornn 1991). Fry associated with fall run spawners are known to utilize shallow water habitats such as eelgrass beds and may remain in the estuary from January to July (Healy 1982). Although little is known about summer run juvenile estuarine habitat utilization, individuals likely move offshore rapidly due to the limited food availability in the nearshore environment that is typical of the winter months (Salo 1991). As body size increases, juveniles move to deeper waters (20-40 meters) to exploit larger food sources (Salo 1991, Johnson et al 1997). Chum salmon typically return to streams for spawning between their third and fifth year (Meehan and Bjornn 1991).

3.2.4 Pacific Herring (*Clupea pallasi*)

Pacific Herring (*Clupea pallasi*) are listed as state species of concern in Region 6 (WDFW) which includes the areas of southern Puget Sound and Hood Canal. Herring spawn at Squaxin Pass in South Sound and south Hood Canal and Quilcene Bay in Hood Canal. The areas utilized for spawning and the time of spawning are very specific. The peak of spawning rarely varies more than 7 days from year-to-year and occurs from January to April (Bergman, 1998). Herring spawn by depositing eggs on vegetation or other shallow water substrate. Spawning occurs in the shallow sub-tidal zone. Most egg deposition occurs from 0 to -10 feet in tidal elevation. The eggs incubate from two to three weeks before hatching (the incubation length varies with water temperature). Following hatching, the larvae drift in the ocean currents for two to three months until metamorphosis and begin to school when they reach lengths of 25-40 mm (Lassuy 1989).

Following metamorphosis, Puget Sound stocks of young herring spend their first year in Puget Sound. Some stocks of herring spend their entire lives within Puget Sound ("resident stocks") while other stocks ("migratory stocks") summer in the coastal areas of Washington and southern British Columbia (Trumble, 1983). Following the attainment of sexual maturity at age two to four, the herring migrate back to the spawning grounds. Typically, each stock has a pre-spawner holding area where ripening adult herring mill prior to spawning. The holding patterns usually begins three to four weeks prior to the first spawning event (Trumble et al. 1982).

3.3 BALD EAGLES AND MARBLED MURRELETS

3.3.1 Bald Eagle (***Haliaeetus leucocephalus***)

In Washington State, the bald eagle has been listed as threatened under the ESA since 1978 (43 FR 6230). However, due to a ten fold increase in population size since 1963, the U.S Fish and Wildlife Service proposed to remove bald eagles from the list of threatened and endangered species in 1999 (64 FR 36453). The decision for delisting the bald eagle is yet to be determined, and therefore all protections afforded the bald eagle and its critical habitat remains intact.

Bald eagles breed and winter throughout most of the United States and Canada. In Washington State they nest primarily west of the Cascade Mountains and winter throughout the Puget Sound region, the San Juan Islands, Hood Canal, the Olympic Peninsula, and the upper and lower Columbia River and its tributaries (WDFW 2001a).

Bald eagles are found along the shores of fresh and saltwater environments. Breeding territories are located in predominantly coniferous uneven-aged forest stands with old-growth components. Nesting locations are generally in mature old-growth trees with nearby available prey. These nests may be used in successive years. The availability of suitable nesting locations is often a limiting factor in the establishment of bald eagle territories (USFWS 1986). In Washington, courtship and nest-building activities occur between the months of January and February. Eggs are laid and cared for beginning in March to early June. Chicks are hatched from mid-April to early May. Eaglets usually fledge in mid-July but may remain in the nesting location for another month (Rodrick and Milner 1991).

Wintering locations for bald eagles are dependent on suitable roosting locations and available prey. Bald eagles will use communal night roosts. Suitable roosts are usually snags or trees that are older and taller than other trees in the area. As many as 50 individuals may share a single roost (Adams et al. 2000). Within the vicinity of the proposed project, wintering activities for bald eagles occur from October 31 through March 31 (USFWS 2003). Food sources during the winter months for bald eagles have been shown to consist primarily of waterfowl, which is 80 to 90 percent of their diet. Fish, carrion, small mammals and other birds make up the remainder of the bald eagles food sources (Fielder and Starkey 1980, Fielder 1982).

Bald eagles have been observed as fly-overs near several Project sites and likely occur in close proximity to all Project sites. During site surveys no nesting sites were observed, but may occur within close proximity to Project sites given the broad range of bald eagles in the region.

3.3.2 Marbled Murrelet (*Brachyramphus marmoratus marmoratus*)

The marbled murrelet, was listed as threatened in Washington State, under the ESA in 1992 (57 FR 45328). This listing occurred as a result of loss of or modification to nesting habitat, primarily older forest habitat and the subsequent population declines. Additional declines have been associated with mortality from gill net fishing and oil spills off the coast of Washington State.

In North America, the marbled murrelet occurs as far north as the Aleutian Archipelago in Alaska to as far south as northern California. These birds spend the majority of their lives in the ocean only coming ashore to nest. However when nesting, marbled murrelets have been found in Washington State as far inland as 80 kilometers (Hamer and Cummins 1991). Nesting occurs from mid-April to late September (Carter and Sealy 1987).

Marbled murrelets are also known to occur in well-defined concentrated areas in the Puget Sound region including Hood Canal, but are considered common only during the breeding season (USFWS 1997). A study conducted by the Sustainable Ecosystems Institute (SEI) in March 1997 in Burrows Bay, Skagit Bay, the Saratoga Passage south to Possession Sound, Port Madison, Admiralty Inlet, and Hood Canal from Port Townsend to Quatsap Point showed that they usually occur between 200 and 500 meters from shore.

Marbled murrelets produce one egg per nest, which are simple cups formed in the moss on thick branches (Ralph *et al.* 1995). These branches used for nest platforms are found 20 to 40 meters above the ground on branches large enough for the marbled murrelet nest. This requirement for large branches that are high above the ground, limits nesting locations to fairly old Douglas fir and Sitka spruce found in older forest stands. Egg incubation lasts approximately 30 days. Adult marbled murrelets alternate feeding duties, returning from ocean feeding grounds usually at dusk and dawn to feed the chick a single fish (Hamer and Cummins 1991; Singer et al. 1992). Chicks fledge about 28 days later and travel to ocean feeding grounds after molting.

No marbled murrelets were observed during survey site visits and there are no known nesting locations within the action area. However, marbled murrelets are known to occur in Oakland Bay (Schirato 2003) and other areas throughout the Puget Sound region (SEI 1997, USFWS 1997). Therefore, it is likely that marbled murrelets occur near Project sites at some times of the year.

4.0 INVENTORIES AND SURVEYS

Field surveys were conducted at intertidal culture sites for Hunter Point, North Bay, and Stretch Island between December fifth and seventh, 2003. Subtidal transect surveys were performed to characterize substrate, general habitat features, and to survey for ESA listed aquatic species and EFH. Transects within the culture sites were randomly selected across the entire width of the geoduck culture beds (seaward to shoreward). Control transects were place outside the normal influence of the culture beds but within the same tidal elevation. Details regarding transect characteristics and locations are presented in Table 4-1.

Table 4-1. Locations and depths of the survey transects for intertidal geoduck culture sites.

Transect	Location	Latitude Longitude	Actual Start Depth (feet)	Actual End Depth (feet)	Adjusted to MLLW Start Depth (feet)	Adjusted to MLLW End Depth (feet)	Notes:
1	Hunter Point	N 47"09'57.97" W 122"55'1.74"	10	5	2.75	+2.25	Clam beds covered by nets higher in the intertidal
2	Hunter Point	N 47"10'1.07" W 122"55'0.26"	9	6	1.5	+1.5	Clam beds covered by nets higher in the intertidal
3 Control	Hunter Point	N 47"10'5.19" W 122"55'1.06"	15	8	6.0	+1.0	
4	North Bay	N 47"22'10.62" W 122"48'40.30"	9	8	0.75	+0.25	Eelgrass bed approximately 10ft beyond surveyed plot
5 Control	North Bay	N 47"22'6.50" W 122"48'38.75"	11	9	2.75	0.75	Eelgrass bed approximately 15ft beyond surveyed plot
6	North Bay	N 47"22'10.62" W 122"48'40.30"	11	10	2.75	1.75	Eelgrass bed just beyond Transect # 4
7 Control	North Bay	N 47"22'6.50" W 122"48'38.75"	11	10	2.75	1.75	Eelgrass bed just beyond Transect # 5
8	Stretch Island	N 47"19'17.42" W 122"49'46.41"	8	7	+2.0	+3.0	Geoduck bed with tubes removed just beyond surveyed plot
9 Control	Stretch Island	N 47"19'22.57" W 122"49'45.69"	8	7	+1.5	+2.5	

Eelgrass beds were observed just beyond the transects at the North Bay sites. At these locations the transects were extended into these beds. Surveys within the eelgrass beds were conducted in the same fashion as the geoduck bed transects.

During surveys, divers moved along anchored transects lines and recorded the location and taxa for all organisms encountered. Observed organisms were classified to the lowest possible taxonomic level in the field. Substrate composition and depth were recorded at 25 foot intervals along transects. To limit errors from changes in visibility between transects, only a one-meter width was surveyed for organisms along each transect. Visibility was generally good, with effective visibility of approximately 12 vertical feet during all transect surveys.

4.1 EXISTING CONDITIONS

4.1.1 Terrestrial Environment

Geoduck culture beds are located throughout the South Puget Sound. In general, terrestrial environments surrounding project facilities are comprised of a mixture of residential areas, open grasslands, and small wooded areas. Vegetation includes big leaf maple and a mixture of shrubs along shorelines and uplands dominated by coniferous forests with a mixture of deciduous trees.

4.1.2 Intertidal and Subtidal Habitat

As discussed in section 2.3 (Operations), site selection for geoduck culture beds is based primarily on specific habitat requirements and mainly substrate composition and slope. The intertidal beach habitat at the study sites were similar in composition, comprised of mostly sand/mud intermixed with small gravel and shell. The slope of the beach at these locations was nearly constant and ranged between one and five percent gradient within the surveyed areas.

4.1.3 Fish and Invertebrate Surveys

No fish were observed during any of the transect surveys. The lack of observed fish can most likely be attributed to several factors including depth of water and a lack of suitable structure for fish species such as rockfish. In addition, fish abundance could also be higher during other seasons.

Invertebrate presence was recorded along each transect. Invertebrates were identified to the lowest taxonomic level practicable and counts of individuals were recorded (Table 4-2). Counts of polychaete worms (tubeworms) were not recorded during the surveys because differentiating between live and dead tubes was not practical during the surveys. Geoducks within PVC culture tubes were not counted, however geoducks were counted when they were observed outside of the culture tubes on the assumption that these geoducks were the result of natural recruitment. The density of individual taxa per 100 feet of transect was calculated to make totals from the various sites more directly comparable. These calculations are presented in Table 4-3.

Table 4-2. **Invertebrates observed, and counts for each genus/species by location and transect.**

		Hunter Pt.			North Bay				Stretch Is.	
		Geoduck bed (150ft)	Geoduck bed (150ft)	Control (150ft)	Geoduck bed (150ft)	Control (150ft)	Eelgrass Below Geoduck Bed (50ft)	Eelgrass Below Control (50ft)	Geoduck bed (150ft)	Control (150ft)
		Transect								
Species		1	2	3	4	5	6	7	8	9
Red rock crab	*C. productus*	1	0	0	0	0	0	0	0	0
Graceful crab	*C. gracilis*	3	4	1	3	7	0	3	0	0
Decorator crabs	*Majidae*	16	12	0	1	0	0	1	0	0
Hermit crabs	*Paguridae*	159	124	179	135	80	50	70	10	10
Flat shrimp	*Crangonidae*	0	0	0	0	0	0	0	0	1
Humped shrimp	*Hippolytidae*	0	0	0	0	0	1	0	0	0
Horse clam	*Tresus nuttalli*	0	1	1	0	0	0	0	0	1
Geoduck clams	*P. abrupta*	1	0	0	0	0	0	0	2	0
Moon snails	*P. lewisii*	1	1	1	0	3	0	0	1	0
Five arm seastar	*Pisaster spp.*	15	4	1	2	24	0	0	0	0
Sunflower star	*P. helianthoides*	2	0	0	0	0	0	0	0	0
Sand dollar	*D. excentricus*	0	0	0	189	150	3	0	0	0
Total Individuals		198	146	183	330	264	54	74	13	12
Count of Taxa		8	6	5	5	5	3	3	3	3

Table 4-3. **Density of observed invertebrates (# / 100 ft^2) by location and transect**

		Hunter Pt.			North Bay				Stretch Is.	
		Geoduck bed	Geoduck bed	Control	Geoduck bed	Control	Eelgrass Below Geoduck Bed	Eelgrass Below Control	Geoduck bed	Control
		Transect								
Species		1	2	3	4	5	6	7	8	9
Red rock crab	*C. productus*	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Graceful crab	*C. gracilis*	2.0	2.7	0.7	2.0	4.7	0.0	6.0	0.0	0.0
Decorator crabs	*Majidae*	10.7	8.0	0.0	0.7	0.0	0.0	2.0	0.0	0.0
Hermit crabs	*Paguridae*	106.0	82.7	119.3	90.0	53.3	100.0	140.0	6.7	6.7
Flat shrimp	*Crangonidae*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7
Humped shrimp	*Hippolytidae*	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0
Horse clam	*Tresus nuttalli*	0.0	0.7	0.7	0.0	0.0	0.0	0.0	0.0	0.7
Geoduck clams	*P. abrupta*	0.7	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0
Moon snails	*P. lewisii*	0.7	0.7	0.7	0.0	2.0	0.0	0.0	0.7	0.0
Five arm seastar	*Pisaster spp.*	10.0	2.7	0.7	1.3	16.0	0.0	0.0	0.0	0.0
Sunflower star	*P. helianthoides*	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sand dollar	*D. excentricus*	0.0	0.0	0.0	126.0	100.0	6.0	0.0	0.0	0.0

During the transect surveys, a few general trends in the distribution and abundance of invertebrate species were noted. Overall, densities and taxa counts for transects placed in the planted beds were similar to transect outside the beds. One notable exception was that decorator crabs were observed only in planted geoduck beds or in adjacent patches of eelgrass. No site-specific trends were observed at either North Bay or Stretch Island. However, observed invertebrate densities at Hunter Point were higher in the geoduck beds than in control areas for six of nine taxa. Due to the limited number of transects, it is difficult to ascertain if taxa abundance and density in the planted beds is significantly different than outside the bed.

Comparisons between the eelgrass beds observed at the North Bay site and the adjacent geoduck beds do show a trend in crab distributions. Where geoduck culture tubes are present, graceful crab and decorator crab densities appear to be greater than in the eelgrass habitat just below. For the control transect, crab density was higher along portions of the transect where eelgrass was present than where it was not. One possible explanation for the observed distribution of these highly mobile crabs is that they migrate up into the culture tubes from the eelgrass beds when water is covering the tubes. Crabs in areas without tubes stay in the eelgrass throughout the tidal cycle. The structure provided by the tubes may increase the area of suitable habitat which may lead to increases in decorator crab densities.

4.1.4 Avian Surveys

No formal avian surveys were conducted for ESA-listed birds, including bald eagles and marbled murrelets. However, several bald eagles were observed as fly-overs during subtidal surveys at Hunter Point and Stretch Island. Marbled murrelets were not observed during field surveys or site visits.

4.1.5 Water Quality Information

Harvest from above the water line at low tide

Surface water runoff resulting from the harvest of geoduck increases suspended solids concentrations and turbidity in the water column adjacent to harvested areas. Suspended solids in the water column is likely the only significant water quality impact related to this BE. To better understand this issue, the consortium collected beach sediment for partical size distribution analysis and supsended sediment concentrations in the water column during harvest operations. The Jackowski site was selected to represent a "worst case" scenario in terms of potential for increase in suspended sediment concentrations. This site is considered marginally suitable for commercial geoduck culture because of the small particle size of the sediments found on the beach. Fine sediment particles are more easily entrained and more likely to remain suspended in the water column than coarse particles. Particle sizes below a certain threshold are also known to affect clam growth and product quality (e.g., color).

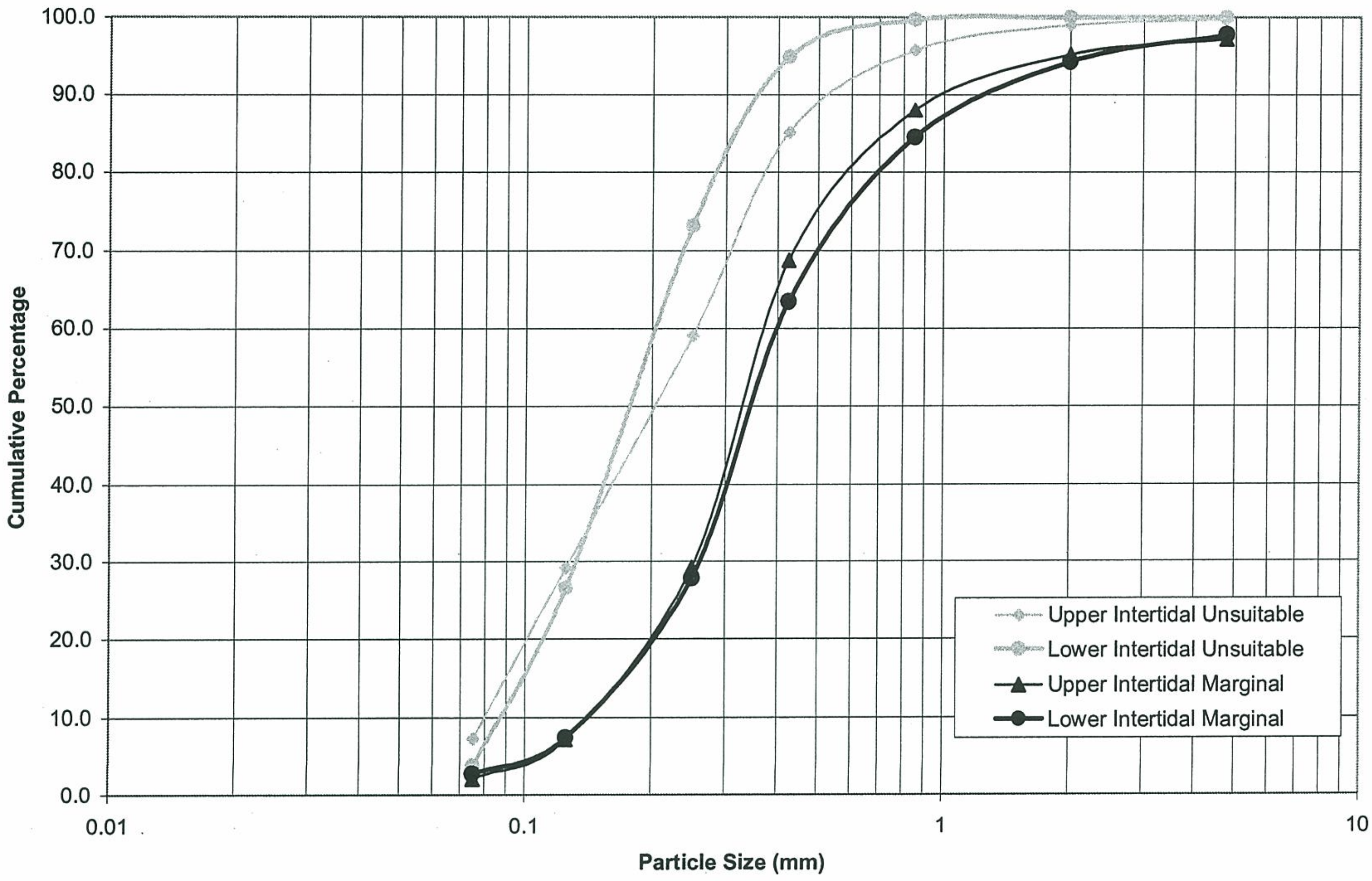
On December 22, 2003, intertidal beach sediment samples were collected from the Jackowski site for sediment particle size analysis. Four samples were collected. Two samples (one from upper intertidal and one from lower intertidal) were collected from an area of the beach that was considered suitable for geoduck culture. Two additional samples (upper and lower intertidal) were collected from an unplanted area of the beach where sediment particle size is considered too small for geoduck culture,

Figure 4-1 provides results from the sediment particle size analysis. As described above, both samples represent particle size distributions representative of fine beach sediment. The particle size distribution for samples collected in unsuitable areas was noticeably smaller than those collected in suitable areas. Median particle sizes in unsuitable areas ranged between 0.17 and 0.20 mm whereas median particle sizes in suitable areas were approximately 0.35 mm. Particle distributions between upper and lower intertidal (where geoduck are normally planted) did not differ substantially.

Water quality data were also collected at the Jackowski site with the objective of characterizing the extent to which harvesting from above the water line at low tide impacted suspended sediment concentrations in the water column. This survey was designed to characterize suspended sediment concentrations both perpendicular and parallel to the beach. A total of nine grab samples were collected from the water column in the area adjacent to active geoduck harvesting. Harvesting had been underway for at least one hour prior to collection of the samples. The tidal height at the time of the study (~11:00 p.m.) was approximately negative 3.7 feet (MLLW) and was taken at about slack current. Very little mixing of surface runoff occurred due to wave action or current. A visible sediment plume was observed to extend away from the site. Because the sampling occurred during the darkness, it was not possible to visually observe the full extent of the sediment plume Samples were collected along three transects perpendicular to the shoreline. The first transect was located approximately 50 feet up-current of the influence of harvesting activities. The second transect was placed immediately down-slope of the harvesters and was intended to capture the greatest influence of harvesting. The third transect was located approximately 100 feet down-current from the influence of harvest activities. Samples were collected at three locations along each transect at five, 25, and 50 feet from the shoreline. Total suspended solids (TSS) and turbidity were analyzed for each of the samples collected.

The same general trend was observed for both TSS and turbidity (Table 4-4). TSS and turbidity concentrations were relatively constant at all three stations along the up-current transect. For the transect immediately below harvest activity, concentrations were

Figure 4-1. Sediment particle size distribution (shown as cumulative percent by size class) from beach samples collected at a site unsuitable for geoduck culture (grey lines) and a marginally suitable site (black lines).



highest near the water's edge and decreased with distance from the shore. Down-current concentrations were somewhat higher than those observed outside the influence of the plume but were considerably lower than those observed in the heart of the plume. It should be noted that these samples were collected during relatively calm conditions. Under circumstances with greater wave energy or tidal exchange, the sediment plume would likely extend much further from the worksite although concentrations would be considerably less.

Table 4-4. **Total suspended solids and turbidity during geoduck harvest at the Jackowski site.**

	Total Suspended Solids (mg/L)			Turbidity (ntu)		
Distance From Shoreline	Up Current	Below Active Harvesting	Down Current (~100ft.)	Up Current	Below Active Harvesting	Down Current (~100ft.)
5 ft	4.2	266.0	8.5	0.8	75	1.4
25 ft	5.8	48.0	10.4	0.9	35	1.5
50 ft	5.0	7.3	8.0	0.7	1	1

Harvest from below the water line at high tide

Harvest from below the water line at high tide is a methodology that is infrequently used by consortium growers. Consortium growers typically use this method in response to changing market forces. If geoduck prices are high, it may be desirable to harvest during high and low tides. No site specific studies were conducted to evaluate intertidal harvest from below the water line and we are not aware of any studies that have evaluated this practice. Subtidal harvest, however, has been evaluated and the results of these studies are highly relevant to consortium practices.

The impact of this harvest methodology on substrate topography was evaluated through the establishment of a set of small experimental plots (Goodwin 1978). In Goodwin's study, geoducks were harvested using standard methods although the subtidal plots were much deeper (~40 feet) than intertidal plots under consideration in this document (-2 to +3 feet MLLW). Harvest and control plots were sampled prior to harvest, immediately after harvest, and periodically thereafter. This study found that the removal of geoducks created holes that were on average 15 inches in diameter and 3 inches deep, although the average depth of disturbed material within the hole extended to 18 inches below the surface. The use of water jets in subtidal geoduck plots did not significantly change the median grain size of the harvested bed relative to an undisturbed control site (Goodwin 1978). Although the presence of "harvest holes" clearly distinguished treatment sites from control sites in the days following the experiment, harvest and control plots were similar in appearance after only two months.

The transport and fate of suspended sediment plumes resulting from subtidal geoduck harvest was evaluated by Short and Walton (1992). The amount of suspended sediment in the water column depends on the harvest rate, current speed, and particle size distribution of the planted bed. The Short and Walton study found that most of the suspended material settled within one meter of the harvest hole. Further, the densest concentrations in the sediment plumes (100 mg/l > background concentrations) were limited to an area within five meters of the harvest hole and, when current speed was low, the down current sediment concentrations returned to background levels within 60 meters.

5.0 ANALYSIS OF EFFECTS

In this section, the culture methods including, planting and harvesting techniques for the geoduck culture practices are examined to determine if federally listed threatened or endangered species within the action area could potentially be affected. Potential impacts resulting from the culture activities associated with the proposed project are evaluated in terms of listed species and associated habitat disturbance and/or loss. The magnitude of these impacts is based upon the type, amount and duration of project effects. Impacts are characterized as direct or indirect. Direct impacts result from an immediate action of a project, such as the removal of bald eagle nesting trees for a new roadway. In contrast, indirect effects are caused by or result from a proposed action, such as the avoidance of a site by bald eagle prey species due to construction noise.

For the purposes of this biological assessment, short-term impacts will be defined as the impacts associated with the planting and harvesting of the geoducks and long-term impacts are related to the growing out of the geoducks. Even though planting and harvesting of geoducks is conducted over the long term (i.e. a repeating cycle of planting and harvesting) it is a punctuated and short-term process that may last as little as a single tide-cycle and only repeats every 4 to 7 years. The period of time the geoducks are growing in the substrate, with or without the growing tubes, will be considered for long-term impacts.

Given the presumed similarity of behavior and life histories between adult bull trout, Puget Sound chinook salmon and Hood Canal chum salmon while in the marine environment, the analysis for many of the effects from the proposed project will be combined. If differences do exist, each species will be discussed individually. Table 6-1 lists pathways and indicators that were used to evaluate net effects of the actions on salmonids. Juvenile salmonids have the greatest potential to be impacted by geoduck culture. For the wild Hood Canal summer-run chum salmon it is the juvenile life history stage that is of principal concern. Juvenile wild summer chum salmon use the nearshore environment extensively before they head out to the ocean. They have similar habitat requirements as juvenile chinook salmon and should be treated accordingly. Fry are known to utilize shallow water habitats such as eelgrass beds and may remain in the estuary from January to July (Healy 1982). Little is known about utilization of nearshore habitat by summer run chum salmon juveniles. However, it is known fall run chum salmon juveniles spend less time in the nearshore environment when food availability is low (Salo 1991). Given that summer chum salmon juveniles are likely present in the nearshore environment during the unproductive winter months, it is reasonable to conclude that they spend even less time in the nearshore environment than their fall run counterparts.

Table 5.0 **Pathways and Indicators Used to Evaluate Effects on Salmonids, and the Net Effects of the Actions on Relevant Pathways and Indicators.**

		Effects of Action		
	Indicators	**Improve[1]**	**Maintain[2]**	**Degrade[3]**
	SHORT TERM EFFECTS			
• **Planting and Harvesting Disturbances**	Noise			X
	Entrainment		X	
	Stranding		X	
	Water quality (turbidity, etc.)			X
	LONG TERM EFFECTS			
• **Water Quality**	Light Penetration	X		
	Chemical contamination/nutrients	X		
	Temperature		X	
	Dissolved oxygen		X	
• **Sediment**	Sedimentation sources/rates			X
	Sediment quality		X	
• **Habitat Conditions**	Fish access/refugia	X		
	Depth		X	
	Substrate		X	
	Slope		X	
	Shoreline		X	
	Riparian conditions		X	
	Flow and hydrology/current patterns/salt-freshwater mixing patterns		X	
	Overwater structures		X	
	Disturbance		X	
• **Biota**	Prey-epibenthic and pelagic zooplankton		X	
	Infauna		X	
	Prey-forage fish		X	
	Aquatic vegetation		X	
	Nonindigenous species		X	
	Ecological diversity	X		

[1] Action will contribute to long-term improvement, over existing conditions of the indicator

[2] Action will maintain existing conditions.

[3] Action will contribute to long-term degradation, over existing conditions of the indicator

Adult summer chum and chinook salmon primarily use the nearshore environment as a migration corridor and as a staging area to their spawning stream. Bull trout adults behave differently than adult chinook and chum salmon in that they will commonly utilize the nearshore marine habitat for foraging.

5.1 ESSENTIAL FISH HABITAT

As required by the Magnuson-Stevens Fishery Conservation and Management Act (MSA), this section will consider project actions that have the potential to adversely impact or alter Essential Fish Habitat for any fish that are covered under a Fishery Management Plan (FMP). As previously stated, this includes habitat that is required by managed fish for spawning, breeding, feeding, or growth to maturity. Like the ESA-listed birds and fish covered in the previous sections, this EFH assessment will define short-term impacts as the impacts associated with the planting and harvesting of the geoducks and long-term impacts are related to the growing out of the geoducks. The level of impacts will be assessed in section 7.0 (Determination of Effects).

5.1.1 Short Term Effects

Planting

Some limited avoidance of the immediate project site by fish could occur from boat traffic and the unloading of materials to the beach. Since work is conducted on the exposed intertidal during planting, no other avoidance impacts are envisioned. Sediment disturbance during planting is minimal and impacts to nearshore water quality are not expected.

Planting operations have the potential to impact intertidal eelgrass if present. Eelgrass, which is known to occur in intertidal habitat throughout the Puget Sound exhibits a seasonal biomass cycle with higher densities in spring and summer months dying back in the fall and winter. Tube placement can damage eelgrass roots or rhizomes. In addition, workers have the potential to trample or crush exposed eelgrass while moving around the beach and in staging areas where equipment is placed on the beach. Under current practices the consortium of growers does not plant new beds in areas where eelgrass is present and great care is taken to avoid staging equipment in eelgrass areas. Therefore, trampling of eelgrass is not expected to occur under any of the operations associated with planting or harvesting envisioned into the future.

Trampling could also impact the eggs of herring, sand lance, and surf smelt, all of which deposit eggs in the intertidal zone. In the Puget Sound region, herring typically spawn between 0 and –10 feet in tidal elevation (WDFW 2004a, Lassuy 1989). Eggs adhere to rocks, eelgrass or other solid surfaces including the protective geoduck tubes. Spawning peaks in February and March (WDFW 2004a). Sand lance spawning occurs between November 1st through February 15th (WDFW 2004b). This species of forage fish usually deposit eggs in the sand in the high intertidal between +5 feet to about the mean higher high water line (WDFW 2004b). Surf smelt spawn in the fall and winter months in the

Southern Puget Sound and Hood Canal (WDFW 2004c). These fish tend to spawn even higher in the sandy intertidal than other local forage fish, between +7 and the mean higher high water line (WDFW 2004c).

As these studies have indicated, the intertidal habitat utilized by sand lance and surf smelt for spawning is higher in elevation than where geoduck beds are planted. Therefore impacts related to planting should be minimal. Herring do spawn in the same tidal range utilized for the intertidal culture of geoducks. However, since the growers do not plant new beds in areas with eelgrass or in rocky areas where herring eggs may be present, impacts during the planting process should be generally avoided. However, it is notable that project personnel have rarely observed herring eggs attached to the protective tubes placed for planting the geoduck spat (Dave Robertson of Taylor Shellfish, per. comm.). In such cases, tubes are not disturbed in order to avoid adverse impacts to egg development.

Harvesting

Small internal combustion engines are utilized to pump water to the pressurized nozzles which are used to harvest geoduck. These water pumps are typically located in a small boat just offshore. This pumping noise and the offloading and loading of people, equipment and geoducks has the potential to cause some sort-term avoidance of fish at the project site. In addition, the water intake of the pump could cause some entrainment or impingement of fish. To limit entrainment, pump intakes are fitted with intake screens.

Potential impacts related to foot traffic and staging were discussed in the planting section also apply during harvesting. In-place Best Management Practices (BMP's) limit this kind of disturbance. If eelgrass happens to colonize a previously planted geoduck bed, harvesting will still take place. Under such conditions, the harvesting will more than likely displace individual eelgrass plants.

Erosion and surface water runoff related to harvesting practices causes increased sediment concentrations in the water column. The particle size distribution of substrate where the geoducks are planted will have an effect on the magnitude of this impact. Finer materials will stay suspended in the water column longer the coarser materials. The magnitude and length of the local tides will also influence the extent of this sedimentation. Observation recorded during a harvest effort showed that both total suspended solids and turbidity levels were near background concentrations within approximately 50 feet from the shoreline and 100 feet down current (Table 4-4). Since harvesting impacts through sedimentation occur infrequently (approximately once every 4 to 7 years) and the surrounding habitat is generally mud and silt, this should not cause any significant impacts to EFH.

When the geoducks are harvested the substrate (sand) is liquefied to extract the clam. This will cause a highly localized disturbance to the beach habitat to a depth approximately three feet over the entire area to be harvested. This disturbance may impact benthic and epibenthic invertebrates in the harvest area, which may result in the destruction of the associated fauna or cause a shift in the taxa composition. Since the geoducks are only harvested after 4 to 7 years, this impact is relatively infrequent. No studies were conducted to determine if the native benthic and epibenthic communities in areas of geoduck culture and controls sites exhibited any shifts in population composition or densities.

Estuaries in the Pacific Northwest experience moderate levels of natural disturbance mostly in the form of storm events. Endemic benthic and epibenthic invertebrates have adapted to this regime of disturbances and exhibit life history traits that enable rapid recovery from these episodic events. Some studies have shown that benthic communities can recover from devastating events such as hurricanes quite rapidly, in some cases within one year (Wolff 1973; Boesch et al. 1976). As long as the degree of anthropogenic disturbance does not exceed that to which the communities are adapted, endemic communities should rebound. Simenstad and Fresh (1995) found that disturbances associated other shellfish aquaculture practices in the Pacific Northwest (i.e. oysters and manila clams) fall within the scale of natural disturbance regimes. However, they pointed out that the temporal and spatial scale as well as the intensity of anthropogenic disturbances can influence the level of impact to endemic communities. Additional research is needed to determine at what levels of the aforementioned scales geoduck culture practices start to exceed natural disturbance regimes and alter the structure and function of intertidal habitat.

Divers commonly harvest naturally produced geoducks from subtidal habitat, as previously discussed. The impacts associated with this harvest method are similar to those of the intertidal harvest methods with a few exceptions. There is no foot traffic or staging area on the beach therefore impacts related to foot traffic and staging are no longer relevant. Erosion from surface water runoff related to beach harvesting practices is not relevant. Although sub-surface harvest in intertidal areas has not been evaluated. Short and Walton (1992) evaluated sediment transport related to subtidal harvest. Sediment suspension and transport associated with this type of harvest is relatively localized. This study measured the sediment plumes at a 0.05 m/sec current and found the plume extended down-current approximately 60 meters and was about 10-15 meters wide.

5.1.2 Long Term Effect

Grow-out

Some direct modification of EFH and ESA-critical habitat will arise from the placement of protective tubes and the additional biomass of the planted geoducks. Comparison of planted and unplanted intertidal habitat indicates that a slight increase in both taxa abundance and density for certain species in areas with tubes compared to surrounding areas. The species composition in tube areas is more similar to nearby eelgrass habitat than nearby open habitat. The tubes most likely provide additional habitat structure that is attractive to many invertebrate species. The increase in biomass may lead to additional sources of prey for fish species (e.g. flatfish and salmonid juveniles) under the jurisdiction of the Magnuson–Stevens Fishery Conservation and Management Act adding to the productivity of EFH in the action area.

The impact of intertidal geoduck aquaculture on the trophic status of estuarine waters has not been studied extensively and is not well understood. There are two primary mechanisms by which marine bivalves may influence water quality and water clarity 1) removal of nutrients from the water column as a result of feeding activity, and 2) addition of nutrients resulting from metabolic wastes in the form of both particulate and dissolved materials. Nutrients removed from the water column are, in effect, "fixed" in the biomass of the clam or are deposited on the substrate in the form of feces or psuedofeces. The dissolved portion of the metabolic waste is excreted into the sediments and water column and may serve as a significant source of nutrients for phytoplankton (Dame 1996). Both mechanisms have the potential to effect EFH in that eelgrass is sensitive to ambient light conditions in the water column and nutrient concentrations in the sediment.

It is clear that bivalves have tremendous filtering capacities. For example an individual geoduck clam is capable pumping 31 gallons of water per day (Taylor Resources unpublished data). In comparison, the Eastern Oyster (*Crassostrea virginica*) individuals may pump 14 gallons of water per day (Pietros and Rice 2003). Although we found no studies that specifically evaluated the relationship between geoduck clam filtering capacity and water clarity, numerous studies have evaluated the collective filtering capacity of other bivalves using assumptions regarding filtering rates and the total standing stock of biomass. In several cases (e.g., Delaware Bay and Chesapeake Bay) the bivalve filtration rate greatly exceeds the the residence time of water in the estuary (as reviewed in Dame 1996). It is also clear that eelgrass distribution and abundance is regulated, in part, by ambient light levels (Thom and Albright 1990, Duarte 1991, and Zimmerman et al. 1991). From a simple mechanistic perspective, it appears that increasing the biomass of geoduck clams in the intertidal zone could potentially improve light penetration and consequently improve conditions for eelgrass growth. The extent to which the additional geoduck biomass resulting from intertidal aquaculture clarifies water in Puget Sound thereby influencing eelgrass distribution is currently being studied by the Western Regional Aquaculture Center (unpublished).

There is some anecdotal evidence that eelgrass may encroach on geoduck beds after an area is planted (Jim Gibbons of Seattle Shellfish, per. comm.). Many studies have shown that suspension feeding bivalves such as oysters (*Crassostea virginica*) and blue mussels (*Mytilus edulis*) have the potential to increase seagrass productivity by increasing nutrient availability in the surrounding sediments (Haven and Morales-Alamo 1966; Peterson and Heck 1999; Pietros and Rice 2003). The bivalves remove nutrients in the water column in the form of phytoplankton and deposit nutrients to the seafloor in their feces and pseudo-feces. Peterson and Heck (2001) in an experimental manipulation of mussel densities (*Modiolus americanus*), doubled nitrogen and phosphorous concentrations in the sediment. This study also found that these nutrients were biologically available to the the seagrass *Thallasia testudinum* as indicated by increased leaf widths and lengths. The Western Regional Aquaculture Center (WRAC) recently began studies to determine if these same processes are present in the intertidal culture of geoducks. This study will investigate the relationship between clam culture and eelgrass productivity and distribution, and impacts on water quality and sediment fertilization. Results of these studies may be expected in 2008.

5.2 BULL TROUT, CHINOOK SALMON, AND CHUM SALMON

5.2.1 Direct Effects

Short Term Effect

Planting

Some limited avoidance of the immediate project site by ESA-listed fish bull trout, Puget Sound ESU chinook salmon and Hood Canal summer-run ESU chum salmon could occur from boat traffic and the unloading of materials to the beach. Since work is conducted on the exposed intertidal during planting, no other avoidance impacts are envisioned. Sediment disturbance during planting is minimal and impacts to nearshore water quality are not expected. Impacts to these fish are expected to be minimal during planting operations.

Harvesting

Small internal combustion engines are utilized to pump water to the pressurized nozzles which are used to harvest geoduck. These water pumps are typically located in a small boat just offshore. This pumping noise and the offloading and loading of people, equipment and geoducks has the potential to cause some short-term avoidance of ESA-listed fish at the project site. In addition, the water intake of the pump could cause some entrainment or impingement of fish. To limit entrainment, pump intakes are fitted with 2.38 mm intake screens.

Intertidal and subtidal harvesting practices cause a sediment plume in the water column. The duration of this plume is relatively short and the spatial extent is limited to a small area (see section 4.1.5). This sediment plume is expected to be small enough for fish to avoid or easily escape . The plume may cause the ESA listed salmonids to be displaced and/or avoid the area. However, this plume may also provide a feeding opportunity along the margins of the plume for some species of fish (Boehlert and Morgan). Impacts to ESA listed fish are expected to be minimal during harvesting operations.

Long Term Effects

Adult Hood Canal summer chum salmon and Puget Sound chinook use the nearshore environment as a migration corridor and as a staging area to their spawning stream. Bull Trout adults behave differently than chinook and chum salmon adults. They utilize the nearshore marine environment to forage. Juvenile chinook and chum salmon use the nearshore habitat extensively on their outmigration. Juvenile salmonids generally migrate along shallow shoreline habitat and will have a high likelihood of encountering the protective tubes when they are present. Yearling chinook and chum also utilize the nearshore environment to forage. However the tubes will pose no specific barrier to fish migration. The structure provided by culture tubes may be beneficial for foraging juvenile salmonids by providing refuge habitat from predation and current in an otherwise coverless environment. Adult salmonids would not be impacted since they do not use the nearshore environment appreciably. No negative long-term direct impacts are reasonably envisioned to occur to ESA listed fish.

5.2.2 Indirect Effects

Short Term Effects

As previously discussed, temporary planting and harvesting disturbances could cause some negative indirect short-term impacts by avoidance of the project areas by salmonid prey fish species due to an increase in turbidity and suspended sediment. However, these impacts should be minimal since they only occur only during a short duration once every 4-7 years. Critical habitat has been proposed for bull trout and chinook salmon, but no official ruling has been adopted (bull trout), or previous definitions are under revision (chinook salmon). Regardless, no loss of habitat critical to support any life history function of bull trout, chinook salmon, or chum salmon is predicted from the proposed action.

Long Term Effects

Subtidal surveys show a slight increase in both number of taxa present and in density for many of the species present in areas with tubes when compared to surrounding areas (see section 4.1.3). The tubes most likely provide additional habitat structure for epiphytes, and other invertebrates to grown on, that in turn can provide foraging opportunities for salmonids species. If the geoduck tubes do create structure and in turn increase prey species abundance, then a benefit to foraging juvenile salmonids could be assumed. No long term changes in the prey base for these fish are expected that would negatively affect either bull trout, chinook salmon or chum salmon.

5.3 BALD EAGLES AND MARBLED MURRELETS

5.3.1 Direct Effects

Short Term Effect

Short-term disturbances related to planting and harvesting activities might have some direct, short-term effects on bald eagles and marbled murrelets in the project vicinity.

Boats involved in the planting and harvesting of the geoduck may flush foraging eagles. Stationary boats may passively displace eagles from foraging areas, reducing foraging success (Watson et al. 1995). Boat presence can also reduce feeding times and the number of foraging attempts (McGarigal et al. 1991, in WDFW 2001b). Eagles foraging on the Columbia River estuary maintained an average distance of 400 meters from stationary boats (McGarigal et al. 1991, in Watson and Rodrick 2001). However, a two-year study conducted by the Washington Department of Fish and Wildlife (Watson et al. 1995) to assess the behavioral responses (foraging, search-capture time, perch visits, and number of flights) of nesting bald eagles to the subtidal harvest of geoduck clams, concluded there were no significant impacts. Eagles were flushed as a result of only one potential disturbance related to geoduck clam harvest during the study. The study concluded that subtidal geoduck harvest is unlikely to adversely impact productivity of bald eagles in Washington State based on the levels and types of eagle behavioral responses that we identified, the current State regulations governing harvest, and harvest tract locations."

Studies also suggest that bald eagles can become tolerant of human presence and activity, particularly the interaction with vehicles (Stalmaster and Kaiser 1998, Skagen 1980). In some cases, an increase in bald eagle foraging activity has been observed in geoduck cultivation areas during harvesting (Gibbons, pers. comm. 2004, and Robertson, pers. comm. 2004). No adverse effects are associated with this occurrence. The additional traffic and human presence associated with the project planting and harvesting is not expected to have any significant adverse effects on breeding or wintering bald eagles.

Direct impacts of planting and harvesting activities on marbled murrelets may result from human presence, boat use, and noise. Potential impacts include the initial flushing of birds from, bird avoidance of the areas, and a decrease in foraging activity. The implications of these effects on bird health and productivity will be minimal. The short duration and infrequent occurrence of planting and harvesting activities combined with the usual bird distance of 200 to 500 meters from the shore (SEI 1997) where geoduck tracts are located minimizes these potential disturbances. No short-term direct impacts on nesting marbled murrelets are expected as the average nest site in the Pacific Northwest is approximately 16.8 km inland (Ralph et al. 1995).

Long Term Impacts

Although some short-term direct impacts such as bird avoidance and temporary reductions in foraging activity may occur, no long-term direct impacts on bald eagles or marbled murrelets are expected.

5.3.2 Indirect Effects

Short Term

Temporary planting and harvesting related disturbances could have some indirect short-term impacts on bald eagles and marbled murrelets. Avoidance of Project areas by bald eagle and marbled murrelet prey may occur. This affect is expected to be minimal since disturbances to terrestrial and aquatic prey habitat will be minor and isolated and therefore, food sources will remain available within close proximity to pre-disturbance locations. Adverse short-term indirect effects are expected to insignificant.

Long Term

Habitat loss to bald eagle terrestrial prey (e.g. rodents) is non-existent and avoidance of the area by bald eagle and marbled murrelet marine prey is not expected. Long-term indirect impacts to bald eagles and marbled murrelets are likely to be insignificant.

5.4 CUMULATIVE, INTERRELATED AND INTERDEPENDENT EFFECTS

In addition to the potential environmental impacts arising from direct or indirect impacts, future and/or cumulative impacts from interrelated and interdependent actions in this action area are also considered. Cumulative effects analysis considers the impacts of other projects within the action area that are unrelated to the project actions specifically addressed by the programmatic BE but that may likely occur in the future. Interrelated effects are defined as those "activities that are part of the larger action and depend on the larger action for their justification," while interdependent effects are defined as actions "which have no independent utility apart from the proposed action being considered.

Cumulative effects include the effects of future state, tribal, local or private actions that are reasonably certain to occur in the action area considered in this biological assessment. Future federal actions or federally approved actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the Endangered Species Act. However, future State, tribal, local, and private actions that are "reasonably certain to occur" must be addressed in this section.

Because of the broad geographic area covered in this document, it is difficult to definitively identify each and every action that is "reasonably certain to occur" in the future. However, based on discussions with representatives of the shellfish industry and private landowners, it is clear that intertidal geoduck culture is a growing industry and that additional culture sites will be planted in the near future. Cumulative effects in the form of suspended sediment, periodic beach disturbance, and temporary avoidance by some listed species may occur. The magnitude of these cumulative effects will be limited for the following reasons. First, the total area of intertidal habitat that is both suitable for intertidal geoduck culture and available to consortium growers for aquaculture (i.e., no property access restrictions) is relatively small when compared to the total area of intertidal habitat in Puget Sound. This necessarily limits the magnitude and scale of disturbances related to consortium practices. Second, disturbances related to intertidal geoduck culture are punctuated and episodic and, typically, separated in space and time. In the unlikely event that two growers in the same area harvest at the same time, the duration of any negative impacts will be relatively short and within range of natural disturbances.

Cumulative effects may also occur as a result of increased development in nearshore areas. The numerous negative impacts related to shoreline development are both numerous and well documented. These impacts include degraded water quality, loss of vegetation, and increased shoreline erosion. Historically, the shellfish industry has promoted the improvement of water quality through efforts to reduce existing sources of pollution and promoting prevention of water quality degradation from future activities and developments.

The consortium growers own and operate a number of facilities that are designed to supply, service, or process products produced at the intertidal geoduck culture sites. Included in this group of facilities are shellfish hatcheries, project offices, equipment maintenance and storage facilities, and processing and distribution facilities. Because the consortium growers also culture many other shellfish species, none of these facilities can reasonably be construed to exist solely as a result of the proposed action. The facilities are not dependent on intertidal geoduck culture “for their justification”. It is also clear that these facilities have “independent utility apart from the proposed action”. Therefore, interrelated or interdependent effects as defined in the ESA Section 7 Consultation Handbook (1998) are not applicable in this case.

6.0 CONSERVATION MEASURES

The following measures will be implemented as part of the best practices of the consortium to ensure that impacts to ESA-listed species and EFH are minimized. These conservation measures have been informed by and are based on the best available science. Numerous studies are underway which will serve to fill information gaps and confirm or refute working hypotheses regarding the influence of intertidal geoduck culture on the structure and function of marine ecosystems. As new information becomes available or as the weight of evidence suggests that operational changes are needed, new and appropriate conservation measures will be adopted.

Site Selection

- Avoid planting in areas near or in native submerged aquatic vegetation (including eelgrass) that is well established.

- Select sites that will minimize sediment plumes. Suspended sediment impacts will likely be greatest at sites where the dominant grain size is small. This is true because small particles are easily entrained and more likely to remain suspended in the water column than large particles. Avoid sites where dominant grain size is less than 0.25 mm.

Planting

- Time planting to avoid spawning and incubation for sand lance (November 1st to February 15th) and herring (late January to early April).

- Select staging areas such that impacts to submerged aquatic vegetation is minimized or avoided. Staging areas will be strategically placed to discourage foot traffic through sensitive areas.

Tube Removal

- All tubes are left in place until May when herring eggs have hatched.

Harvesting

- Time harvest to avoid spawning and incubation for sand lance and herring. Areas will be examined for sand lance and herring spawn before harvest of an area is even considered. Cease harvest if eggs are observed at a work site.

- Select staging area locations such that impacts to submerged aquatic vegetation is minimized or avoided. Staging areas should be strategically placed to discourage foot traffic through sensitive areas.

- Place 2.38 mm screens on intake pumps to minimize potential entrainment of aquatic organisms.

Operation and Maintenance

- All debris or deleterious material resulting from culture practices should be removed from the beach area and bed and prevented from entering the waters. Conduct quarterly trash collection to pick up lost tops and tubes. Utilize equipment and practices to minimize loss of materials at intertidal culture sites.
- Project activities should not degrade water quality to the detriment of fish health. If a fish kill occurs or fish are observed in distress, the project activity will immediately cease and the local WDFW Habitat Program manager and Dept. of Ecology will be notified immediately.
- No petroleum products or other deleterious materials should enter surface waters. Compliance with the spill prevention plan should be ensured information provided to all personnel conducting work.
- Avoid or minimize the use of vehicles and other heavy equipment on sensitive intertidal areas and beaches.
- Where driving on the beach is unavoidable, routes will lead through intertidal areas to hard surfaces along the upper intertidal zone, minimizing intertidal interference to the maximum extent feasible. Shore crossings will be designated at single locations, choosing the shortest route possible, so disturbance to the foreshore is minimized.
- Ensure that pumps, boat motors, and harvesting equipment are routinely serviced in order to avoid/minimize the loss of fluids.
- Optional: Where petroleum products are used, consortium growers will have in their possession, at harvesting sites, equipment necessary to address spills of hydraulic fluids and fuels including a small kit of absorbent materials and a mini-boom.
- Prepare a contingency plan for addressing vehicle breakdowns in the intertidal area.
- Fully insulated noise baffles will be placed on equipment to minimize potential disturbances for wildlife species including nesting bald eagles.

Independent Research

- The Western Regional Aquaculture Center, in association with Taylor Shellfish and Seattle Shellfish, recently began a research program to examine interactions of geoduck culture on eelgrass distribution and abundance. This research will be designed to identify the underlying mechanisms that influence eelgrass presence or absence in intertidal culture areas (e.g., altered nutrient concentrations, natural recruitment, etc.).

Monitoring

- Quantify the eelgrass presence at intertidal culture sites through the establishment of fixed photographic monitoring stations. Monitoring will be conducted on an annual basis.

7.0 DETERMINATION OF EFFECTS

7.1 ESSENTIAL FISH HABITAT

Some limited and short-term avoidance by fish could occur during planting and harvesting but impacts should be limited to the time at which sediments are disturbed, which is generally no more than two tidal cycles at most. Harvest related increases in suspended sediment concentrations are infrequent, relatively short in duration, and confined to localized areas. Because much of the intertidal and subtidal habitat in the Project Area consists of sand/mud intermixed with small gravel substrates in low energy zones, sediment entrainment and transport resulting from geoduck harvest is unlikely to alter the structure and function of adjacent or local habitats. Intertidal habitat is naturally subject to periodic storm disturbance and that punctuated episodes of high sediment concentrations in the water column are part of the natural disturbance regime. Consequently, impacts to EFH should not be significant, especially in relation to natural variations.

The potential for current culture practices to impact eelgrass and forage fish eggs is limited. New geoduck sites are not located in areas with existing eelgrass beds. Herring eggs are not disturbed if present and other forage fish spawn higher in the intertidal than the geoduck beds. Therefore trampling impacts to EFH should not be significant. The use of 2.38 mm intake screens should limit impacts related to entertainment and impingement of fish during water pumping.

Geoducks are only harvested after four to seven years, and therefore this impact is relatively infrequent on a temporal scale. Geoduck beds range in size from 0.25 to 21 acres with an average of 2.9 acres (Table 2-1). Harvest intensity is relatively small, approximately one half acre per tide cycle. While the impact to endemic benthic and epibenthic invertebrates could be significant in the short-term, recovery should be relatively quick. Disturbance impacts to EFH habitat are not expected to be significant.

Essential Fish Habitat in the geoduck culture beds will be temporarily modified by the placement of protective tubes and the added biomass of geoducks. Initial studies suggest that species composition and densities may increase in the presence of culture tubes. Additional research is needed to determine if these trends are statistically significant. Regardless, these changes may not be detrimental to the EFH and may be beneficial by increasing local densities of fauna.

Eelgrass encroachment into the geoduck culture beds may occur as a result of any one of a number of mechanisms. For example, altered nutrient concentrations in the substrate resulting from the deposition of geoduck feces and psuedofeces may influence eelgrass distribution. Studies from other parts of the country have found that biodeposition from bivalves increased nutrient concentrations in the sediment (Pietros and Rice 2003) which increased submerged aquatic vegetation productivity and growth (Haven and Morales-Alamo 1966; Peterson and Heck 1999). Numerous studies suggest that suspension feeding bivalves increase water clarity and enhance water quality (Dame 1996, Newell

1998) although ability to influence these parameters may be dependant upon phytoplankton regeneration rates (Pietros and Rice 2003). Sensitivity to ambient light conditions is a documented trait of eelgrass (Thom and Albright 1990, Duarte 1991, Zimmerman et al. 1991) and increased filter feeder densities may serve to benefit eelgrass. One additional hypothesis that should be considered is that eelgrass colonization in intertidal culture sites may be part of natural processes and is not related to geoduck aquaculture. As mentioned previously, additional research designed to identify the underlying mechanisms that control eelgrass recruitment in around intertidal culture sites is underway.

None of the impacts discussed are expected to adversely affect EFH. Even when each possible impact is examined collectively, many of the impacts are separated by space and/or time therefore impacts will not be cumulative. Based upon the NMFS and USFWS guidelines a conclusion of **may affect, but not likely to adversely affect Essential Fish Habitat** is given.

7.2 ESA-LISTED BULL TROUT, CHINOOK SALMON, AND CHUM SALMON

The geoduck aquaculture operations are not expected to impact the threatened bull trout, chinook salmon or chum salmon. The protective tubes may generally increase the functionality of the existing habitat to support salmonids species, by increasing the habitat diversity without causing long-term water quality impacts. Temporary water quality disturbances will not result in a take of any ESA listed species, but may result in short term behavioral avoidance. **Therefore, a conclusion of may effect but not likely to adversely affect bull trout, the Puget Sound ESU of chinook salmon and the Hood Canal Summer-Run ESU of chum salmon is proposed for this project.**

7.3 BALD EAGLES AND MARBLED MURRELETS

Wintering bald eagles that utilize the shorelines in the project vicinity are not anticipated to undergo any significant impacts from project intertidal geoduck planting and harvesting. Temporary human presence may result in some avoidance of the area by bald eagles during heavy use periods. However, multiple routes to and from principal feeding grounds of the eagle will be maintained. This BE concludes that the proposed **actions may affect, but are not likely to adversely affect bald eagles. Furthermore, the proposed action will result in no adverse modification or destruction of designated critical habitat for this species.**

Marbled murrelets may visit the action area for the proposed expansion project on a limited bases. If these birds do occur in the action area, the same impacts predicted for bald eagles should apply. Therefore this programmatic BE concludes that the proposed **actions may affect, but are not likely to adversely affect marbled murrelets. Furthermore, the proposed action will result in no adverse modification or destruction of designated critical habitat for this species.**

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