UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Northwest Region
7600 Sand Point Way N.E., Bldg. 1
Seattle, Washington 98115

Refer to NMFS Number: 2008/04151

April 28, 2009

Lawrence C. Evans
Chief, Regulatory Branch
Department of the Army
Portland District, Corps of Engineers
PO Box 2946
Portland, OR 97208-2946

Re: Endangered Species Act Section 7 Formal Programmatic Consultation and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation for Nationwide Permit 48 Activities in Washington State.

Dear Mr. Evans:

The U.S. Army Corps of Engineers (COE) and the National Marine Fisheries Service (NMFS) recently completed interagency consultation under Endangered Species Act (ESA) section 7(a)(2) and Essential Fish Habitat (EFH) consultation under section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) on the COE's proposal to issue Nationwide Permit (NWP) 48. The NWP 48 would cover ongoing shellfish aquaculture operations in Washington State. The enclosed document includes NMFS ESA section 7 Biological Opinion (Opinion) and EFH consultation.

As stated in the Opinion, NMFS concludes consultation determining that the proposed action is not likely to jeopardize the continued existence of the following 25 marine and anadromous species listed under the ESA: Steller sea lion (*Eumetopias jubatus)*, Humpback whale (*Megaptera novaeangliae*), Southern Resident killer whale (*Orcinus orca*), Loggerhead sea turtle, (*Caretta caretta*), Green sea turtle (*Chelonia mydas*), Leatherback sea turtle (*Dermochelys coriacea*), Olive ridley sea turtle (*Lepidochelys olivacea*), Green sturgeon southern DPS (*Acipenser medirosris*), Columbia River chum salmon (*Oncorhynchus keta*), Hood Canal summer-run chum salmon (*O. keta*), Lower Columbia River coho salmon (*O. kisutch*), Lower Columbia River steelhead (*O. mykiss*), Middle Columbia River steelhead (*O. mykiss*), Snake River steelhead (*O. mykiss*), Upper Willamette River steelhead (*O. mykiss*), Puget Sound steelhead (*O. mykiss*), Upper Columbia River steelhead (*O. mykiss*), Lake Ozette sockeye salmon (*O. nerka*), Snake River sockeye (*O. nerka*), Lower Columbia River Chinook salmon (*O.tshawytscha*), Upper Willamette River Chinook salmon (*O. tshawytscha*), Snake River spring/summer fun Chinook salmon (*O. tshawytscha*), Snake River fall-run Chinook salmon (*O.tshawytscha*), Puget Sound Chinook salmon (*O. tshawytscha*), and Upper Columbia River spring-run Chinook salmon (*O. tshawytscha*).

The NMFS also concludes that proposed action will not adversely modify or destroy critical habitat for each of these species except Puget Sound steelhead, for which critical habitat has not been designated. Finally, the green sturgeon determination on proposed critical habitat was completed by conference.

Before initiating formal consultation, NMFS concurred with the COE's determination that the proposed action may affect, but is not likely to adversely affect Upper Columbia River (UCR) spring-run Chinook salmon, Snake River (SR) fall-run Chinook salmon, SR spring/summer-run Chinook Salmon, Upper Willamette River (UWR) Chinook salmon, Hood Canal summer-run chum salmon, SR sockeye salmon, Lake Ozette sockeye salmon, LCR coho salmon, Puget Sound steelhead, LCR steelhead, Middle Columbia River (MCR) steelhead, UCR steelhead, SR Basin steelhead, UWR steelhead, Steller sea lion, Humpback whale, and Southern resident killer whale. Therefore, those species were not the subject of formal consultation and are not discussed in the Opinion.

Initially, NMFS determined that the proposed action is likely to adversely affect LCR Chinook salmon, CR chum salmon, Puget Sound Chinook salmon, and the southern DPS of green sturgeon. During consultation, NMFS concluded that while actions conducted under the proposed NWP 48 would have environmental effects, these effects were not reasonably certain to impair normal behaviors resulting in their actual injury or death. Therefore, the action is not reasonably certain to cause incidental take of listed species and the incidental take provision included with the Opinion does not estimate the a quantity of the amount or extent of anticipated take. Nor does that section provide any reasonable and prudent measures (RPMs) or Terms and Conditions (T&Cs).

This document also includes the results of our analysis of the action's likely effects on EFH pursuant to section 305(b) of the MSA, and includes six conservation recommendations to avoid, minimize, or otherwise offset potential adverse effects on EFH. Since there are no ESA T&Cs, the EFH conservation recommendations are unique to the EFH consultation. Section 305(b)(4)(B) of the MSA requires Federal agencies to provide a detailed written response to NMFS within 30 days after receiving these recommendations.

If the response is inconsistent with the EFH conservation recommendation, the Corps must explain why the recommendations will not be followed, including the scientific justification for any disagreements over the effects of the action and the recommendations. In response to increased oversight of overall EFH program effectiveness by the Office of Management and Budget, NMFS established a quarterly reporting requirement to determine how many conservation recommendations are provided as part of each EFH consultation and how many are adopted by the action agency. Therefore, in your statutory reply to the EFH portion of this consultation, we ask that you clearly identify the number of conservation recommendations accepted.

If you have questions regarding this consultation, please contact Dan Guy in the Southwest Washington Habitat Branch of the Washington State Habitat Office at (360)753-9530 or Dan.Guy@noaa.gov.

Sincerely,

for Barry A. Thom
Acting Regional Administrator

Enclosure

cc: Andrea LaTier, USFWS
William Abadie, COE

Endangered Species Act – Section 7 Programmatic Consultation Biological and Conference Opinion

And

Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation

Nationwide Permit 48 Washington

Lead Action Agencies: U.S. Army Corps of Engineers

Consultation Conducted By: National Marine Fisheries Service
Northwest Region

Date Issued: April 28, 2009

Issued by: Michael Tehan for
Barry A. Thom
Acting Regional Administrator

NMFS Tracking Number: 2008/04151

TABLE OF CONTENTS

ACRONYM GLOSSARY

AChE	Acetylcholinesterase
BA	Biological Assessment
BMP	Best Management Practices
BRT	Biological Review Team
CFR	Code of Federal Regulations
CH	Critical Habitat
CHART	Critical Habitat Review Team
COE	U.S. Army Corps of Engineers
CR	Columbia River
CRMC	Coastal Resources Management Council
DO	Dissolved Oxygen
DPS	Distinct Population Segment
DQA	Data Quality Act
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
ESA	Endangered Species Act
ESU	Evolutionarily Significant Units
FLUPSY	Floating Upwelling System
FR	Federal Register
GHSAA	Grays Harbor sub-action area
HAPC	Habitat Areas of Particular Concern
HUC	Hydrologic Unit Code
IPM	Integrated Pest Management
ITS	Incidental Take Statement
LCR	Lower Columbia River
LWD	Large Woody Debris
MCR	Middle Columbia River
Mg/L	milligrams per liter
MHHW	Mean Higher High Water
MM	Millimeter
MSA	Magnuson-Stevens Fishery Conservation and Management Act
N2	Nitrous Oxide or free nitrogen
NFH	National Fish Hatchery
NMFS	National Marine Fisheries Service
Northern DPS	Klamath River distinct population segment
NPDES	National Pollutant Discharge Elimination System
NTU	National Turbidity Units
NWP	Nationwide Permit
NWP 48	Nationwide Permit 48
Opinion	Biological Opinion
PAH	Polycyclic aromatic hydrocarbons
PBDE	Polybrominated dephenyl ethers
PCBs	PolyChlorinated Biphenyls

PCE	Primary Constituent Element
PCN	Pre-Construction Notification
PDO	Pacific Decadal Oscillation
PFMC	Pacific Fishery Management Council
PPB	Parts per billion
PS	Puget Sound
PSP	Paralytic Shellfish Poisoning
PVC	Polyvinyl Chloride
SAV	Submerged Aquatic Vegetation
Southern DPS	Sacramento-San Joaquin distinct population segment
SPSAA	South Puget Sound Action area
SR	Snake River
TSS	Total Suspended Solids
UCR	Upper Columbia River
U.S.C.	United States Code
USFWS	U.S. Fish and Wildlife Service
UWR	Upper Willamette River
VSP	Viable Salmonid Populations
WDF	Washington Department of Fisheries
WDFW	Washington Department of Fish and Wildlife
WDNR	Washington Department of Natural Resources
WDOE	Washington State Department of Ecology
WRIA	Water Resource Inventory Area

INTRODUCTION

The biological opinion and conference opinion (Opinion) and Incidental Take Statement (ITS) portions of this consultation were prepared by the National Marine Fisheries Service (NMFS) in accordance with section 7(b) of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531, et seq.), and implementing regulations at 50 CFR 402. With respect to designated Critical Habitat (CH), the following analysis relied only on the statutory provisions of the ESA, and not on the regulatory definition of "destruction or adverse modification" at 50 CFR 402.02. The essential fish habitat (EFH) consultation was prepared in accordance with section 305(b)(2) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) (16 U.S.C. 1801, et seq.) and implementing regulations at 50 CFR 600.

This consultation was initiated before, but completed after January 15, 2009, the effective date of amendments to 50 CFR section 402 described in 73 FR 76272 (December 16, 2008). The NMFS has considered whether the analysis or corresponding conclusions and ITS would differ substantively depending on whether it applied the pre- or post-January 15 regulations, and has determined that it would not. The administrative record for this consultation is on file at the Washington State Habitat Office in Lacey Washington.

Background and Consultation History

On March 12, 2007, the U.S. Army Corps of Engineers (COE) announced the issuance of Nationwide Permit (NWP) 48, Existing Commercial Shellfish Aquaculture Activities. On June 30, 2008, NMFS received a written request for ESA section 7 formal programmatic consultation and EFH consultation from the COE on the effects of shellfish aquaculture activities associated with existing commercial shellfish growing farms in Washington State. A Biological Assessment (BA) analyzing the effects of the proposed action on listed species and CH accompanied this request. The BA also included the information necessary to complete an EFH assessment.

The NWP 48 authorizes the continuance of existing shellfish operations, subject to certain limitations. The NWP 48 is an unusual permit in that it authorizes the continuance of an activity (shellfish culture) that has been conducted for more than a century in Washington State. The COE determined that the proposed commercial shellfish aquaculture activities were "may affect, not likely to adversely affect" Lower Columbia River (LCR) Chinook salmon, Upper Columbia River (UCR) spring-run Chinook salmon, Puget Sound (PS) Chinook salmon, Snake River (SR) fall-run Chinook salmon, SR spring/summer-run Chinook salmon, Upper Willamette River (UWR) Chinook salmon, Columbia River (CR) chum salmon, Hood Canal summer-run chum salmon, SR sockeye salmon, Lake Ozette sockeye salmon, LCR coho salmon, LCR steelhead, Middle Columbia River (MCR) steelhead, UCR steelhead, SR Basin steelhead, UWR steelhead, PS steelhead, southern Distinct Population Segment (DPS) green sturgeon, Steller sea lion, Humpback whale, Southern resident killer whale. The COE also determined that the activities would not adversely affect CH, but would adversely affect EFH.

Early in the consultation the COE, NMFS, the U.S. Fish and Wildlife Service (USFWS), and shellfish growers met to discuss the proposed action. The purpose of the meetings was to gather appropriate information, review the best available science, and develop a process to evaluate the potential effects of the action on listed species, designated CH, and EFH.

The NMFS concurred with the COE's determination that the proposed action may affect, but is not likely to adversely affect UCR spring-run Chinook salmon, SR fall-run Chinook salmon, SR spring/summer-run Chinook Salmon, UWR Chinook salmon, SR sockeye salmon, Lake Ozette sockeye salmon, LCR coho salmon, PS steelhead, LCR steelhead, MCR steelhead, UCR steelhead, SR Basin steelhead, UWR steelhead, Steller sea lion, Humpback whale, Southern resident killer whale. For the Columbia Basin salmonids listed immediately above, NMFS has determined that they are not present in the action area and consequently not exposed to any of the effects of the action. Steller sea lion and Humpback whale, while conceivably present in Puget Sound, are not likely to venture into the near shore environment comprising the action area, and are therefore extremely unlikely to encounter any effects of the action. Lake Ozette sockeye are not present in the action area, and are not likely to encounter any effects of the action. Furthermore, PS steelhead life history is such that they quickly bypass the nearshore, using deeper, offshore water immediately after entry into the PS estuary, rendering exposure to any effects of the action unlikely. Therefore, none of these species is discussed further in this Opinion. Finally, an analysis supporting NMFS' concurrence with the COE determination that the proposed action is not likely to adversely affect Southern resident killer whales is appended to this Opinion.

The NMFS disagreed with the COE determinations as to certain species and initiated formal consultation on those species and their designated CH. The NMFS originally believed that the proposed action is likely to adversely affect LCR Chinook salmon, CR chum salmon, Hood Canal summer-run chum salmon, PS Chinook salmon, and the southern DPS of green sturgeon. During consultation, NMFS analyses revealed that although the activities carried out under the proposed action were likely to adversely affect the environment in the action area, they were not likely to adversely affect these species. The bases for this conclusion are described in the biological opinion, below. Furthermore, NMFS determined that although application of the insecticide, carbaryl, only occurs in the action area to support activities that will be carried out under the proposed action, they are not themselves part of the proposed action. In fact, the COE has no discretion to prescribe or otherwise regulate the application of carbaryl. Therefore, the effects of carbaryl application are analyzed with the effects of the action for the purpose of conducting the relevant jeopardy analyses, but the accompanying ITS does not exempt harm, wounding, or death of affected animals from the ESA section 9 prohibition against take.

Finally, NMFS proposed to designate CH for the southern DPS of green sturgeon and on September 8, 2008 (73 FR 52084) and provides a conference opinion on whether the proposed action will adversely modify proposed CH.

Description of the Proposed Action

The COE proposes to issue NWP 48 that covers certain activities of already ongoing shellfish aquaculture operations in Washington State. An "ongoing existing operation" is one that has been granted a permit, license, or lease from a state or local agency specifically authorizing commercial aquaculture and which has undertaken such activities prior to the date of issuance of the proposed NWP 48.

The areas of Washington State covered by the proposed NWP 48 include waters of the United States within Washington State occupied by existing commercial shellfish aquaculture operations. More specifically these areas include Willapa Bay, Grays Harbor, Hood Canal, and Puget Sound. Typically, those operations consist of several sites covered by the state or local aquaculture permit, license, or lease. Operations are not always spatially contiguous and can include areas in which there has been no recent aquaculture activity and/or areas that periodically are allowed to lie fallow as part of normal operations. Aquaculture resuming in fallow, previously operated areas will be covered by the proposed permit.

In addition to the permit coverage described above, NWP 48 will cover activities within existing operations that are relocated or expanded into portions of the project area that have been left fallow and are therefore not presently in use, but only where those activities meet the definition of "existing commercial aquaculture activity" as defined in the NWP 48 "Existing Commercial Shellfish Aquaculture Activities" (3/19/2007) available on the COE's NWR website. However, this latter group of activities will require Pre-Construction Notification (PCN) of the COE by the operator. The spatial total of aquaculture operations considered in this consultation as reported by the COE is approximately 38,327 acres. Effects of the action defining the action area considered in this consultation may also affect an additional area on the basis described in "Action Area," below.

The proposed NWP 48 will cover the installation of buoys, floats, racks, trays, nets, lines, tubes, containers, and other structures necessary for existing commercial aquaculture operations. Rafts and other floating structures will be securely anchored and clearly marked. The NWP 48 will also cover discharges of dredged or fill material necessary for shellfish seeding, rearing, cultivating, transplanting, and harvesting activities.

The proposed issuance of NWP 48 does not authorize or cover the effects of new operations or the expansion of an existing commercial shellfish operation except as noted above. The proposed issuance of NWP 48 does not cover the expansion of operation for the cultivation of new species (i.e., species not previously cultivated in the water body). The proposed issuance of NWP 48 does not cover construction of new attendant features such as docks, piers, boat ramps, stockpiles, staging areas, or depositing shell material back into waters of the United States as waste. These activities are not part of the proposed action and are not analyzed in this consultation document.

Finally, the NWP 48 will not cover pest management methods other than the installation of predator exclusion nets as considered in this consultation. The application of the pesticide, carbaryl in Willapa Bay and Grays Harbor is considered an interdependent activity and its effects are analyzed in this consultation as required in 50 CFR 402.02. However, the COE has no regulatory mechanism to affect the insecticide treatment to further avoid or minimize its impacts. Therefore, the ITS accompanying this Opinion does not repeat the assessment of the extent of harm, wounding, or death of affected animals. Nor does it exempt any harm, wounding, or death of affected animals from the ESA section 9 prohibition against take.

As mentioned above, some activities will require a PCN under the NWP 48. A PCN is required for projects where: (1) the project area is greater than 100 acres; (2) there is any reconfiguration of the aquaculture activity, such as relocating existing operations into portions of the project area not previously used for aquaculture activities; (3) there is a change in species being cultivated; (4) there is a change in culture methods (e.g., from bottom culture to off-bottom culture); or (5) dredge harvesting, tilling, or harrowing is conducted in areas inhabited by submerged aquatic vegetation (SAV).

For activities not requiring a PCN, the permittee will still report to the district engineer on: (1) the size of the project area for the commercial shellfish aquaculture activity (in acres); (2) the location of the activity; (3) a brief description of the culture method and harvesting method(s); (4) the name(s) of the cultivated species; and (5) whether canopy predator nets were used.

The use of a PCN enables the COE district office to review the project, in coordination with appropriate resource agencies, within a 45-day timeframe and respond to the applicant with either a verification of the applicability of the NWP 48 or a determination that an individual permit or other type of permit is required. If the COE does not respond within 45 days, the default result is verification that NWP 48 applies.

Shellfish Aquaculture in Washington State

The NWP 48 authorizes certain activities carried out by existing ongoing shellfish aquaculture operations, subject to certain limitations. Shellfish aquaculture includes some activities that are relevant to listed salmon, marine mammals, green sturgeon, and their CH and EFH by virtue of their effects on the environment. Many aspects of shellfish aquaculture do not have such effects. To provide a complete discussion of shellfish aquaculture, all aspects of aquaculture are described briefly below. Those aspects of aquaculture specifically relevant with negative effects to salmon and green sturgeon, and their CH and/or EFH because of their environmental effects are mentioned specifically in the Effects Analysis section of the Opinion and summarized again in the EFH consultation. The proposed NWP 48 includes one specific minimization measure to reduce turbidity impacts in that growers will be required to use washed sand or gravel only when such materials are used in bed preparation. The BA also lists, in chapter six, additional conservation measures which are proposed to be part of this action. These include the general provisions but also include:

- Cleanup of debris (geoduck tubes, nets, longlines, etc.) on grower beaches shall be performed on an annual basis.
- All pump intakes (for geoduck harvest, washing down gear, etc.) that use seawater should be screened in accordance with NMFS and Washington Department Fish and Wildlife criteria. Note: The NMFS recognizes this does not apply to work boat motor intakes (jet pumps).
- Re: All Terrain Vehicles: Vehicle wash water must be treated before discharge
- Vehicles will be stored, fueled, and maintained in a vehicle staging area placed 150 feet or more from any stream, waterbody or wetland where practicable. Where this practice is not practicable the operators shall have a spill prevention plan and maintain a spill

prevention kit, readily available, whenever refueling operations occur within 150 feet of the waterbody.

- Inspect all vehicles operated within 150 feet of any stream, waterbody or wetland daily for fluid leaks before leaving the vehicle staging area. Repair any leaks detected in the vehicle staging area before the vehicle resumes operation. Document inspections in a record that is available for review on request by COE or NMFS.
- And as previously noted; gravel used for shellfish bed preparation shall be washed prior to use in the subject waters. NOTE: The COE shall provide information about the percentage of fine sediments present, if gravel-washing is removed from the proposal.

<u>Activities Common to All Shellfish Aquaculture--Hatchery and Nursery Operations</u>

All shellfish culture species addressed in this document are grown from seed that is caught as wild spat onto cultch (mother shell) that is set out expressly for this purpose, or from seed produced in hatchery and nursery operations. Use of wild stock is relatively rare in most parts of the West Coast, but is still practiced extensively in Willapa Bay oyster culture and at Dabob Bay in Hood Canal, where most oyster beds are established naturally from spawning of the oysters currently cultured in these waterbodies. In Willapa Bay, the spawning occurs in early to mid-July, with spat settling out two to three weeks later. In Dabob Bay spawning typically occurs two to three weeks after Willapa Bay.

Hatchery and nursery operations can be divided into distinct sectors: algal production, larval rearing, nursery seed culture, and broodstock maintenance. Hatchery rearing is carried out onshore in special systems designed to achieve the highest survival rates possible. This operation occurs continuously throughout the year.

Algal production involves culturing a variety of phytoplankton for use as feed for larvae, seed, and broodstock. Algal tanks are filled with seawater, which is treated by filtering and then either heating or cooling, followed by sterilization either through heating, ultraviolet radiation, or by the addition of chlorine to kill microflora. If chlorine is used, it is then neutralized using sodium thiosulphate. A variety of species of microalgae are then added to the seawater and grown in isolated cultures of graduated sizes. These are used as inoculants to start larger cultures for use as feed. Algal cultures are grown under natural and artificial light.

Larval culture involves the rearing of free-swimming bivalve larvae. The larvae are free-swimming from the time the gametes are spawned by adult shellfish, until the larvae metamorphose and lose their ability to swim. The larvae are raised in tanks filled with filtered, heated seawater that is changed every few days or continuously refreshed. Metamorphosis varies depending on the bivalve species. Oyster larvae secrete glue and cement themselves on to hard substrates, preferably clean oyster shell. For cluster/shucked meat production whole shells are used to catch multiple larvae.

Nursery seed production is the rearing of larvae from the time they near the settle-out or setting phase, to the time they are ready for planting. Mature larvae are placed in tanks where they are allowed to settle out onto screens or cultch. Seawater and microalgae are pumped to the newly set larvae ("seed") to feed them. When the seed reaches a suitable size, depending upon species, the time of year and the end use, it is taken to a secondary nursery for further controlled growth, or delivered to farms for planting.

To offset the added costs of raising clam and oyster seed to a commercially viable size in primary nurseries, some companies have developed secondary floating and tideland nursery methods placed in the natural marine waters to take advantage of abundant naturally occurring algae.

Clam and mussel larvae do not require cultch, but can be set on screens in an up-well or flow-through system. Single set oyster seed are produced by inducing the larvae to set on tiny cultch fragments. This is usually made from grinding shells and then screening them to obtain uniform fragment sizes. The optimum size is large enough for one larva to settle on it, but small enough so two or more cannot. Once they have been set this way, single seed is commonly boosted in size by using a secondary nursery system such as a Floating Upwelling System (FLUPSY).

The FLUPSY, an integral part of many companies' seed production systems, is a highly efficient method for growing seed out to a larger size. It translates the technique of the tank-enclosed upweller to a much larger scale by moving the upwellers into a floating structure that continuously draws natural seawater through the system. Juvenile clams and oysters, one to two millimeters in length, are transported to the FLUPSY from shellfish primary hatcheries and nursery settings. The seed is placed in bins with screened bottoms that are lowered into openings in a floating frame and suspended in the seawater. Several bins are placed in a row on either side of a central enclosed channel that ends at a paddlewheel or pump. The wheel or pump draws water out of the central channel, creating an inflow of seawater through the bottom of the seed bins, continuously feeding the juvenile shellfish. The outflow from the bins is through a dropped section on one side of the bin facing the central channel. Typically, the FLUPSY platform is equipped with overhead hoists so the bins can be cleaned and moved. Once seed have reached a suitable size, they are removed from the FLUPSY and transplanted to a grow-out site.

Geoducks are not normally raised in a FLUPSY, but are grown to seed size in small screened containers that are filled with native-bed sand. The containers are placed on the beds to allow the seed to continue growing in a protected environment during a summer period where seawater can flow through naturally. These containers vary in size and shape depending on site conditions. Not all geoduck farms contain such nursery systems. If a farm does use pools, they generally require approximately 1,000 square feet of nursery for every three acres of geoduck plantings; thus, these systems occupy less than one percent of the farm acreage.

Broodstock maintenance consists of the care and feeding of adult bivalves used for propagating future generations of various shellfish species.

Activities Common to All Shellfish—Supporting Activities

Vessel Operations

Shellfish culture generally employs vessels to access the beds used in intertidal culture or the rafts used in suspended oyster and mussel culture. Typical vessels are small, open work boats powered by two- or four-stroke outboard motors. Vessels ferry crews and material to and from the culture beds and rafts. Larger work boats and occasionally barges are used for activities like spreading oyster shell or graveling, transporting rafts or mechanical equipment such as harvesters, and transporting harvested shellfish. The work boats serving shellfish beds are normally grounded on mudflats or vacant culture beds to load and offload personnel and equipment. These activities are conducted so as to cause the smallest possible impact or footprint in order to avoid damage to shellfish beds or creation of excessive turbidity, which is also harmful to shellfish beds. Vessels avoid grounding in areas of eelgrass to the extent practicable and vessel operations avoid eelgrass areas as far as possible. Large vessels are maintained and fueled at designated shore facilities, although small vessels used by small-scale growers are normally maintained and fueled at the growers' own docks.

Work on Beach

Crews must walk over the culture beds and immediately adjacent areas to perform almost all activities that occur on the beds. These include bed preparation, inspection and maintenance during grow-out, and harvest. At some sites, the beach is accessed directly from the land, and in these cases the crews also traverse (by foot or All Terrain Vehicle) the nearshore riparian environment. This is generally done along a pre-existing access route that, by virtue of repeated and ongoing use for this purpose, has low habitat value, and avoids more dispersed impacts to forage fish spawning habitat.

Onshore Facilities

After harvest, shellfish are transported to a processing house. Usually transportation is done by boat, truck, or a combination of these. Once received, shellstock may be processed directly or placed in cold dry storage or wet storage until ready for processing.

Wet storage is the temporary storage of shellstock in water after harvest from growing areas and before shipping or processing. The shellstock is placed in containers or floats in natural bodies of water or in tanks. The water used may be synthetic (made from potable water with salts added), or pumped from an adjacent water body. The water is typically filtered and disinfected using ultra violet light. Systems can be run in a flow-through mode with water released back to the adjacent water body, but are usually run in a recirculation mode. Regular cleaning of the tanks occurs. Any shell fragments or other solid wastes are disposed of in upland facilities. Water is released back to the source water body, or allowed to leach into upland gravel fields.

Wastewater, both fresh and saline, is a byproduct of offloading, storing, and rewashing shellfish in processing facilities. Wastewater resulting from processing operations is collected and reused or recycled. State regulations and the nature of the processing operations dictate the specific requirements for wastewater disposal.

Shells and shell fragments are the main by-product of processing shellfish. Whole oyster shell may be reclaimed for use as cultch. Shell may also be crushed for other uses. For example, the COE has used oyster shell as substrate in restoration projects, and growers often use old oyster shell to modify beach substrate for shellfish beds.

<u>Activities Specific to Mussel Raft and Longline Culture</u>

Two species of mussels are farmed on the United States west coast: *Mytilus trossulus*, commonly known as the Blue Mussel and *Mytilus galloprovincialis*, commonly known as the Mediterranean or Gallo Mussel. The mussel culture activities described below may be performed at any time of the day and at any time of the year. They are not dependent on season or tides.

Mussels are grown suspended from rafts or surface longlines anchored in subtidal waters. Raft platforms are constructed of lumber, aluminum, galvanized steel, and plywood. Raft sizes range from 30 by 34 feet, to 40 by 40 feet. Typically, two to three rafts are moored together to form a unit.

Flotation is made from reclaimed polyurethane food-grade barrels, or coated or vinyl-wrapped polystyrene foam. Raft structures and longlines are anchored in place with concrete anchors attached with nylon or polypropylene line. Raft cultures may be enclosed by nets to exclude predators. Surface longlines are made of heavy polypropylene or nylon rope suspended by floats or buoys attached at intervals along the lines and anchored in place at each end. Anchors are made of concrete, and floats are either foam filled or recycled food-grade containers.

Seeding

Naturally spawned mussel seed sets on lines or metal screen frames in net cages that are suspended in the water during the late spring spawning season. Hatchery seed, when used, is set on lines or screen frames at the nursery, and then transported to the mussel farm for planting. Once the seed reaches six to twelve millimeters long, which can take several months in winter or several weeks in summer, it is scraped from the frames or stripped from the lines and sluiced into polyethylene net sausage-like tubes, called "socks," each with a strand of line threaded down the length of the sock for strength. Concrete weights with stainless steel wire hooks are hung on the bottom end of each mussel sock for tension. The socks are then lashed to the raft, longlines or stakes, and suspended under the water.

Grow-out

When the mussels reach about one inch in length, the weights are often removed from the socks and saved for reuse. If the predator exclusion nets become fouled, blocking the flow of microalgae to the mussels, the nets may be removed, and shell or other debris cleaned off.

Harvesting

When the mussels reach market size, socks or lines of mussels are freed from the longline, stake or raft structure for cleaning and grading. The mussels are stripped from the socks and bulk-bagged and tagged for transport to shore and the processing plant. Weights are reclaimed for re-use, and used socking and lines are recycled or disposed of at an appropriate waste facility.

<u>Activities Specific to Oyster Culture</u>

Several species of oysters are cultured on the West Coast including the Pacific oyster (*Crassostrea gigas*), Olympia oyster (*Ostrea conchaphila*), Kumamoto oyster (*Crassostrea sikamea*), Eastern oyster (also known as American oyster) (*Crassostrea virginica*), and the European flat oyster (*Ostrea edulis*).

Productive oyster ground is dependent on a number of variables including salinity, temperature, substrate quality, water quality, and types of predators present. Oyster ground is often classified or referred to by its use, such as seed ground, grow-out ground or fattening beds.

Different approaches can be taken to oyster bed preparation, seeding, grow-out, and harvesting depending upon target market, beach characteristics, and environmental conditions.
For instance, bag, rack and bag, and suspended culture methods are typically employed to supply single oysters destined for the half-shell market. For the shucked meat market, however, oysters can be grown in clusters, so the method used is determined primarily by environmental conditions, such as substrate composition and the presence or absence of certain predators. Suspended cultures, such as longline and stake culture, are primarily used in areas that are not suitable for bottom culture.

Oyster culture activities and also clam culture activities are predominantly performed during tides that are low enough to expose the culture bed, so that operations can be performed by workers on foot. Such tides occur for a period of several days each lunar month (29 days). These tides occur near midnight in December, near noon in June, and at corresponding intermediate times in the other months. During these low tides, the workers may typically be on the bed for three to six hours, depending on tidal elevations. In this document, work performed during these monthly low tides is described as occurring "during low tide." Except as noted below, such work can occur at any time of the year.

Oyster Longline Culture

In some areas, silt may build up as a result of wave and wind action on the substrate and need to be leveled manually at the end of a growing cycle. Most residual oysters ("drop offs") dislodged from the lines during the previous growing cycle are removed from the ground prior to replanting. These actions are performed during low tides.

After a harvest, some growers pull all the pipe stakes from the bed, harvest residual drop-off oysters using bottom culture methods, and drag the ground to level it and remove debris before putting the stakes back for the next cycle. Other growers leave the stakes in place from cycle to cycle, depending on the conditions in their growing area.

Seed is prepared as described above under "oyster cultch preparation and setting." Stakes of metal or polyvinyl chloride (PVC) pipe are stuck in the ground in rows by hand during low tides. Long polypropylene or nylon lines with a piece of seeded oyster cultch attached approximately every foot are suspended above the ground by the stakes.

The oysters grow in clusters supported by the longlines, which keep them from sinking into soft substrate and protect them from certain pests and predators. Oysters are allowed to grow out over two to three years. Longlines are checked periodically during low tides to ensure that they remain secured to the PVC pipe and that the PVC pipe remains in place.

Longlined oysters may be harvested by hand or by machine. Hand harvest entails cutting oyster clusters off lines by hand at low tide and placing the clusters in harvest tubs equipped with buoys for retrieval by a vessel equipped with a boom crane or hydraulic hoist at a higher tide. The oysters are then barged to shore. Some smaller operations carry the tubs off the beach by hand.

With mechanical harvesting, buoys are attached at intervals along the lines at low tide. On a high tide, the buoys are hooked to a special reel mounted on a vessel that pulls the lines off the stakes and reels them onto the boat. The oyster clusters are cut from the lines, then barged to shore and transported to processing plants or market.

Oyster Rack-and-Bag Culture

Beds are prepared during low tides by removing debris such as small driftwood, and pests such as oyster drills. In some cases, the substrate is hardened with crushed oyster shells and/or gravel. The ground may be marked with stakes for working purposes. During low tides, some operations install lines and PVC pipe or metal stakes on the bed to secure the bags. Wood or metal racks may be used to support the bags off the ground. Racks with legs may be placed directly on the bottom, or supports may be driven into the bottom. Bags are typically attached to racks with reusable plastic or wire ties.

Single-set seed is placed in reusable plastic net bags closed with plastic ties or galvanized metal rings. Oysters are allowed to grow out in the bags on the metal or wooden racks. The operation is checked periodically during low tides to ensure that the bags remain secured to the racks. During harvest, bags are released from supports, if any, loaded into a boat or (during low tides) a wheelbarrow for transport to shore, and then transported to processing plants or market.

Oyster Stake Culture

Beds are prepared during low tides in the intertidal zone by removing debris such as small driftwood, and pests such as drills and starfish. In some areas, the substrate may occasionally be hardened with crushed oyster shells, but usually soft mud or sand bottoms require little or no enhancement. During low tide, stakes made of hard-surfaced non-toxic materials, such as PVC pipe, are driven into the ground approximately two feet apart to allow good water circulation and easy access at harvest. Stakes are typically limited to two feet in height to minimize obstruction to boaters.

Stakes can be seeded in hatchery setting tanks before being planted in the beds or bare stakes might be planted in areas where there is a reliable natural seed set. Bare stakes might be planted during the prior winter to allow barnacles and other organisms to attach to the stakes, increasing the surface area available for setting oyster spat. An alternative method of seeding is to attach from one to several pieces of seeded cultch to each stake.

Stakes are left in place through a two to four year growing cycle. Each piece of seeded cultch attached to stakes grows into a cluster of market-size oysters suspended above the mud and most pests. In areas where natural spawning occurs, multiple year classes of oysters grow on the stakes, with smaller, younger oysters growing on top of older oysters.

Oysters are selectively hand harvested during low tide by prying clusters of market-sized oysters from the stakes, or removing the clusters and the stakes, and placing them in baskets or buckets. The containers are tagged and either hand carried off the beach or loaded into a boat at a higher tide for transport to shore.

The clusters are separated into singles, sorted, culled and rinsed if destined for the single oyster market, or left as clusters if intended for the shucked oyster market, and transported to processing plants. Undersized single oysters from the clusters are transplanted to a special bed for grow-out, since they cannot reattach to the stakes, and are harvested using bottom culture methods when they reach market size.

Oysters that fall from or are knocked off the stakes are harvested periodically using bottom culture methods. Market-sized drop-offs that have not settled into the mud are harvested along with those pried from the stakes, and those that have settled into the mud are periodically picked and transplanted to firmer ground to improve their condition for harvest at a later time. Bed maintenance takes place during harvest when stakes are repositioned, straightened, or replaced, and the oysters are thinned to relieve overcrowding.

Oyster Bottom Culture

Prior to planting a new crop of oysters, oyster beds may be cleaned of debris such as small driftwood and pests such as oyster drills by hand or by dragging a chain or net bag during a low tide. The bag removes any oysters remaining on the bed after a harvest as well as pests, debris and mud build-up. If the substrate is too soft or muddy and not naturally suitable for planting oysters, it may be hardened, typically by spraying crushed shell, often mixed with washed gravel, from the deck of a barge using a pump and hose. Several runs are made over marked ground to ensure the material is spread evenly. The ground may be marked with stakes.

Seed oysters attached to cultch shell may be sprayed from the deck of barges or cast by hand onto marked beds at an even rate to achieve optimum densities. In some cases, farms rely solely on natural set of oyster seed on existing beds. If bottom culture is done with bags, single-set seed is placed in reusable plastic net bags closed with plastic ties or galvanized metal rings. The bags are placed in the intertidal zone directly on the ground during a low tide.

Oysters may be transplanted from one site to another at some point during grow-out. For example, oysters may be moved from an initial growing area to "fattening" grounds where higher levels of nutrients are found, allowing the oysters to grow more rapidly for market. Growers must abide by all transfer permits, regulations, and requirements when transplanting oysters from one area to another to assure pests (such as oyster drills) are not accidentally introduced into growing areas.

In areas where the substrate is soft, the oysters may sink into the mud, usually in response to substrate bioturbation caused by ghost and mud shrimp. Unlike clams that live in the substrate, oysters must stay on the surface to survive. When this happens, the oysters must be dug with a harrow to periodically pull them up out of the mud. The harrow is a skidder with rake-like tines, towed along the bottom by a boat. The harrow penetrates the substrate by a few inches and moves the oysters back to the surface.

During hand harvest, workers hand-pick oysters into bushel-sized containers at low tide. These may be emptied into large (10 to 30 bushel) containers equipped with ropes and buoys so they can be lifted with a boom crane onto the deck of a barge at high tide. Smaller containers are sometimes placed or dumped on decks of scows for retrieval at high tide or are carried off the beach at low tide.

In mechanical harvest, a harvest bag is lowered from a barge or boat by boom crane or hydraulic winch at high tide and pulled along the bottom to scoop up the oysters. Where feasible, the area may be hand harvested at low tide afterward to obtain any remaining oysters. After harvest, oysters are tagged and transported to processing plants.

Single oysters cultured loose on the bottom are often hand harvested into mesh bags or baskets to minimize handling and damage to shells. When single oyster culture on the bottom is done in hard plastic mesh bags, the bags are simply loaded into a boat or (during low tide) a wheelbarrow for transport to shore, then transported to processing plants or market.

Oyster Suspended Culture

Oysters are farmed in the subtidal zone using lantern nets, bags, trays, cages, or vertical ropes or wires suspended from surface longlines, or to a lesser extent, rafts. Surface longlines are heavy lines suspended by floats or buoys attached at intervals along the lines, anchored in place at each end. Lantern nets, adopted from Japanese shellfish culture, are stacks of round mesh-covered wire trays enclosed in tough plastic netting. The nets, bags, trays, cages, or vertical ropes or wires are hung from the surface longlines under the floats or buoys, or from rafts.

Single oysters are regularly sorted and graded throughout the growth cycle. Every three or four months the trays are pulled up, the stacks taken apart, oysters put through a hand or mechanical grading process, the trays restocked, stacks rebuilt and de-fouled and returned to the water. Oysters grown on vertical lines are in clusters and receive little attention between seeding and harvesting.

A vessel equipped with davits and winches works along the lines, and the trays, nets or bags are detached from the line one by one and lifted into the boat. The gear is washed down as it is pulled aboard. Oysters are emptied from the gear and placed into tubs, then cleaned and sorted on board the harvest vessel, on an on-site work raft, or at an offsite processing facility.

Oysters grown using suspended culture may be transplanted to an intertidal bed for two to four weeks to "harden." Hardening extends the shelf-life of suspended culture oysters by conditioning them to close their shells tightly when out of the water and retaining body fluids. Abrasion on the beach substrate literally hardens the shell making it less prone to chipping, breakage, and mortality during transport. If hardened, the oysters are re-harvested using bottom culture harvest methods. Alternatively oysters grown by suspended culture may be hung from docks when tidal cycles expose and harden them. This improves their shelf life as they are trained to close up tightly to survive between tidal cycles.

Littleneck, Manila, and Butter Clam

Clams are grown according to two methods considered during this consultation, ground culture and bag culture.

Ground Culture

Prior to planting clam seed on the tidelands, beds are prepared in a number of ways depending on the location. Bed preparation increases the chances of seed survival and allows for full use of available land. Types of preparatory work may include raking debris; adding gravel and/or crushed shell to the beach to create more suitable substrate; cleaning the beds of algae, mussel mats and other growth; and conducting environmental assessments of conditions, such as salinity and water quality. This work is done during low tide.

When graveling, a method termed "frosting" is preferred where several light layers are placed over many days in order to minimize the "burying" impact on the benthic and epibenthic environment. Frosting is only performed in previously treated areas. In addition to these types of activities, other preparations may include laying down netting to protect against predators such as crabs and ducks; and marking boundaries. Many growers remove the predator netting within a few days of planting clam seed, giving the clams enough time to burrow sufficiently into the substrate to avoid most predators, while minimizing the chances that netting will escape into the environment.

Typically, clam seed is planted in the spring and early summer. Most of the clam seed used comes from West Coast hatchery and nursery facilities; although natural sets of clams occur in some areas. Clam seed sizes and methods of seeding vary, depending on site-specific factors such as predators present and weather conditions. Planting methods include: hand-spreading seed at low tide upon bare, exposed substrate; hand-spreading seed on an incoming tide when the water is approximately four inches deep; hand-spreading seed on an outgoing tide when the water is approximately two to three feet deep; or spreading seed at high tide from a boat.

After each growing season, surveys and samplings are typically conducted during low tides to assess seed survival and spreading adequacy, and to estimate harvest yield for the upcoming year. Surveys determine whether additional seeding is required to supplement a natural set or poor hatchery seed survival. The goal is to maintain the optimum sustainable productivity of the growing ground.

Before harvest begins, bed boundaries are typically staked and any remaining predator netting is folded back during a low tide. Harvesting crews typically hand-dig clams during low tides, using a clam rake. Market-sized clams are selectively harvested, put in buckets, bagged, and tagged, and transported to processing plants. Undersized clams are left in beds for future harvests. Harvested clams are generally left in net bags in wet storage, either in the marine waters or upland tanks filled with seawater, to purge sand for at least 24 hours.

Technology has been developed to harvest clams mechanically, although this is utilized by only one or two growers at present. This technology may become more widely practiced due to labor and industry workforce concerns. Multiple crops may be in the ground at any time, depending upon the level of productivity of the ground. Beds may be dug annually, or as infrequently as once every four years.

Bag Culture

Prior to setting bags on the tidelands, debris is removed from the area to be planted and shallow (typically two to four inches) trenches may be dug during low tide with rakes or hoes to provide a more secure foundation for setting down the clam bags.

Clam seed (typically five to eight millimeters) is placed in reusable plastic net bags closed with plastic ties or galvanized metal rings. Substrate, consisting of gravel and shell fragments, may be added to the bags. Bags may be placed in shallow trenches during low tide and allowed to "silt-in," i.e., burrow into the substrate. In high current or wind areas, bags may be held in place with four- to-six inch metal stakes, placed by hand. Bags are monitored during low tides throughout the grow-out cycle to make sure they are properly secured, and turned occasionally to optimize growth.

When the clams reach market size, the bags are removed from the growing area. Harvesting occurs when there is one to two feet of water, so that sand and mud that accumulated in the bags during grow-out can be sieved from the bags in place. Bags are brought to the processing site, and any added substrate is separated for later reuse.

Geoduck Culture

Native geoduck (*Panopea abrupta*), the largest known burrowing clam, is a relatively new species for culture, and techniques are rapidly evolving and changing. Currently, Washington is the principal U.S. state actively farming geoducks, though there are pilot operations in Alaska. Farms are located in the intertidal zone, although subtidal farming of geoducks is currently in an initial experimental phase.

Prior to planting geoduck, bed preparation may include raking debris and cleaning the beds of algae, mussel mats and other growth. This work is done during low tide.

The most common method of culture currently in use consists of placing 10- to 12-inch long sections of four to six inch-diameter PVC pipe by hand into the substrate during low tide, usually leaving two to three inches of pipe exposed. Two to four seed clams are placed in each tube where they burrow into the substrate. The top of each pipe is covered with a plastic mesh net and secured with a rubber band to exclude predators. Additional netting may be placed over the tube field in addition to or in lieu of individual nets to prevent the tubes from being dislodged due to storm or wind and wave action.

Tubes and netting are removed after one or two growing seasons, once the young clams have buried themselves to a depth adequate to evade predators, normally about 14 inches. The tubes are saved to reuse at another planting. Used nets are cleaned and re-used, or disposed of in upland waste facilities.

When geoducks reach market size, approximately two pounds in four to seven years, the crop is harvested, either at low tide or, if at high tide, by divers. The geoduck, which have burrowed as far as three feet into the sand, are extracted by loosening the sand around each clam using a pressurized hose and nozzle, spraying approximately 20 gallons per minute of seawater delivered at approximately 40 pounds per square inch pressure.

The clam can then be pulled easily to the surface without damaging the animal. Small internal combustion engines are utilized to pump the seawater. These water pumps are typically located in a small boat just offshore of the harvest work. The water intakes of the pumps are fitted with intake screens to prevent entrainment of fish.

After harvest, clams are transferred to upland facilities by truck or brought to shore by boat on a flood tide and then transported to processing facilities.

Interdependent and Interrelated Actions

The joint consultation regulations (50 CFR 402 et. seq.) require consideration of the effects of interrelated and interdependent actions during consultation. Interrelated actions are those that are part of a larger action and depend on the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration (50 CFR 402.02).

During consultation, NMFS and the COE identified the use of the pesticide carbaryl as an interdependent action. Growers use the material as part of their aquaculture management operations and would not do so in the absence of those operations. Carbaryl, a carbamate insecticide with the trade name Sevin, has been applied to control burrowing ghost shrimp (*Neotrypaea californiensis*) and mud shrimp (*Upogebia pugettensis*) in Willapa Bay oyster beds since 1963. The Washington State Department of Ecology (WDOE), National Pollutant Discharge Elimnation System (NPDES) Permit No. WA0040975, currently allows treatment of up to 600 acres annually at the rate of eight pounds active ingredient per acre. Up to 200 acres may be similarly treated in Grays Harbor. Spraying may take place during low tides from July through October.

Willapa Bay and Grays Harbor are the only U.S. marine waters where the use of carbaryl or other insecticides is permitted. Carbaryl is applied as a soluble powder to tidelands at low spring or summer (primarily) tides, usually by helicopter. Hand spraying may be used in some instances. Carbaryl may be applied to commercial oyster beds when shrimp infestations exceed more than ten shrimp burrows per square meter.

The helicopters used to apply carbaryl are equipped with a ten-foot boom with large orifice nozzles directed downward. The droplet size is relatively high compared to most aerially applied pesticides, averaging 1,400 to 1,500 µm in diameter, increasing droplet weight and reducing evaporation. Sprayed material falls directly from the helicopter's nozzles to precisely target the treatment area. To minimize drift, carbaryl is applied from a height of 10 to 20 feet above the beds when wind speed is less than ten miles per hour. To further minimize impacts to sensitive species and habitat, aerial applications are restricted from within 200 feet of a channel or slough.

Action Area

The action area is all areas directly or indirectly affected by the Federal action and not merely the immediate area involved in the action (50 C.F.R. 402.02). The action area for this consultation consists of several, non-contiguous portions of the waters of Washington State in which ongoing shellfish aquaculture operations affect the local environment. These areas include small, separate locations in parts of Puget Sound (including Hood Canal), Willapa Bay, and Grays Harbor. The larger geographic area containing the action area is depicted in Figure 1, below, but the action area itself is but a fraction of the geography depicted in that figure.

The action area specifically includes the total area within the footprint of sites under present aquaculture operations, which includes areas that have been previously managed but might now be fallow. In addition, the action area includes additional area surrounding each individual managed site to account for the drift of turbid water beyond the footprint of each managed site. After reviewing data and studies related to turbidity settlement in the marine environment, where covered operations cause turbid water, the effects of turbidity are likely to extend to an area at most 5 percent larger than the footprint of the plot from which the turbidity emanates.
All activities affecting listed species considered in this consultation will occur on: (1) land that is currently being used for shellfish aquaculture; (2) land that is currently laying fallow as part of a rotational cycle; and (3) locations within the range of ESA-listed species, designated CH, and/or EFH designated under the MSA.

Action areas involved in this consultation are also designated as EFH for Pacific Coast groundfish (PFMC 2006), coastal pelagic species (PFMC 1998), and/or Pacific Coast salmon (PFMC 1999), or are in areas where environmental effects of the proposed project may adversely affect designated EFH for those species.

ENDANGERED SPECIES ACT

The Endangered Species Act establishes a national program to conserve threatened and endangered species of fish, wildlife, plants, and the habitat on which they depend. Section 7(a)(2) of the ESA requires Federal agencies to consult with USFWS and NMFS to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or adversely modify or destroy their designated CHs. Section 7(b)(4) requires the provision of an ITS that specifies the impact of any incidental taking and includes reasonable and prudent measures to minimize such impacts.

Biological and Conference Opinion

This Programmatic Opinion presents NMFS' review of the status of each listed species of Pacific salmon and southern DPS green sturgeon[1] considered in this consultation, the condition of designated CH, the environmental baseline for the action area, all the effects of the action as proposed, and cumulative effects (50 CFR 402.14(g)). For the jeopardy analysis, NMFS analyzes those combined factors to conclude whether the proposed action is likely to appreciably reduce the likelihood of both the survival and recovery of the affected listed species.

The CH analysis determines whether the proposed action will destroy or adversely modify designated CH for listed species by examining any change in the conservation value of the essential features of that CH. The regulatory definition of "destruction or adverse modification" at 50 CFR 402.02 is not used in this analysis. Instead, the analysis relies on statutory provisions of the ESA, including those in section 3 that define "critical habitat" and "conservation," in section 4 that describe the designation process, and in section 7 that sets forth the substantive protections and procedural aspects of consultation, and on agency guidance for application of the "destruction or adverse modification" standard.[2]

Status of the Species

This section defines the biological requirements of each listed species affected by the proposed action, and the status of each designated CH relative to those requirements. Listed species facing

[1] "An 'evolutionarily significant unit' (ESU) of Pacific salmon (Waples 1991) and a 'distinct population segment' (DPS) of steelhead (1/05/06; 71 FR 834) are considered to be 'species,' as defined in Section 3 of the ESA."

[2] Memorandum from William T. Hogarth to Regional Administrators, Office of Protected Resources, NMFS (Application of the "Destruction or Adverse Modification" Standard Under Section 7(a)(2) of the Endangered Species Act) (November 7, 2005).

a high risk of extinction and CHs with degraded conservation value are more vulnerable to the aggregation of effects considered under the environmental baseline, the effects of the proposed action, and cumulative effects.

The NMFS reviews the listed salmon and species affected by the proposed action using criteria that describe a viable salmonid population (VSP) (McElhany et al. 2000). Green sturgeon is considered separately according to its own criteria for extinction risk. Attributes associated with a VSP include abundance; productivity, spatial structure, and genetic diversity that maintain its capacity to adapt to various environmental conditions and allow it sustain itself in the natural environment. These attributes are influenced by survival, behavior, and experiences throughout the entire life cycle, characteristics that are influenced, in turn, by habitat and other environmental conditions. Table 1 lists Federal Register notices for final rules that list threatened and endangered species, designate CHs, or apply protective regulations to listed species considered in this consultation.

Table 1. Federal Register notices for final rules that list threatened and endangered species, designate CHs, or apply protective regulations to listed species considered in this consultation. (Listing status: 'T' means listed as threatened under the ESA; 'E' means listed as endangered; 'P' means proposed).

Species	Listing Status	Critical Habitat	Protective Regulations
Chinook salmon (*Oncorhynchus tshawytscha*)			
Lower Columbia River	T 6/28/05; 70 FR 37160	9/02/05; 70 FR 52630	6/28/05; 70 FR 37160
Puget Sound	T 6/28/05; 70 FR 37160	9/02/05; 70 FR 52630	6/28/05; 70 FR 37160
Chum salmon *(O. keta*)			
Columbia River	T 6/28/05; 70 FR 37160	9/02/05; 70 FR 52630	6/28/05; 70 FR 37160
Hood Canal summer-run	T 6/28/05; 70 FR 37160	9/02/05; 70 FR 52630	6/28/05; 70 FR 37160
Green Sturgeon (*Acipenser medirostris)*			
Southern DPS	T 4/7/06; 71 FR 17757	P9/8/08; 73 FR 52084	Not promulgated

Lower Columbia River Chinook Salmon

The status of LCR Chinook salmon was initially reviewed by NMFS in 1998 (Myers et al. 1998) and updated by the biological review team (BRT) in that same year (NMFS 1998). In the 1998 update, the BRT noted several concerns for this listed species. The BRT was concerned that there were very few naturally self-sustaining populations of native Chinook salmon remaining in the LCR. A majority of the previous (1998) BRT concluded that the LCR Chinook salmon were likely to become endangered in the foreseeable future. A minority felt that LCR Chinook salmon were not presently in danger of extinction, nor were they likely to become so in the foreseeable future.

New data acquired for the Good et al. (2005) report includes spawner abundance estimates through 2001, new estimates of the fraction of hatchery spawners and harvest estimates.
In addition, estimates of historical abundance have been provided by the WDFW. Information on recent hatchery releases was also obtained. New analyses include the designation of relatively demographically independent populations, recalculation of previous BRT metrics with additional years data, estimates of median annual growth rate under different assumptions about

the reproductive success of hatchery fish, and estimates of current and historically available kilometers of stream.

A majority (71 percent) of the BRT votes for LCR Chinook salmon fell in the likely to become endangered category, with minorities falling in the in danger of extinction and not likely to become endangered categories. The BRT reported moderately high concerns for each of the characteristics of VSP elements. The BRT noted specific estimates of moderate to moderately high risk for abundance and diversity, but maintained that all of the risk factors identified in prior status reviews were still considered important by the BRT. The Willamette/Lower Columbia River Technical Review Team has estimated that eight to ten historic populations have been extirpated, most of them spring-run populations. Near loss of that important life history type remains an important BRT concern. Although some natural production currently occurs in 20 or so populations, only one exceeds 1,000 spawners. High hatchery production continues to pose genetic and ecological risks to natural populations and to mask their performance. Most LCR Chinook salmon populations have not seen increases in recent years as pronounced as those that have occurred in many other geographic areas.

Limiting factors identified for this species include: (1) Reduced access to spawning/rearing habitat in tributaries, (2) hatchery impacts, (3) loss of habitat diversity and channel stability in tributaries, (4) excessive fine sediment in spawning gravels, (5) elevated water temperature in tributaries, and (6) harvest impacts (NMFS 2005b).

Puget Sound Chinook Salmon

The PS Chinook salmon evolutionarily significant unit (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 (March 24,1999, 64 FR 14208). The PS Chinook salmon ESU is composed of 31 historically quasi-independent populations, 22 of which are believed to be extant currently (NMFS-TRT 2001). The populations presumed to be extinct are mostly early returning fish; most of these are in central to southern Puget Sound or Hood Canal and the Strait of Juan de Fuca. The ESU populations with the greatest estimated fractions of hatchery fish tend to be in central to southern PS, Hood Canal, and the Strait of Juan de Fuca.

Twenty-six artificial propagation programs are considered to be part of the ESU. Eight of the programs are directed at conservation, and are specifically implemented to preserve and increase the abundance of native populations in their natal watersheds where habitat needed to sustain the populations naturally at viable levels has been lost or degraded. Each of these conservation hatchery programs includes research, monitoring, and evaluation activities designed to determine success in recovering the propagated populations to viable levels, and to determine the demographic, ecological, and genetic effects of each program on target and non-target salmonid populations. The remaining programs considered to be part of the ESU are operated primarily for fisheries harvest augmentation purposes (some of which also function as research programs) using transplanted within-ESU-origin Chinook salmon as broodstock. The NMFS determined that these artificially propagated stocks are no more divergent relative to the local natural population(s) than what would be expected between closely related natural populations within the ESU (NMFS, 2005a).

Assessing extinction risk for the PS Chinook salmon ESU is complicated by high levels of hatchery production and a limited availability of information on the fraction of natural spawners that are of hatchery-origin. Although populations in the ESU have not experienced the dramatic increases in abundance in the last two to three years that have been evident in many other ESUs, more populations have shown modest increases in escapement in recent years than have declined (13 populations versus nine). Most populations have a recent five-year mean abundance of fewer than 1,500 natural spawners, with the Upper Skagit population being a notable exception (the recent five-year mean abundance for the Upper Skagit population approaches 10,000 natural spawners). Currently observed abundances of natural spawners in the ESU are several orders of magnitude lower than estimated historical spawner capacity, and well below peak historical abundance (approximately 690,000 spawners in the early 1900s). Recent five-year and long-term productivity trends remain below replacement for the majority of the 22 extant populations of PS Chinook salmon. The BRT was concerned that the concentration of the majority of natural production in just a few subbasins represents a significant risk. Natural production areas, due to their concentrated spatial distribution, are vulnerable to extirpation due to catastrophic events. The BRT was concerned by the disproportionate loss of early run populations and its impact on the diversity of the PS Chinook salmon ESU. The Puget Sound Technical Recovery Team has identified 31 historical populations (Ruckelshaus et al. 2006), nine of which are believed to be extinct, most of which were "early run" or "spring" populations. Past hatchery practices that transplanted stocks among basins within the ESU and present programs using transplanted stocks that incorporate little local natural broodstock represent additional risk to ESU diversity. In particular, the BRT noted that the pervasive use of Green River stock, and stocks subsequently derived from the Green River stock, throughout the ESU may reduce the genetic diversity and fitness of naturally spawning populations.

The BRT found moderately high risks for all VSP categories. Informed by this risk assessment, the strong majority opinion of the BRT was that the naturally spawned component of the PS Chinook salmon ESU is "likely to become endangered within the foreseeable future." The minority opinion was in the "not in danger of extinction or likely to become endangered within the foreseeable future" category (Good et al. 2005).

In terms of productivity, these hatchery programs collectively do not substantially reduce the extinction risk of the ESU in-total (NMFS 2004). However, long-term trends in abundance for naturally spawning populations of Chinook salmon in Puget Sound indicate that approximately half the populations are declining, and half are increasing in abundance over the length of available time series. The median over all populations of long-term trend in abundance is 1.0 (range 0.92–1.2), indicating that most populations are just replacing themselves. Over the long term, the most extreme declines in natural spawning abundance have occurred in the combined Dosewallips and Elwha populations. Those populations with the greatest long-term population growth rates are the North Fork Nooksack and White rivers. All populations reported above are likely to have a moderate to high fraction of naturally spawning hatchery fish, so it is not possible to say what the trends in naturally spawning, natural-origin Chinook salmon might be in those populations. White River spring Chinook salmon (among others) were the subject of discussions with the Tribes during consultation because their life history is adapted to glacial runoff patterns. This life history distinguishes the White River spring Chinook salmon from most of the other PS Chinook salmon populations increasing their importance to recovery of PS Chinook salmon for their contribution to life history diversity within the ESU.

Fewer populations exhibit declining trends in abundance over the short term than over the long term, 4 of 22 populations in the ESU declined from 1990 to 2002 (median = 1.06, range = 0.96–1.4) (Good et al. 2005). In contrast, estimates of short-term population growth rates suggest a very different picture when the reproductive success of hatchery fish is assumed to be one.

Limiting factors for PS Chinook salmon include: (1) Degraded floodplain and in-river channel structure, (2) degraded estuarine conditions and loss of estuarine habitat, (3) riparian area degradation and loss of in-river Large Woody Debris (LWD), (4) excessive sediment in spawning gravels, (5) degraded water quality and temperature (NMFS 2005b).

Columbia River Chum Salmon

The NMFS provided an updated status report on CR chum salmon in 1999 (NMFS 1999). As documented in the 1999 report, the BRT was concerned about the dramatic declines in abundance and contraction in distribution from historical levels. The BRT was also concerned about the low productivity of the extant populations, as evidenced by flat trend lines at low population sizes. A majority of the BRT concluded that the CR chum salmon ESU was likely to become endangered in the foreseeable future and a minority concluded that the ESU was currently in danger of extinction.

New data includes spawner abundance through 2000, with a preliminary estimate in 2002, new information on the hatchery program, and new genetic data describing the current relationship of spawning groups. New analyses include designation of relatively demographically independent populations, recalculation of previous BRT metrics with additional years data, estimates of median annual growth rate, and estimates of current and historically available kilometers of stream.

Updated information provided in the Good et al. (2005), the information contained in previous Lower Columbia River status reviews, and preliminary analyses by the Willamette/Lower Columbia Technical Review Team suggest that 14 of the 16 historical populations (88 percent) are extinct or nearly so. The two extant populations have been at low abundance for the last 50 years in the range where stochastic processes could lead to extinction. Encouragingly, there has been a substantial increase in the abundance of these two populations. In addition there are the new (or newly discovered) Washougal River mainstem spawning groups. However, it is not known if the increase will continue and the abundance is still substantially below the historical levels.

Nearly all of the likelihood votes for this ESU fell in the likely to become endangered (63 percent) or in danger of extinction (34 percent) categories. The BRT had substantial concerns about every VSP element, as indicated risk estimates scores that ranged from moderately high for growth rate/productivity to high to very high for spatial structure. Most or all of the risk factors identified previously by the BRT remain important concerns. The Willamette/Lower Columbia Technical Review Team has estimated that close to 90 percent of the historical populations in the ESU are extinct or nearly so, resulting in loss of much diversity and connectivity between populations. The populations that remain are small, and overall abundance for the ESU is low. This ESU has showed low productivity for many decades, even though the remaining populations are at low abundance and density dependent compensation might be expected. The BRT was encouraged that unofficial reports for 2002 suggest a large increase in abundance in some (perhaps many) locations. Whether this large increase is due to any recent management actions or simply reflects unusually good conditions in the marine environment is not known at this time, but the result is encouraging, particularly if it were to be sustained for a number of years.

Limiting factors identified for CR Chum Salmon include: (1) altered channel form and stability in tributaries, (2) excessive sediment in tributary spawning gravels, (3) altered stream flow in tributaries and mainstem Columbia, (4) loss of some tributary habitat types, and (5) harassment of spawners in tributary and Columbia mainstem (NMFS 2005b).

Hood Canal Summer-Run Chum Salmon

This ESU includes all naturally spawned populations of summer-run chum salmon in Hood Canal and its tributaries as well as populations in Olympic Peninsula rivers between Hood Canal and Dungeness Bay, Washington (March 25, 1999, 64 FR 14508). Eight artificial propagation programs are considered to be part of the ESU: the Quilcene NFH, Hamma Hamma Fish Hatchery, Lilliwaup Creek Fish Hatchery, Union River/Tahuya, Big Beef Creek Fish Hatchery, Salmon Creek Fish Hatchery, Chimacum Creek Fish Hatchery, and the Jimmycomelately Creek Fish Hatchery summer-run chum salmon hatchery programs. The NMFS determined that these artificially propagated stocks are no more divergent relative to the local natural population(s) than what would be expected between closely related natural populations within the species (NMFS, 2005a).

Adult returns for both populations in the Hood Canal summer-run chum salmon species showed steady improvements since 2001. Hood Canal summer-run chum salmon are the focus of an extensive rebuilding program developed and implemented since 1992 by the state and tribal co-managers. The estimated historical abundance (circa 1900) of the Hood Canal Summer-Run Chum salmon ESU is 60,000 to 80,000. Based on the most recent 5 years of available data, the estimated mean total abundance (natural and hatchery-origin fish) of the ESU is approximately 30,600, and recent mean natural abundance is estimated to be approximately 19,900. The last formal review of ESU status, based on data previous to 2003, indicated that since the time of listing or first review, abundance and productivity of this ESU had improved. Preliminary information based on the most recent 12 years of available data indicates a positive short-term trend in total abundance (natural and hatchery-origin fish) for the ESU (Tynan, pers. comm.).

The BRT found high risks for each of the VSP categories. Informed by this risk assessment, the majority opinion of the BRT was that the naturally spawned component of the Hood Canal summer-run chum salmon is "likely to become endangered within the foreseeable future," with a minority opinion that the ESU is "in danger of extinction" (Good et al. 2005).

Of the eight programs releasing summer chum salmon that are considered to be part of the Hood Canal summer chum salmon ESU, six of the programs are supplementation programs implemented to preserve and increase the abundance of native populations in their natal watersheds. These supplementation programs propagate and release fish into the Salmon Creek, Jimmycomelately Creek, Big Quilcene River, Hamma Hamma River, Lilliwaup Creek, and

Union River watersheds. The remaining two programs use transplanted summer-run chum salmon from adjacent watersheds to reintroduce populations into Big Beef Creek and Chimacum Creek, where the native populations have been extirpated. Each of the hatchery programs includes research, monitoring, and evaluation activities designed to determine success in recovering the propagated populations to viable levels, and to determine the demographic, ecological, and genetic effects of each program on target and non-target salmonid populations. All the Hood Canal summer-run chum salmon hatchery programs will be terminated after 12 years of operation.

The NMFS' assessment of the effects of artificial propagation on ESU extinction risk concluded that these hatchery programs collectively do not substantially reduce the extinction risk of the ESU (NMFS 2004a). The hatchery programs are reducing risks to ESU abundance by increasing total ESU abundance as well as the number of naturally spawning summer-run chum salmon. Several of the programs have likely prevented further population extirpations in the ESU. The contribution of ESU hatchery programs to the productivity of the ESU in-total is uncertain. The hatchery programs are benefiting ESU spatial structure by increasing the spawning area utilized in several watersheds and by increasing the geographic range of the ESU through reintroductions. These programs also provide benefits to ESU diversity. By bolstering total population sizes, the hatchery programs have likely stemmed adverse genetic effects for populations at critically low levels. Additionally, measures have been implemented to maintain current genetic diversity, including the use of native broodstock and the termination of the programs after 12 years of operation to guard against long-term domestication effects.

Collectively, artificial propagation programs in the ESU presently provide a slight beneficial effect to ESU abundance, spatial structure, and diversity, but uncertain effects to ESU productivity. The long-term contribution of these programs after they are terminated is uncertain. Despite the current benefits provided by the comprehensive hatchery conservation efforts for Hood Canal summer-run chum salmon, the ESU remains at low overall abundance with nearly half of historical populations extirpated. Informed by the BRT's findings (Good et al. 2005) and our assessment of the effects of artificial propagation programs on the viability of the ESU, the Artificial Propagation Evaluation Workshop concluded that the Hood Canal summer-run chum salmon ESU in-total is "likely to become endangered in the foreseeable future" (NMFS, 2004).

Limiting factors identified for this species include: (1) Degraded floodplain and mainstem river channel structure, (2) Degraded estuarine conditions and loss of estuarine habitat, (3) Riparian area degradation and loss of in-river wood in mainstem, (4) Excessive sediment in spawning gravels, (5) reduced stream flow in migration areas (NMFS 2005b).

Southern Distinct Population Segment Green Sturgeon

Green sturgeon consist of two DPSs that qualify as species under the ESA: A northern DPS, consists of populations in coastal systems from the Eel River, California northward, that was determined to not warrant listing and a southern DPS consisting of coastal and Central Valley populations south of the Eel River, with the only known spawning population in the Sacramento River (Adams et al. 2002). The southern distinct population segment (DPS) of green sturgeon was listed as threatened under the ESA by NMFS on April 7, 2006 (71 FR 17757).

The green sturgeon is the most marine-oriented of the North American sturgeon species. Juveniles of this species are able to enter estuarine waters after only one year in freshwater. During this time, they are believed to feed on benthic invertebrates, although little is known about rearing habitats and feeding requirements. Green sturgeon are known to range in nearshore marine waters from Mexico to the Bering Sea, and are commonly observed in bays and estuaries along the west coast of North America, including the Columbia River (NMFS 2008b). McLain (2006) noted that Southern DPS green sturgeon were first determined to occur in Oregon and Washington waters in the late 1950s when tagged San Pablo Bay green sturgeon were recovered in the Columbia River estuary. The proportion of the Southern relative to Northern DPS is high (approximately 67 to 82 percent, or 121 fish, of 155 fish sampled) (Israel and May 2007). Aggregations of adults occupy the lower Columbia River and estuary, up to the Bonneville Dam, primarily during summer months (WDFW and ODFW 2002, Moser and Lindley 2007). The largest concentrations of green sturgeon, including Southern DPS fish, occur within the lower Columbia River estuary, Willapa Bay, and Grays Harbor (September 8, 2008; 73 FR 52091). Beamis and Kynard (1997) suggested that green sturgeon move into estuaries of non-natal rivers to feed. Information from fisheries-dependent sampling suggests that green sturgeon only occupy large estuaries during the summer and early fall in the northwestern United States. Green sturgeon are known to enter Washington estuaries during summer (Moser and Lindley 2007). There is no evidence of spawning in the Lower Columbia. Green sturgeon in the Lower Columbia River are most likely feeding, but studies have only yielded empty stomachs (Grimaldo and Zeug 2001).

Quality data on current population sizes and trends for green sturgeon is non-existent. Lacking any empirical abundance information, Beamesderfer et al. (2007) recently attempted to characterize the relative size of the Sacramento-San Joaquin green sturgeon population (Southern DPS) by comparison with the Klamath River population (Northern DPS). Using Klamath River tribal fishery harvest rate data and assuming adults represent 10 percent of the population at equilibrium, they roughly estimate the Klamath population at 19,000 fish with an annual recruitment of 1,800 age-1 fish. Given the relative abundance of the two stocks in the Columbia River estuary based on genetic samples, they speculate abundance of the Sacramento population may equal, or exceed the Klamath population estimate. Collectively, Beamesderfer et al. (2007) estimate abundances of the various green sturgeon populations may be larger than previously thought due to seasonal high abundances in the Columbia River, Willapa Bay, and Grays Harbor estuaries and other coastal tributaries, historical high harvest in different areas at different times, and a significant portion of each population likely remains in the ocean at any given time.

The principal factor in the decline of the Southern DPS is the reduction of the spawning habitat to a limited section of the Sacramento River (NMFS 2006). The potential for catastrophic events to affect such a limited spawning area increases the risk of the green sturgeon's extirpation. Insufficient freshwater flow rates in spawning areas, bycatch of green sturgeon in fisheries, potential poaching (e.g., for caviar), entrainment of juveniles by water projects, influence of exotic species, small population size, impassable migration barriers, and elevated water temperatures in the spawning and rearing habitat likely also pose threats to this species (NMFS 2006). Pesticides pose a water quality issue and may affect the abundance and health of prey items as well as the growth and reproductive health of Southern DPS green sturgeon through bioaccumulation. Of particular concern are activities that affect prey resources. Prey resources likely include species similar to those fed on by green sturgeon in bays and estuaries (e.g., burrowing ghost shrimp, mud shrimp, crangonid shrimp, amphipods, isopods, Dungeness crab), and these prey resources are known to occur within the marine specific areas. Activities that can affect these prey resources include: Commercial shipping and activities generating point source pollution (subject to National Pollutant Discharge Elimination System requirements) and non-point source pollution that can discharge contaminants and result in bioaccumulation of contaminants in green sturgeon; disposal of dredged materials that can bury prey resources; and bottom trawl fisheries that can disturb the bottom (but may result in beneficial or adverse effects on prey resources for green sturgeon). In addition, petroleum spills from commercial shipping activities and proposed tidal and wave energy projects may affect water quality or hinder the migration of green sturgeon along the coast (September 8, 2008; 73 FR 52091).

Status of Critical Habitat

The proposed action is likely to adversely affect CH designated for PS Chinook salmon and Hood Canal summer-run Chum salmon. The Opinion also includes a conference opinion on proposed CH for southern DPS green sturgeon. Therefore, status of CH for each of these species is included in this section.

Critical habitat is the specific area within the geographical area occupied by the species at the time of listing, if (1) they contain physical or biological features essential to conservation, and whether those features may require special management considerations or protection; and (2) specific areas outside the geographical area occupied by the species if the agency determines that the area itself is essential for conservation.

Each of the salmonid species considered in this consultation had CH designated in 2005 (refer to table 1). Critical habitat was proposed for the Southern DPS green sturgeon on September 8, 2008. At such a time as CH for the Southern DPS of North American green sturgeon is designated, NMFS will reassess the conference opinion to ensure it remains valid and disposes of the matter for the proposed action.

The NMFS reviews the status of designated CH affected by the proposed action by examining the condition of primary constituent elements (PCEs) throughout the designated area. The PCEs consist of the physical and biological features NMFS identified as essential to the conservation of the listed species when designating CH (Tables 2 and 3).

Table 2. Salmonid PCEs in the Action Area.

Primary Constituent Elements		Species Life History Event
Site Type	**Site Attribute**	
Nearshore marine areas	Forage Free of obstruction Natural cover Water quantity Water quality	Adult sexual maturation Smolt/adult transition
Estuarine areas	Forage Free of obstruction Natural cover Salinity Water quality Water quantity	Adult sexual maturation Adult "reverse smoltification" Adult upstream migration, holding Fry/parr seaward migration Fry/parr smoltification Smolt growth and development Smolt seaward migration

Table 3. Southern DPS green sturgeon PCEs in the Action Area.

Primary Constituent Element	Essential Physical and Biological Features	Species Life Stage
Estuarine areas	food resources, water flow, water quality, migratory corridor, water depth, and sediment quality	Migration and feeding
Coastal marine areas	Migratory corridor, water quality, and food resources	Migration and feeding

Salmonid Critical Habitat

Puget Sound and Hood Canal. Critical habitat has been designated in Puget Sound for PS Chinook salmon and Hood Canal summer-run chum salmon. Major tributary river basins in the Puget Sound Basin include the Nooksack, Samish, Skagit, Sauk, Stillaguamish, Snohomish, Lake Washington, Cedar River, Sammamish River, Green River, Duwamish River, Soos Creek, Puyallup River, White River, Carbon River, Nisqually River, Deschutes, Skokomish, Duckabush, Dosewallips, Big Quilcene, Elwha, and Dungeness Rivers.

Salmon life history stages that require properly functioning freshwater habitat components have been affected by natural and man-made influences. In the steep mountainous and foothill areas of the Puget Sound Basin, relatively unconsolidated glacial deposits and heavy rainfall make this region vulnerable to landslides (WDNR 1993, WDNR 1997a, WDNR 1997b). Lands prone to shallow rapid landslides are often managed for timber, because they are unsuited to most other uses. Landslides can occur naturally, but inappropriate land use practices greatly accelerate their frequency.

Fine sediment enters the channel from unpaved roads. Unpaved roads are widespread on forestlands, and to a lesser extent, in rural residential areas and recreational forestlands. Forestlands throughout the Puget Sound basin have extensive networks of unpaved roads.

Historic old growth timber harvest removed most of the riparian trees from the stream channels. Subsequent agricultural and urban conversion permanently altered riparian vegetation in the river valleys, leaving either no trees, or a thin band of trees. The riparian zones along many agricultural areas are now dominated by alder, invasive canary grass and blackberries, and provide substantially reduced shade and LWD recruitment.

Diking, agriculture, revetments, railroads and roads in lower stream reaches have caused significant loss of secondary channels in major valley floodplains in this region. Confined main channels create high-energy peak flow events that remove smaller substrates and LWD. The loss of side-channels, oxbow lakes, and backwater habitats results in a significant loss of juvenile salmonid rearing and refuge habitat (WSCC 2000). When the water level of Lake Washington was dropped nine feet in the 1910s, thousands of acres of wetlands along the shoreline of Lake Washington, Lake Sammamish and the Sammamish River corridor were drained and converted to agricultural and urban uses (WSCC 2001).

Loss of riparian habitat, elevated water temperatures, elevated levels of nutrients, increased nitrogen and phosphorus, and higher levels of turbidity, presumably from urban and highway runoff, wastewater treatment, failing septic systems, and agriculture or livestock impacts, have been documented in many Puget Sound tributaries.

Peak stream flows have increased over time due to paving (roads and parking areas), reduced percolation through surface soils on residential and agricultural lands, simplified and extended drainage networks, loss of wetlands, and rain-on-snow events in higher elevation clearcuts.

Dams constructed for hydropower generation, irrigation, or flood control have substantially affected PS Chinook salmon populations in a number of river systems. The construction and operation of dams have blocked access to spawning and rearing habitat (e.g., Elwha River dams block anadromous fish access to 70 miles of potential habitat) changed flow patterns, resulted in elevated temperatures and stranding of juvenile migrants, and degraded downstream spawning and rearing habitat by reducing recruitment of spawning gravel and LWD to downstream areas. These actions tend to promote downstream channel incision and simplification, limiting fish habitat. Water withdrawals reduce available fish habitat and alter sediment transport. Hydropower projects often change flow rates, stranding and killing fish, and reducing aquatic invertebrate (food source) productivity (Hunter 1992).

If migrating fish are diverted into unscreened or inadequately screened water conveyances or turbines, unnecessary mortality results. Blockages by dams, water diversions, and shifts in flow regime due to hydroelectric development and flood control projects are major habitat problems in many Puget Sound tributary basins.

The nearshore marine habitat has been extensively altered and armored by industry activities and intensive residential development near the mouths of many of Puget Sound's tributaries. A railroad runs along large portions of the eastern shoreline of Puget Sound, eliminating natural cover along the shore and natural recruitment of beach sand.

Degradation of the near-shore environment has occurred in the southeastern areas of Hood Canal in recent years, resulting in late summer marine oxygen depletion and significant fish kills. Circulation of marine waters is naturally limited, and partially driven by freshwater runoff, which is often low in the late summer. However, human development has increased nutrient loads from failing septic systems along the shoreline, and from use of nitrate and phosphate fertilizers on lawns and farms. Shoreline residential development is widespread and dense in many places. The combination of highways and dense residential development has impacted both physical and chemical characteristics of the near-shore environment (WSCC 2003a).

Status of proposed Critical Habitat of Southern Distinct Population Segment of Green Sturgeon

Critical habitat was proposed for green sturgeon on September 8, 2008 (73 FR 52084). One of the proposed coastal marine areas includes the Strait of Juan de Fuca, west of Point Wilson near the City of Port Townsend. Within the nearly 800 square miles of the Strait of Juan de Fuca proposed for CH lie 8.7 square miles of commercially available geoduck tracts, located mostly within 1 mile or up to 3 miles from the coast. Willapa Bay and Grays Harbor are also included in the proposed CH designation.

The review team recognized that the different systems occupied by green sturgeon at specific stages of their life cycle serve distinct purposes and thus may contain different PCEs. Based on the best available scientific information, the team identified PCEs for freshwater riverine systems, estuarine areas, and nearshore marine waters. The PCEs proposed for coastal marine waters are migratory corridors (within marine and between estuarine and marine habitats), water quality, and food resources.

Migration. Unimpeded passage within coastal marine waters is critical for subadult and adult green sturgeon to access over-summering habitats within coastal bays and estuaries and over-wintering habitat within coastal waters between Vancouver Island, BC, and southeast Alaska. Access to and unimpeded movement within these areas is also necessary for green sturgeon to forage for prey and make lengthy migrations necessary to reach other foraging areas. Passage is also necessary for subadults and adults to migrate back to San Francisco Bay and to the Sacramento River for spawning. Acoustically tagged green sturgeons have been observed during their coastal migrations to travel at depths of 130 to 230 feet, and no greater than 360 feet.

Water Quality. Based on studies of tagged subadult and adult green sturgeon in the San Francisco Bay estuary, California, and Willapa Bay, Washington, subadults and adults may need a minimum dissolved oxygen level of at least 6.54 mg O2/l

Food Resources. The scant information about their marine food indicates that small fishes and benthic invertebrates typical of silty/sand substrates of the continental shelf, in addition to benthic fauna (i.e., burrowing shrimp and sand lance) of shallow coastal bays with mud/silt bottoms. Sturgeon are particularly adapted for feeding in silty substrates in low light conditions.

The Willapa Basin estuary consists of about 88,000 acres at mean high tide, with a complete water exchange every two to three weeks (WBFEG 2009). While toxins have not been identified as a problem in the Willapa basin, *Spartina alterniflora* invasion is significant. Spartina was introduced to Willapa Bay from the East Coast about 100 years ago, and the invasion increased dramatically in the last few decades (WBFEG 2009). It grows into a "meadow", covering the mudflats. This changes the composition of the mudflat dwellers, displaces native eelgrass, and raises the elevation of the flats. Spartina's impact on fish rearing habitat, as well as the ecosystem upon which the young fish depend is unknown, but the displacement of native eelgrass is a great concern. Sturgeon feed on, among other things, copepods that are living on the bacteria from decaying eelgrass (WBFEG 2009). Recently, spartina infestation has been reported to have been reduced to a small fraction of what formerly occurred in Willapa Bay.

Willapa Bay salinity appears to be linked not only to the Willapa Basin drainages, but also to flow from the Columbia and Chehalis River basins (WBFEG 2009). Many salinity profiles for Pacific Coast estuaries show a peak in the summer and a low in the winter, but Willapa Bay salinity drops in the late spring when snowmelt in the Columbia and Chehalis Basins is emptying into the Pacific Ocean. The greatest source of freshwater for Willapa Bay is the Columbia River. The Willapa Bay ecosystem depends upon the maintenance of high water quality in the Columbia River.

Land use practices in the Willapa Basin, such as forestry, grazing, agriculture and urbanization, disrupt aquatic ecosystems that ultimately influence the attributes of the estuary. Examples of human caused impacts leading to habitat degradation in Willapa Bay include: mass wasting, altered hydrologic regimes, riparian habitat destruction, reduction of LWD, increased fine sediment inputs, dikes, and tide gates.

In addition to the common factors affecting CH in Willapa Bay, Schroder and Fresh (1992) also documented severe water quality problems in Grays Harbor. Since then, several causes of the water quality problems have been addressed, and current water quality conditions in the Grays Harbor estuary may have improved. The estimated loss of estuarine habitat is 30 percent and this is believed to be an underestimate. However, compared to estuaries elsewhere in Washington State, this is a low level of loss. Dredging impacts are another concern within Grays Harbor (Smith and Wenger 2001).

<u>Environmental Baseline</u>

The action area consists of numerous sub-areas, each with many shellfish farms. Within each farm, there are one or more managed sites or plots. The aquatic lands are either privately owned or leased from another private individual or the Washington Department of Natural Resources (WDNR). Shellfish aquaculture activities have been ongoing in these various sub-areas for many years. In some areas, such as Willapa Bay, shellfish aquaculture has been occurring for as long as 150 years. The existence of shellfish management, in addition to other factors in managed areas, has influenced prevailing conditions in these places. For example, the introduction of invasive species such as spartina and oyster drills, among other things attributed to past aquaculture activities, have likely affected eelgrass presence and the habitat function of SAV generally.

The spatial extent of aquacultural acreage covered by proposed NWP 48 drives the size of the action area for this consultation. The amount of acreage within existing farms is summarized in Table 4. The majority of activities are confined to the immediate farm. Activities that generate sediment may cause turbid water to drift outside of the footprint of the active plot, expanding the affected area by as much as five percent. The more critical consideration with regard to effects of the action are the hydrodynamics of the farm site, and the proximity between, and density of, farms within sensitive aquatic habitats and CH. Table 4 presents the number of shellfish aquaculture parcels in each sub-action area.

Table 4. Approximate Number of Shellfish Farms and Total Farmed Acreage in the Action Area

Sub-action Area	Number of Parcels	Farmed Acreage	Acres of Tidelands
Willapa Bay	923	25,562	45,000
Grays Harbor	68	3,995	34,460
South Sound	398	4,748	27,520
Hood Canal	78	1,677	
North Sound	56	2,345	
Grand Total	1,523	38,327	

These numbers are approximate as the reports submitted to the COE did not always have a parcel number or accurate parcel size

The Willapa Basin consists of six watersheds: the North, Willapa, Palix, Nemah, Naselle, and Bear Watersheds. The largest river systems in the region are the North, Willapa, and Naselle systems. In total, there are roughly 745 streams encompassing over 1,470 linear stream miles in the Willapa region (Phinney and Bucknell 1975). The major tributaries which support salmon include the South Fork Willapa River, Trap Creek, Mill Creek, Wilson Creek, Fork Creek, and Ellis Creek. Approximately two-thirds of the upland in the watershed is composed of commercial forest lands. Cranberry farms comprise an additional seven percent, including 1400 acres of bogs. The Willapa watershed supports fall Chinook salmon, coho salmon, fall chum salmon and winter steelhead trout. There are no ESA-listed salmon runs in the Willapa Watershed. However, the southern DPS of green sturgeon likely migrate from their natal area in the Sacramento River and mature for some portion of their life history in Willapa Bay. Likewise, adult CR chum salmon and LCR Chinook salmon dip into Willapa Bay on their migration back to their natal streams (Kirt Hughes,WDFW, pers comm. 2009). Although it is likely that juvenile ESA-listed salmonids migrate from their natal areas in the Lower Columbia River and rear for some period in Willapa Bay, there have been no investigations or data collected to confirm this occurrence. However, recent findings of juvenile LCR Chinook salmon utilizing north coast and Straits of Juan de Fuca estuaries is strong evidence they do so. (E. Casillas, NW Sci. Cntr. pers comm. November 14, 2008).

The relatively shallow bay has more than 50 percent of its 79,000 acres exposed at low tide with much of the remaining surface area, except for channels, covered by one to six feet of water. Tidal levels in the bay vary from 14 to 16 feet and during a complete tidal cycle about 45 percent of the water in the bay is exchanged into the Pacific Ocean. Willapa Bay opens to the Pacific Ocean at its northwestern corner through a broad shallow pass about six miles wide between Cape Shoalwater and Leadbetter Point. Roughly 923 shellfish aquaculture parcels totaling approximately 25,562 acres currently exist within Willapa Bay, according to data received from the COE. The primary aquaculture species cultivated in Willapa Bay are oysters and clams.

Grays Harbor is a shallow, bar-built estuary located on the central Washington coast north of Willapa Bay. Depths average less than 20 feet, with depths at the entrance reaching a maximum of 80 feet. The navigation channel is dredged annually to a depth of 30 feet. Freshwater inputs are attributed to the Chehalis, Hoquiam, Wishkah, Humptulips, Johns, and Elk River systems which have a combined drainage basin of approximately 2,550 square miles. The Chehalis River provides approximately 80 percent of the freshwater input into Grays Harbor. There are no ESA-listed salmon runs in the Grays Harbor Watershed. However, the southern DPS of green sturgeon, CR chum salmon and LCR Chinook salmon may migrate from their natal areas and rear and mature for some portion of their life history in Grays Harbor (Casillas, pers comm. November 14, 2008).

Within the Grays Harbor sub-action area (GHSAA), shellfish aquaculture occurs in the estuary. The average parcel size in the GHSAA is greater than the other sub-action areas with a mean parcel size of 59 acres.

Table 5. Approximate Number of Shellfish Farms and Total Farmed Acreage in the Bays of the Grays Harbor Action Area

Waterway	Total Parcels	Total Acreage
North Bay	47	3,088
South Bay	21	907
Grand Total	68	3,995

These numbers are approximate as the reports submitted to the COE did not always have an accurate parcel size

The south Puget Sound action area (SPSAA) consists if WRIA's 14 (Kennedy-Goldsborough) and 41 (Deschutes River). The basin is drained by many small streams covering 139 stream miles. There are no major river systems in this basin. Inlets and mudflats laid down at stream confluences provide a variety of nearshore habitats. Slow tidal mixing consistent with the long, finger-like water bodies of Oyster Bay, Oakland Bay, Mud Bay, North Bay, Eld Inlet Hammersley Inlet, Totten Inlet, Skookum Inlet, and upper Case Inlet provides nutrient rich waters at stream outlets. These sheltered, nutrient rich waterways are highly conducive to shellfish aquaculture. As with most accessible shorelines, residential development is generally found at the lower portions of streams near salt water bays in this basin. The SPSAA has the greatest number of parcels (approximately 398) with an average parcel size of 12 acres (Table 4). This sub-Action Area appears to be the most active aquaculture area relative to the other sub-Action Areas. Within the SPSAA, Totten Inlet has the greatest number of active parcels averaging approximately 18 acres/parcel.

Table 6. Approximate Number of Shellfish Farms and Total Farmed Acreage in the Inlets and Bays of the South Sound Action Area

Waterway	Total Parcels	Total Acreage
Carr Inlet	2	307
Case Inlet	21	167
Dana Passage	4	2.0
Drayton passage	3	36
Eld Inlet	72	570
Hammersley Inlet	75	78
Henderson Inlet	6	155
Little Skookum Inlet	25	332
Nisqually Reach	11	468
North Bay	13	80
Oakland Bay	35	351
Peale Passage	3	22
Pickering Passage	13	30
Totten Inlet	115	2150
Grand Total	398	4,748

These numbers are approximate as the reports submitted to the COE did not always have an accurate parcel size

The Hood Canal sub-action area consists of three WRIA's (14, 15, and 16). The WRIAs 14 and 15 include the east and south shores of Hood Canal. The WRIAs 14 and 15 extend from Foulweather Bluff in the north to the town of Union in the south. The WRIA 16 is located along the eastern slope of the Olympic Mountains. The WRIA 16 extends from the Turner Creek watershed in southeast Jefferson County southward to, and including, the Skokomish watershed in northwest Mason County. The four principal watersheds, the Dosewallips, the Duckabush, the Hamma Hamma and the Skokomish, originate in the Olympic Mountains and terminate along the western shore of Hood Canal.

Hood Canal is made up of a diverse network of mudflats, dendritic tidal channels, lagoons, salt marshes, eelgrass beds, and sandy beaches that provide estuarine habitat for both juvenile and adult salmonids and their prey (Kuttel 2003 pg 12).

Shellfish aquaculture is conducted in Hood Canal with a total of approximately 78 parcels comprising approximately 1,677 acres (Table 4). The small coves and bays have minimum activity although Port Gamble has a substantial farm growing geoduck and other clam species and oysters.

Table 7. Approximate Number of Shellfish Farms and Total Farmed Acreage in the Bays of the Hood Canal Action Area

Waterway	Total Parcels	Total Acreage
Annas Bay	1	60
Bywater Bay	1	6.5
Dabob Bay	11	316
Dewatto Bay	1	23
Frenchman's Cove	1	4.7
Hood Canal proper	59	1,126
Hood Head	1	5.7
Port Gamble	1	98
Spencer Cove	1	17
Thorndike Bay	1	20
Grand Total	78	1,677

These numbers are approximate as the reports submitted to the COE did not always have an accurate parcel size

The North Puget Sound sub-action area contains Whidbey Basin, Admiralty Inlet, Strait of Juan de Fuca, and the San Juan Archipelago. The largest fresh water inputs come from the Skagit, Stillaquamish Snohomish, Nooksack, and Elwha Rivers. The relative shallowness of the Whidbey Basin is complemented by a much larger percentage of tidelands than any of the other Puget Sound basins. There are a reported 56 parcels in shellfish production in the North Puget Sound sub-area. The Samish Bay portion of the North Puget Sound sub-area includes WRIA 6 and WRIA 3, the Lower Skagit/Samish basins. Shellfish farming in Samish Bay occurs on approximately 28 parcels comprising approximately 1,106 acres of the Bay. Geoduck clams as well as other species of clams and oysters are grown in this 7.5 km (5 miles) wide area.

Listed salmonids considered in this consultation are present in and express rearing and migration life histories in each portion of the action area described above. This includes the occasional presence and "dipping in" of LCR Chinook salmon (and probably CR chum salmon) in Grays Harbor and Willapa Bay. While NMFS has information on Southern DPS green sturgeon presence in both the Willapa Bay and GHSAAs, there is little data relative to green sturgeon in North or South Puget Sound, and Hood Canal. Early information from on-going studies indicates off-shore use in the Straits of Juan de Fuca but no information relative to nearshore, shallow water areas comprising the North and South Puget Sound and Hood Canal portions of the action area.

Factors Affecting the Condition of the Environmental Baseline

Below, NMFS summarizes the factors affecting the condition and quantity of habitat features and processes necessary to support the listed species in the action area. These factors are contaminants, habitat modification, nutrients and pathogens, the condition of estuarine submerged vegetation (especially eelgrass). Each of the listed species considered in this consultation expresses some life history stage in the action area. In the marine nearshore, juvenile salmon transitition to adult salmon, while adult salmon grow to sexual maturity. In contrast, green sturgeon reside in and migrate through, estuarine and coastal marine habitat as sub-adults transitioning to adults.

Environmental Contaminants. Contaminants enter marine and fresh waters and sediments from numerous sources, but are typically concentrated near populated areas of high human activity and industrialization. In the past 150 years, people have released a wide variety of chemicals into various water bodies affecting conditions in the action area, many of which are toxic to humans, animals, and plants. While contamination by a number of toxics, such as lead, polychlorinated biphenyls (PCBs), and dioxins, has been reduced by use restrictions, other chemicals continue to be used and many enter into Puget Sound through stormwater runoff, wastewater discharges, and nonpoint sources, adding to a legacy of contamination. These factors are also likely present for Grays Harbor, which is surrounded (albeit to a lesser extent than is Puget Sound) by suburban, urban, and industrial land uses. Willapa Bay is surrounded by rural and undeveloped land uses such that contaminants from these sources are less influential on existing conditions than in Grays Harbor or Puget Sound.

Toxic chemicals in the sediments of the action area expose salmon and other organisms to unhealthy concentrations of contaminants. Toxic contamination of nearshore and marine ecosystems in Puget Sound and the coastal estuaries can reduce the ability of the nearshore and marine ecosystems to provide high quality prey items for listed fish.

Oil spills have occurred in the action area in the past, and there is potential for spills in the future. Oil can be discharged into the marine environment in any number of ways, including shipping accidents, refineries and associated production facilities, and pipelines. Despite many improvements in spill prevention since the late 1980s, much of the action area remains at risk from serious spills because of the heavy volume of shipping traffic and proximity to petroleum refining centers in inland waters. Numerous oil tankers transit through the action area throughout the year. The magnitude of the risks posed by oil discharges in this area is difficult to precisely quantify or estimate, but may be decreasing because of new oil spill prevention procedures in the state of Washington (WDOE 2007).

The combination of hydrologic isolation with the persistent (resisting degradation) and bioaccumulative (increasing within in organisms over time) nature of many chemical contaminants creates additional risk for the Puget Sound and coastal estuary ecosystems. Neither Grays Harbor nor Willapa Bay are as hydrologically isolated as Puget Sound. Chinook salmon that remain as residents in Puget Sound (both as a result of natural tendencies and hatchery practices), rather than migrate to the ocean, are several times more contaminated than other Chinook salmon populations along the West Coast. Another indication of this is found in Pacific herring, one of Puget Sound's keystone forage fish species. These fish live almost all of their lives in pelagic waters, so one might suspect they would be among the least contaminated of fish species. However, scientists have shown high body burdens of PCBs in this species from the central and Southern basins of Puget Sound—comparable to herring from northern Europe's severely contaminated Baltic Sea (PSP 2007).

The toxic contaminants that harm or threaten the health of the action area include chemicals designed and synthesized to meet industrial needs, agricultural products such as pesticides, byproducts of manufacturing or the combustion of fuel, fossil fuels, and naturally occurring toxic elements that may become unusually highly concentrated in the environment because of human uses or other activities. Release of these chemicals to the environment can occur through designed and controlled human actions (e.g., application of pesticides or the discharge of wastes through outfall pipes, smokestacks, and exhaust pipes) or as unintended consequences of human activities (e.g., oil and chemical spills, leaching from landfills, and runoff of chemicals from the deterioration or wear of roofs, pavement, and tires).

Hood Canal is less developed and as yet does not show the same indications of contaminants as does the greater Puget Sound region. Likewise Willapa Bay and Grays Harbor are sparsely developed and have not registered contaminant issues when investigated by state resource agencies. Willapa Bay has been listed for fecal coliform bacteria on Ecologies 303(d) list but overall toxins have not been reported as a problem in the region. Grays Harbor's inner harbor is heavily industrialized with mills, landfills, and log storage. Chemicals from pulp mills have historically damaged water quality. But no areas of the harbor are currently listed by Ecology.

Nutrients and Pathogens

Water quality is a primary factor affecting the health of marine and freshwater species in Western Washington. As Washington's population grows and urbanization of the action area continues, freshwater and marine ecosystems are under rising pressure from human activities that increase nutrient and pathogen pollution. Inputs of nutrients and pathogens affect ecosystem functions, the health and habitat of aquatic species, including economically important species (such as salmon and shellfish), and human health.

Nutrients consist of a variety of natural and synthetic substances that stimulate plant growth and enrich aquatic ecosystems. As a general rule, phosphorus tends to be the limiting nutrient in freshwater systems, and nitrogen tends to be the limiting nutrient in marine systems. This means that increased loadings of these nutrients can have significant effects on the character and condition of these respective systems.

Human activities have had a profound effect on the cycling of nutrients worldwide and nutrient pollution in the action area. Nutrient availability in the action area involves inputs from natural and human sources, such as upwelling and inflow of oceanic waters, flows from rivers and streams, stormwater runoff carrying fertilizers and other materials, discharges from sewage treatment plants, atmospheric deposition, and numerous other sources. It also involves uptake by phytoplankton and other aquatic vegetation and export to oceanic waters.

Increased nutrient loading can dramatically change the structure and function of freshwater and marine ecosystems by altering biogeochemical cycles and producing cascading effects throughout the ecosystem and food web, such as prolonged algae blooms, depressed oxygen levels, fish kills and losses of aquatic vegetation. Eutrophication, as these nutrient-driven changes are known, is one the most important challenges facing Puget Sound ecosystems.

Pathogen pollution is an equally significant water quality problem in the action area. Pathogens are disease-causing microorganisms that include a variety of protozoa, bacteria, and viruses. Some pathogens occur naturally in the marine environment (e.g., *Vibrio parahaemolyticus*). Most, however, are carried by host organisms and are associated with human and animals feces from such sources as onsite sewage systems and municipal sewage treatment plants, stormwater runoff, and boat waste. Pathogen pollution causes a range of environmental, human health, and economic impacts that include the contamination of shellfish beds, recreational waters and beaches, drinking water supplies, and other water-related resources.

Habitat Modification

Human activities have combined to degrade areas of habitat in the action area. Polluted water bodies, dredged and filled estuarine rearing areas (Bishop and Morgan 1996), nearshore overwater structures, and shoreline armoring (Penttila 2007) have affected nearshore and marine functions and processes.

Condition of Submerged Aquatic Vegetation (Eelgrass)

Eelgrass (*Zostera marina*) habitat is known for the ecological functions it provides to the nearshore estuarine community (Blackmon et al. 2006). Estuarine eelgrass habitats provide structure for a complex intertidal food web; spawning and forage habitat for fish that salmon eat; and cover for migrating juvenile salmonids.

Eelgrass supports a complex food web. In addition to providing the surface area for growth of epiphytic algae, eelgrass beds reduce wave energy, which causes the deposition of fine sediments and detrital material. This material supports the base of a complex food web (Simenstad et al. 1979). Micro-invertebrates associated with eelgrass beds (e.g., harpacticoid copepods, gammarid amphipods, and cumaceans), are commonly reported to be important components in the diets of juvenile Pacific salmonids, herring, smelts and flatfishes (Blackmon et al. 2006).

The WDNR estimates that there are approximately 50,000 acres of eelgrass in Puget Sound, on 37 percent of the shoreline (Mumford 2007). A map showing the distribution of eelgrass is in Figure 2.

Eelgrass beds are divided into two habitat types. A significant amount of eelgrass occurs in "flats", which can be large shallow embayments or small pocket beaches. Close to one-fifth of all the eelgrass in Puget Sound grows in one large flat, Padilla Bay. Eelgrass also occurs in narrow fringing beds along steeper shorelines. These fringing beds can be corridors for migrating salmon and other wildlife. About one-half of all eelgrass in Puget Sound occurs in these fringing beds. In Puget Sound, the optimal growth range for eelgrass is about plus 1 to minus 8, as reported in the BA. Other sources, however, also report eelgrass growth from plus 2.5 to 10 feet below the low tide line, meaning much of the Puget Sound eelgrass exists subtidally.

Eelgrass is found in sediments ranging from mud to clean sand; its upper limit is set by desiccation (in the intertidal zone) and its lower limit by light limitation (in the shallow subtidal zone). *Z. marina* grows in several bed configurations or patterns. In areas where conditions are thought to be most suitable, beds are solid or continuous. In other areas there may be persistent patchy beds, often at the ends or edges of solid beds. Continuous beds are often found in extensive tideflats, and more fragmented beds in areas fringing linear shorelines. Little is known about interannual variation in bed area, but it appears to be less than 10 percent (Mumford 2007).

Z. marina shows several interesting landscape distribution attributes. First, the lack of beds in southern Puget Sound is attributed to a combination of high tidal amplitudes and timing of low tides during the summer. During low tide events, especially during hot summer middays, desiccation/heat stress limits the upper distribution, while at high tides, enough water covers the plants to limit net photosynthesis at depth. At the point where tidal amplitude is enough to cause the lower limit to be the same as the upper limit, eelgrass will not grow. The problem is exacerbated by the fact that the timing of extreme low tides in southern Puget Sound is in midday, when temperatures are the highest. In contrast, on the outer coast and straits, low tides are early in the morning, before the heat of the day (Mumford 2007).

Eelgrass is threatened by human activities that increase water turbidity (such as agriculture or road building), block light (construction of docks), or disturb the bottom (anchoring or dredging). These impacts have caused significant declines in eelgrass in many U.S. coastal waters.
The Washington State Department of Ecology (WDOE2008) estimates that the State has lost approximately 33 percent of its historic eelgrass beds. The WDNR, which has been monitoring the distribution of eelgrass in Puget Sound since 2001, has not found evidence of recent large-scale loss; however, fragmentation and losses have occurred in some areas (e.g. Bellingham Bay, small embayments in the San Juan archipelago, and Hood Canal), and the increasing urbanization of the region poses threats to eelgrass and the entire nearshore ecosystem (USGS 2004: Takesue et al. 2005).

A variety of human impacts affects eelgrass growth. These include docks, which shade the bottom; increased nutrient inputs to the nearshore, which can cause plankton blooms or excess growth of eelgrass epiphytes (both of which can reduce the ability of eelgrass to get enough light); and numerous aquaculture activities, which compete for space. Toxics, such as metals and crude oil, directly impact eelgrass and kelp. Low oxygen and the related high sulfide levels in sediments impact eelgrass. Bioturbation, grazing, and disease are additional possible causes for eelgrass decline. (Mumford 2007).

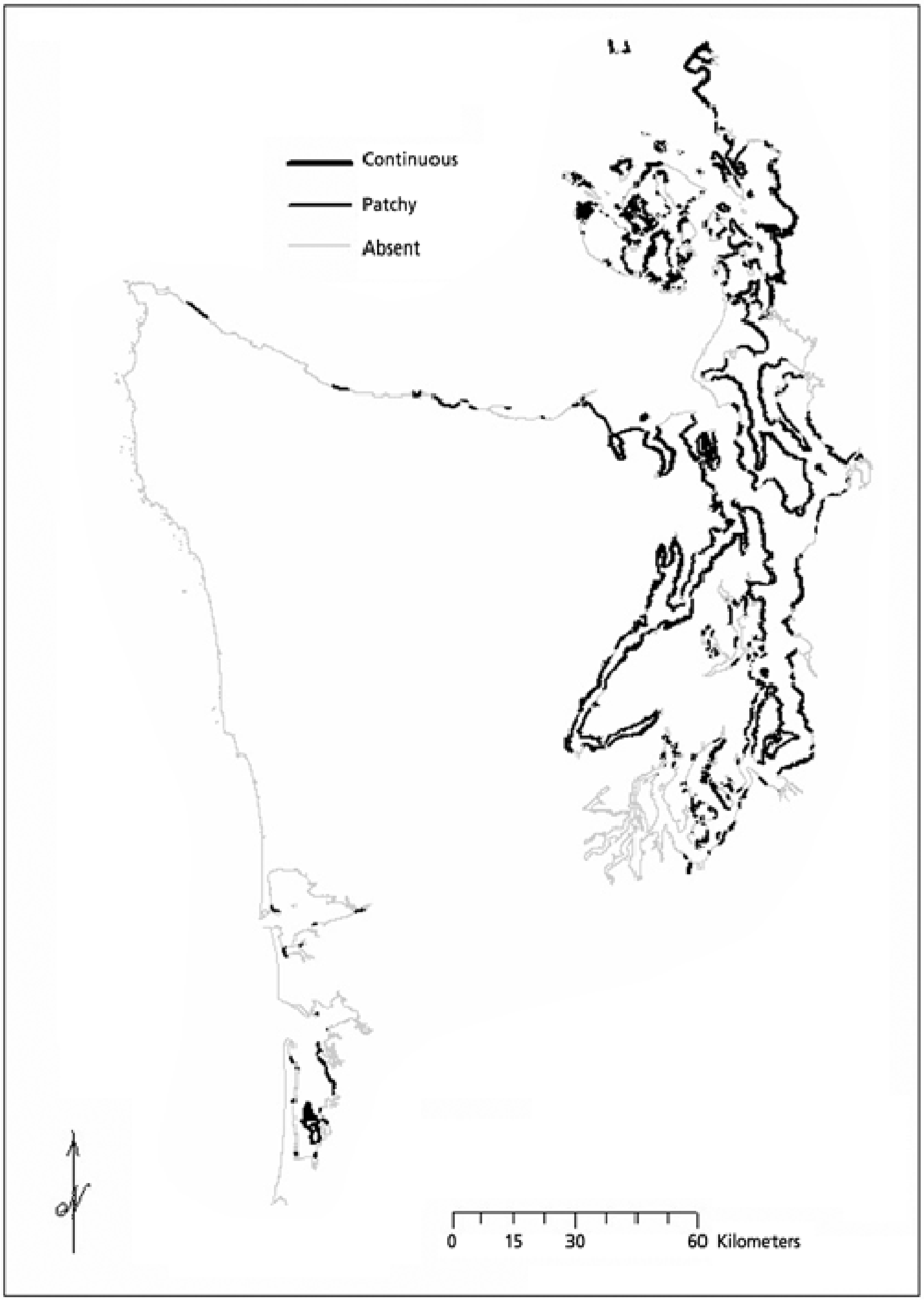

Figure 2. Eelgrass Presence in Washington State. Data from Washington Department of Natural Resources and Puget Sound Assessment and Monitoring Program Shore Zone data set (Nearshore Habitat Program 2001).

Effects of the Action

Effects of the action are the direct and indirect effects of an action on the listed species or CH, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR 402.02). The proposed action is issuance of a NWP 48 permit that will enable the continuation of ongoing shellfish aquaculture activities whose past effects already inform, in part, the condition of the environmental baseline.

Therefore, this section describes those effects, and examines whether and to what extent listed fish will be exposed to the effects, and whether exposure is extensive enough to impair normal behavioral patterns in fish that respond to exposure. Review of the literature during consultation revealed divergent findings on many relevant issues such that there remains some uncertainty regarding the likelihood of the effects of these activities on the environment and whether or not likely effects would bear on individual fish or the populations to which they belong. In cases of such uncertainty, NMFS considers the breadth of findings in the literature during consultation.

Complete descriptions of the aquaculture methods for growing and harvesting shellfish were presented in the description of the proposed action. The activities fall within the general categories of bed preparation, seeding, grow out, and harvest. Some of these activities occur only once in a harvest cycle of a shellfish species at a particular site while other activities, e.g. harrowing, may occur more than once in the planting and harvesting cycle. In addition, carbaryl application is described so that the effects of that interrelated action can be described with the effects of the action. Some of these activities cause environmental effects to which listed species will be directly or indirectly exposed. With the exception of carbaryl application, NMFS determined that although the effects of these activities could include changes in the environment, none do so to an extent that would impair normal behavioural patterns of listed species.

Shellfish aquaculture activities can temporarily increase water turbidity during some bed preparation and harvest activities, e.g. tilling, harrowing, dredge harvest of oysters and geoduck harvest. These same aquaculture activities can contribute total suspended solids (TSS) or turbidity down-current that may alter physical habitat, cause short-term disturbances to benthic communities, and may affect eelgrass growth in the project area. Some aquaculture activities, e.g. tilling, dredge harvest, and geoduck harvest can also remove some SAV (eelgrass). The presence of some existing shellfish operations considered in the baseline can impair the establishment of eelgrass, although there is some uncertainty regarding how this might affect listed salmonids, if at all. Shellfish aquaculture activities are also reported, however, to contribute to water clarity via the filter feeding of cultured mollusks, removing phytoplankton from the water column. Such improved water quality can also contribute to improving habitat for the establishment of SAV (e.g., eelgrass). The presence of oyster shell habitat can also provide better habitat for the establishment of eelgrass than soft, bioturbated substrates (Dumbauld and Wyllie-Echeverria 2003). Graveling substrates for clam culture can also provide habitat better suited for various amphipod and copepods species, important prey items for the species considered in this consultation (Simenstad et al. 1991, Thom et al. 1993, Jamieson et al. 2001)

The environmental effects on listed fish from farming shellfish in the intertidal zone are:
(1) episodic water quality effects from physical interactions with the bottom (raking, tilling, and harvesting) increasing turbidity (2) Impacts to SAV(eelgrass) from aquaculture activities;
(3) water quality and related effects from application of carbaryl insecticide to control burrowing shrimp in certain places; and (4) benthic disturbance. Each of these effects could influence behaviour, but only where fish presence overlaps with effects (exposure) occurring above certain duration and/or intensity levels to cause responses in the form of behavioural changes that decrease performance in individual fish. However, with the exception of the application of carbaryl in minute portions of certain sections of the action area, the effects of the proposed

permitted activities will neither reach durations nor intensities that would be necessary to cause such responses in exposed fish. The section below discusses the environmental effects of the action, and describes why the effects on water turbidity, SAV, and benthic interactions are not likely to adversely affect listed fish. The section also describe why application of carbaryl in limited portions of the action area are likely to adversely affect certain listed fish. The section concludes with a discussion of the extent and relevance of those impacts on affected populations and the species that those populations comprise. The relationship of these issues to CH is discussed separately, below.

Effects on Fish

Water Quality--Turbidity and Suspended Sediments. Several shellfish aquaculture activities physically interact with the bottom at managed sites. Some of these activities include raking, tilling, dredging, and geoduck harvest. When these activities disturb sediments, they can alter sediment stability and lead to changed grain size distribution (Willner 2006). Changed grain size distribution might affect benthic production of forage for listed fish, and is discussed under benthic disturbances, below. Disturbed sediment can become suspended in water near the disturbed site, increasing turbidity. In certain circumstances, increased turbidity can have effects on individual listed fish ranging from no effect, to both increased and decreased vulnerability to predators, to physiological stress and injury that reduce individual performance. This subsection assesses whether increased turbidity from activities covered under the proposed NWP 48 will be significant enough to reduce performance to a degree that impairs normal behaviors.

In intertidal systems such as the action area, the transport of sediments is a dynamic, short-term cyclical and morphological process that is largely attributed to the tides (ENVIRON 2008a) and local drift cell currents. Sediment particles suspended by these activities settle in ways that make them susceptible to further resuspension. When individual fish are exposed to and encounter increased turbidity, their responses can vary from enhanced performance to decreased performance, and injury or death. Turbid water can both enhance cover conditions, reducing vulnerability to predation (Gregory and Levings 1998), and yet also increase predator cover making listed fish more vulnerable to predation. Furthermore, chronic exposure to increased turbidity can lead to physiological stress and reduce feeding and growth in individual fish (Redding et al. 1987, Lloyd et al. 1987, Servizi and Martens 1991).

The extent to which increased turbidity will bear on individual fish and reduce their individual performance depends on the intensity and duration of turbid conditions, the life stage of the exposed individual salmon or steelhead, and length of their exposure. Intensity and duration of turbid conditions are related to the concentration of suspended sediment, the suspended sediment grain size, and the water temperature. Intensity and duration also depend on current and tidal flow conditions at the site. Of the management activities contemplated under the proposed NWP 48, geoduck harvest and dredge harvest of oysters are the most likely to have bottom interactions that will increase in-water turbidity. According to ENVIRON (2008a), data collected at several farms sites during geoduck harvest showed increased localized turbidity from the harvest activity. Increased turbidity was concentrated at the harvest site, and quickly dissipated down-current within a few feet of the harvest site.

ENVIRON (2008a) conducted an examination of the potential risk of a turbidity plume in a worst-case test, wherein geoduck harvest occurred right at the water's edge. Water samples were taken immediately adjacent to the harvest site. Using the "concentration-duration suspended sediment response model" (Newcombe and Jensen 1996), the study found that if salmon were exposed to turbid water caused by geoduck (mechanical dredge) harvest for three straight hours, they would respond with minor to moderate physiological stress which might include short term changes in fish behavior (ENVIRON 2008a).

While the finding in ENVIRON 2008a is useful, the model in Newcombe and Jensen 1996 on which that finding relies was developed considering factors specific to freshwater environments. There exists no marine-specific counterpart to the Newcombe and Jensen 1996 model and the model has not been verified for marine conditions. Assuming all other factors are constant (e.g. current and temperature), suspended sediments will not remain suspended as long in saltwater as in freshwater. Robbins, (1978) found that turbid saltwater clarifies more quickly than fresh water. Therefore, the worst-case test of the model likely overstates the extent of possible turbidity effects on listed fish, even from geoduck harvest.

While increased turbidity is an expected result for a short time following some aquaculture activities, specifically mechanical dredge harvest, turbid water resulting from these activities is not reasonably certain to adversely affect listed fish. Most harvest activities, such as the removal of staked and bagged oysters (among others), do not interact with and suspend settled sediment in the water column during and after harvest. In contrast, harvest activities that involve digging or dredging will interact with the bottom, but will only suspend sediment when done under water, in which cases turbidity would remain localized and limited in duration. Suspension of sediment from these types of harvests is typically brief in the nearshore environment, as sediment settles out of the salt water column more rapidly than in the freshwater environment. Furthermore, the presence of a harvester and the operation of a mechanical dredge decrease the likelihood of fish presence, creating an extremely low likelihood that fish will be exposed to increased turbidity. Therefore, increased turbidity from the proposed action is not likely to adversely affect listed species.

Mechanical dredge harvest is conducted in Willapa Bay, Grays Harbor, and in the Samish Bay portion of the North Puget Sound sub-area. Puget Sound Chinook salmon may be exposed to dredge harvest at Samish Bay, but the presence of the activity is likely to cause fish to depart the active area, avoiding the footprint of the turbid water column and any related effects. The same is true in Willapa Bay and Grays Harbor where LCR Chinook salmon and CR chum salmon can be present during summer months (Kirt Hughes, WDFW, pers. comm., 12/2008) Therefore, mechanical dredge harvest activities are not likely to adversely affect PS Chinook salmon, or LCR Chinook salmon or CR chum salmon.

Water Quality—Change in Nutrient Balance. Molluscan aquaculture is relatively benign in terms of effects on water quality compared to fish and shrimp culture. Because no organic inputs are added (the mollusks filter their food directly from the water), the impacts on water quality from changes in nutrient content are, if anything, small, low intensity, and of brief duration. However, mollusks concentrated on a farm still consume oxygen, produce carbon dioxide, and produce ammonia as an excretory product, the extent of which these accumulate depends on flushing of water around the farm.

Rhode Island's Coastal Resources Management Council (CRMC 2008) acknowledges that although oysters excrete ammonia, the ammonia is quickly taken up by phytoplankton, macro algae and eelgrass as a nutrient source. The report also found that oysters significantly increased rates of sedimentation to the bottoms of the tanks and altered the phytoplankton composition in the tanks (presumably because of selective feeding on one particular phytoplankton species). The CRMC report (2008) also points out that oysters are one of the mollusk species particularly useful in clearing phytoplankton from the water column because they continue to feed even when food concentrations are high and they presumably have enough food. The excess, undigested phytoplankton (along with other less digestible particulate matter) is incorporated into pseudofeces that sink more quickly to the bottom than would the phytoplankton particles themselves.

The fate of the nutrients such as organic nitrogen in the sediment resulting from the presence of farmed shellfish depends to some degree on the amount of sedimentation in relation to the absorptive capacity of the benthic microbial community. Microbes break down the organic material residual to the presence of the farmed shellfish (e.g. pseudofeces). Under normal conditions, aerobic bacteria will decompose that material into ammonia, which enters the process of nitrification to be converted to nitrite and nitrate, which in turn can be used as nutrients for benthic algae, SAV, or phytoplankton (if suspended again into the water column). In addition, deposition of organic nitrogen to the sediments may increase denitrification. Denitrification is the process by which nitrate or nitrite is converted to nitrous oxide or free nitrogen (N_2). This denitrification process represents a primary shellfish effect on estuarine nitrogen cycling and is the principal process by which shellfish can attenuate or reverse eutrophication processes in estuaries (Newell et al. 2002, Newell 2006, Rice 2007). The process can be completed by either aerobic or anaerobic bacteria and production of free nitrogen in particular represents a way by which nitrogen can be fixed by plants or returned to the atmosphere as nitrogen gas. The CRMC report (2008) also reported that most of sediment nitrogen is fixed by benthic algae (in the presence of light) and that substantial amounts of nitrogen are not released back to the water column as nutrients for phytoplankton.

On the other hand, if conditions are not normal (e.g., excessive amounts of organic material can be deposited), anaerobic processes can come into play once the deposited material exhausts the oxygen available for aerobic decomposition. In this case, the water above the sediments can become anoxic and ammonia, hydrogen sulfide and methane can be released into the water column. One such study conducted in the River Exe estuary in England found a thinning of the aerobic zone (Nugues et al. 1996). However this situation is probably unique to the study area (relative to the action area for this consultation) and unusual as growers in the action area would avoid these types of culture areas as they are not conducive to optimum shellfish productivity (Jones and Stokes 2007). The critical aspect is the rate of deposition of organic material to the sediments compared to the rate at which the bacteria there can process that material, in particular the nitrogen (CRMC, 2008).

Because shellfish aquaculture is not likely to change the balance of nutrient materials given the absorptive capacity of local microbial communities, the covered activities are unlikely to cause anoxia, excessive denitrification, or any of the results described above. Therefore, these activities are not likely to adversely affect listed salmon, steelhead, or sturgeon.

Water Quality—Application of Carbaryl. During consultation, NMFS considered whether the application of the insecticide Sevin (carbaryl) is an interrelated and interdependent action. Such applications are not an element of the proposed action as the COE has no jurisdiction over and cannot condition those applications through the issuance of NWP 48. But assessment of the practice during consultation revealed that such applications have no independent justification in the action area other than in supporting the larger action of shellfish aquaculture management in Grays Harbor and Willapa Bay. Since carbaryl applications are dependent on the larger action (issuing NWP 48) for their justification, NMFS must analyze the effects of carbaryl with those of the proposed action considered in this biological opinion.

Because application of carbaryl is not a part of the proposed action and the COE has no regulatory authority over such applications, the COE has no capacity to minimize the effects of this activity. Therefore, although the effects of interdependent actions must be considered with the effects of the action, those effects are not considered in the ITS that accompanies this biological opinion.

Pacific salmon (LCR Chinook salmon and CR chum salmon juveniles and adults) may use the estuarine habitat in Willapa Bay and Grays Harbor where carbaryl is applied. The southern DPS of green sturgeon (sub-adults and adults) also use the estuarine habitat in Willapa Bay and Grays Harbor where carbaryl is applied. Effects of the proposed carbaryl applications include potential reduction of the prey items, and waterborne exposure through drinking and across gills, and AChE inhibition.

The BA carbaryl addendum (ENVIRON 2008) explains the mechanism of action of a pesticide as the biochemical and/or physical method used to kill or suppress the growth of the target receptors. The addendum also informs the efficacy of carbaryl on target species as 90 to 95 percent effective on the target species when applied at a maximum rate of 8.0 a.i. lb per acre. The primary pathway for environmental degradation in water is via hydrolysis followed by photodegradation. Toxicity to aquatic receptors and exposure is also presented in the Addendum. The NMFS reviewed additional studies as well.

The EPA has listed carbaryl as a “low to moderate” toxicant. Stonick (1999) reported that carbaryl may have mutagenic activity and may be an endocrine disrupter. She noted that while carbaryl itself is toxic to crustaceans, 1-naphthol (a toxic breakdown product) is more toxic to fish, mollusks, and starfish than to crustaceans. More recent review of available information and literature has produced no affirmative information that carbaryl has endocrine disrupter properties (S. Hecht, PRD/HQ, pers. comm. Feb. 2009).

Numerous monitoring studies have been conducted in coordination with applications of carbaryl to control burrowing shrimp in commercial oyster beds in Washington State. The results of the studies are quite variable, as are the study designs and objectives. Several investigations have documented water column concentrations exceeding several mg/L (which is substantially higher than the µg/L concentrations observed in freshwater aquatic habitats) following the first flood tide post-application (Hurlburt 1986; Creekman and Hurlburt 1987; Tufts 1989; Tufts 1990). Water column concentrations measured at Willapa Bay in 1984 detected a mean concentration of 10.6 mg/L upon initial flooding of the treated area (Hurlburt 1986). Concentrations were monitored at varying depths for several hours following flooding. The concentrations decreased rapidly but were detectable in the low µg/L range throughout sampling. In 1985 samples were collected along transects from treated areas following the direction of the tide to monitor the dispersal of carbaryl (Creekman and Hurlburt 1987). The data indicate that carbaryl is transported off the treated area by the tide. Average concentrations measured above the treated area ranged from 2.4 – 5.5 mg/L. The highest average concentration (7.9 mg/L) was collected 510 feet from the treated area. Average concentrations at the most distant sampling point (650 feet from initial treated area) were 2.5 mg/L. In 1996, further study was taken to evaluate carbaryl movement off the treated spray area (Tufts 1989). Samples were collected along a transect corresponding to the direction of the incoming tide. The peak concentration measured was 27.8 mg/L. Over one treated area, the concentration of carbaryl decreased from 13.2 mg/L to 9.3 mg/L as the water depth increased from 1.5 to 10 inches. The concentration further decreased to 600 µg/L when the water rose to 16 inches. The monitoring indicated concentrations of carbaryl decreased with increasing distances along the transect, but concentrations greater than 1 mg/L were detected in several instances at distances several hundred feet from treated plots. Carbaryl was found in the water column at the detection limit (0.1 mg/L) as far as 1,725 feet from the treated area.

The dilution pattern and concentrations of carbaryl in shallow pools and streams were monitored in 1987 (Tufts 1990). Peak concentration for one sample site was 18.8 mg/L upon initial flooding. The concentrations decreased to 0.2 mg/L when covered by 18 inches of water. Results were somewhat variable among sites. For example, another sample site showed no detections of carbaryl upon initial flooding. Peak concentrations of 8.4 mg/L were detected at a depth of 11 inches. This sample station was located 300 feet from treated area. Maximum carbaryl concentrations detected at other sites were 17.4, 7.8, and 4 mg/L with samples collected at depths of 6, 4, and 13 inches from the bottom. Average concentrations of carbaryl detected in tide pools and small streams ranged from 3.6 to 11.2 mg/L. The 11.2 mg/L detection was associated with application of 5 lbs carbaryl/acre. An average concentration of 7.8 mg/L in tidepools and streams was associated with an application rate of 4 lbs carbaryl/acre. Similarly, a more recent study found a peak of 820 µg/L in the water column 50 feet from the application site following a typical treatment application of 8 lbs/acre (n=3) (Weisskopf and Felsot 1998).

Several studies demonstrate that carbaryl dissipates rapidly from over the treatment site due to degradation, metabolism, dilution, and off-site transport (Hurlburt 1986; Creekman and Hurlburt 1987; Tufts 1989; Tufts 1990; Weisskopf and Felsot 1998). In 2006 and 2007, samples collected at the mouth of channels adjacent to treated oyster beds in Willapa Bay had maximum concentrations of 29.1 µg/L after 6 h (high tide), 38 µg/L after 12 h (low tide), and 21.1 µg/L after 24 h (low tide) (Major et al. 2005)

The NPDES permit for Willapa Bay and Grays Harbor requires annual monitoring of water column concentrations in treated areas. It specifies an acute effluent limit of 3 µg/L and a chronic limit of 0.06 µg/L. However, data associated with this monitoring are of questionable value because the monitoring plan specifies that monitoring is suspended for the first 48-hours following application to assess the acute effluent, and further suspends monitoring for 30 days from the last application to assess the chronic limit. We expect that most of the carbaryl will be degraded and transported to other locations by the time carbaryl monitoring is initiated.

Carbaryl sprayed on mud flats can be transported substantial distances at concentrations that may have ecological impacts. Researchers found that close to 100 percent of Dungeness crabs were killed up to 100 m off the carbaryl application area (Doty, Armstrong et al. 1990). Levels decrease to below 1 mg/L when transported more than 200m or more. The WDOE reports that carbaryl concentrations in the "potential effects threshold range" of 0.1-0.7 µg/L have been detected at locations several miles from oyster beds soon after large areas were treated (Johnson 2001).

Carbaryl is not a persistent bioaccumlative toxicant (IARC 1976). However, longer-term persistence has been observed in the treated sediments relative to the overlying waters where treatment occurs. The WDOE 2001 found an average carbaryl concentration of 105 µg/Kg (parts per billion) in sediment from treated sites 60 days after application, and carbaryl was detected in sediment pore water at 0.57-1.2 µg/L (parts per billion) on day-60 (Stonick, 1999). Dumbauld et al. (1997) reported shorter persistence in the sediments, 40-45 days or less, and that the rate of initial decline after application is rapid (WDOE 2001). Carbaryl persists for a short time in sediments because it binds tightly to sediment and this characteristic facilitates its efficacy against burrowing shrimp.

There have been concerns that carbaryl applications in Willapa Bay and Grays Harbor may have adverse effects to the commercial Dungeness crab fishery (Feldman, et al. 2000). Consequently, WDF conducted several surveys to estimate the number of crabs killed (Hurlburt 1986; Creekman and Hurlburt 1987; Tufts 1989; Tufts 1990). Transect surveys conducted on treatment beds the day following applications indicate large numbers of crabs are killed by the applications (Table 6). Other acute mortalities to nontarget organisms were generally not reported. However, transect surveys were conducted during 1986 and 1987 due to concerns over potential impacts to fish given staff observations from the WDF reported that fish mortality was "routinely" noted, but not quantitatively assessed following applications of carbaryl (Tufts 1989). Mortalities were characterized as small fish apparently trapped in shallow pools during low tide and directly exposed during carbaryl treatments. The surveys indicate several thousand fish were killed each year from carbaryl applications to approximately 400 acres at rates of $\leq$ 7.5 lbs a.i./acre. Currently, the NPDES permit allow for treatment of up to 600 acres. The current 24 (C) label does not specify acreage restrictions and allows for applications of carbaryl up to 8 lbs a.i./acre.

Table 6. Estimated dungeness crab mortalities resulting from carbaryl applications in Willapa Bay and Grays Harbor, Washington

Year	Maximum Application Rates*	Total Acres Treated**	Dungeness Crab Killed
1984	≤ 10 lbs a.i. / acre	490	38,410
1985	≤ 7.5 lbs a.i./acre	391	59,933
1986	≤ 7.5 lbs a.i./acre	398	16,286
1987	≤ 7.5 lbs a.i./acre	434	44,053

* Current 24(c) label allows for application of up to 8 lbs a.i./acre.

** Current NPDES permit allows for a total of 600 hundred acres to be treated in Willapa Bay and Grays Harbor, WA. The Label places no restrictions on acres or geographic restrictions for use of carbaryl on Oyster beds in Washington.

Given that the fish that reside in standing water on mud flats are likely to be the most vulnerable to carbaryl exposure, staff from the Washington Department of Fisheries also estimated the available marine fish habitat that existed on exposed mudflats of treated areas. This was characterized as water that was at least 2 inches in depth, a depth that is adequate for salmon fry. This habitat comprised substantial portions of the treated areas. In 1986, surveys indicate 135 acres of the 398 of the treated area (approximately 34 percent) were marine fish habitat (Tufts 1989). In 1987, 67 of the 434 (15 percent) acres were characterized as marine fish habitat. The current NPDES specifies that there be a 200 foot buffer zone for sloughs and channels when carbaryl is applied by helicopter. A 50 foot buffer is required for those aquatic habitats when carbaryl is applied by hand sprayer. AgDrift estimates for aerial application at an application rate of 8 lbs a.i./acre with a 200 foot buffer indicate the average initial concentration from drift to a body of water that is 2 inches deep (about 5 cm) and 10 meters wide would be 771 μg/L. A direct overspray of 2 inches of water would result in an average initial concentration of approximately 18 mg/L, a concentration comparable to measured concentrations associated with initial tidal inundation of treated mud flats (see surface water detections above). Acute exposure to these concentrations are expected to kill a portion of exposed salmonids in a matter of hours i.e., 24 h-LC50s for carbaryl range from 948-8000 ug/L, n= 60 (Mayer and Ellersieck 1986), and significantly reduce AChE activity that will lead to myriad sublethal effects such as impaired swimming. The AChE activity is reported to be affected, 20 percent inhibition, when exposure is around 23 μg/l for six hours.

Table 7. Estimated fish mortalities resulting from carbaryl applications in Willapa Bay and Grays Harbor, Washington

Year	Maximum Application Rates*	Total Acres Treated**	Fish Killed
1986	≤ 7.5 lbs a.i./acre	398	14, 954
1987	≤ 7.5 lbs a.i./acre	434	8,041

* Current 24(c) label allows for application of up to 8 lbs a.i./acre

** Current NPDES permit allows for a total of 600 hundred acres to be treated in Willapa Bay and Grays Harbor, Washington. The Label places no restrictions on acres or geographic restrictions for use of carbaryl on Oyster beds in Washington.

Salmonids were not reported in the sampling data which occurred over two seasons. The authors report that the fish kills were extremely variable and unpredictable. The fish mortality reported for transect surveys included only four species in 1986: saddleback gunnel, threespine stickleback, staghorn sculpin, and arrow goby. In 1987, mortalities included English sole, sand sole, kelp greenlings, shiner perch, saddleback gunnels, staghorn sculpin, and arrow goby. A WDF employee with knowledge surmised that fish with swim bladders may not have been found on the next low tide survey as they would have floated off and/or been consumed by avian species that were readily observed feeding on the nekton (Thom Hooper, pers. comm., Feb. 2009). Another observer does report collecting one Chinook salmon of approximately 100 plus mm on the day of a spray monitoring exercise in the late 1980s.

An important issue for listed fish exposed to carbaryl is the potential for exposure to affect performance in response to exposure. Behavior such as swimming and predator avoidance can be impaired when the brain chemical acetylcholinesterase (AChE) is inhibited, as occurs after carbaryl exposure. The extent to which exposure to carbaryl inhibits AChE is unclear. Major (2005) found that brain AChE assays showed statistically significant levels of inhibition during the first tide post treatment on one spray event with recovery to pre-spray levels of AChE by the second tide post-treatment. Both spray events showed significant increases in AChE levels by the third tide post treatment. The results suggest that juvenile Chinook salmon are being exposed to low levels of carbaryl over at least 50 hours, but are not exhibiting levels of AChE inhibition associated with mortality or overt behavioral effects (lethargy, erratic swimming, or on-bottom gilling) (Major et al. 2005). However, Major et al. (2005) caution that enzyme inhibition thresholds for locomotor effects (endurance and predator avoidance) and olfactory-mediated behaviors (attraction to food and predator avoidance) cannot be ruled out.

Other studies considered whether despite low AChE inhibition from carbaryl exposure seen in the studies like Major 2005, some animals might still be vulnerable to lowered performance in terms of predator avoidance. Scholz et al. (2006) found that carbamates (among other things), a group of materials to which carbaryl belongs, are likely to have additive effects on the neurobehavior of salmon under natural exposure conditions. Thus, they concluded that ecological risk assessments that focus on individual AChEs might underestimate the actual risk to salmon in watersheds in which mixtures of these chemicals occur.

Based on reviews of multiple years of water quality monitoring data that has been compiled as part of the NPDES program for carbaryl use, and fisheries data showing the use of nearshore culture areas by Chinook salmon, ENVIRON (2008b) concluded that acute carbaryl exposure to Pacific salmonids in Willapa and Grays Harbor could be adverse but chronic exposure conditions did not exist through waterborne exposure. As oral ingestion has not been shown to elicit significant toxicity, dietary exposure through sediment and sediment-associated benthos was not considered to represent an acute or chronic hazard or adverse effect. These findings are, however, evidence that the application of carbaryl on tide flats in Willapa Bay and Grays Harbor can lead to waterborne exposure of sturgeon or salmon in Willapa Bay.

Juvenile and adult Chinook salmon from ESA-listed Columbia River populations are expected to be present in Willapa Bay at the time of carbaryl applications. Based on the documented behaviors, it is expected that juvenile Chinook salmon from the Lower Columbia River utilize these estuaries during the period when carbaryl is applied (E. Casillas, NW Sci. Cntr., Anne Shaffer, WDFW, and Thom Hooper, NMFS, pers. comm. 2009). Further, their use of dendritic channels to access inundated mud flats suggests that juvenile Chinook salmon will be exposed to peak carbaryl concentrations in the water column and from feeding on live and dead, contaminated prey. Given the proximity of Willapa Bay to Grays Harbor, LCR Chinook salmon are reasonably certain to be present in Grays Harbor.

Studies conducted by Dumbauld and others in Willapa Bay and Grays Harbor have used tow nets to capture juvenile Chinook salmon utilizing the water column over oyster beds after application of carbaryl. Juvenile Chinook salmon exposed to carbaryl in the water column will exhibit AChE inhibition and be subjected to increased risk of predation as a result. The NMFS concludes based on genetic data from adult Chinook salmon captures and recent studies of juvenile salmonids rearing outside their natal estuaries (E. Casillas pers comm. 2009) that it is likely that some ESA juvenile Chinook salmon from the LCR ESU will be taken.

Consultation did not reveal studies addressing the effects of carbaryl on sturgeon. Researchers noted that there is no direct evidence that sturgeon forage on carbaryl treated tide flats. No sturgeon feeding pits on oyster beds have been observed and Dumbauld suspects that, at least at current population levels, they rarely use these areas to feed, and, in fact, they are more likely to forage elsewhere -- either in the channels or on tide flats where burrowing shrimp are more abundant (Dumbauld, pers. comm.). However, Dumbauld cautions that this conclusion is based on a sample of very few animals.

Although up to 51 percent of the biomass ingested by sturgeon captured in Willapa Bay is burrowing shrimp (Dumbauld et al. 2008), there is no evidence that the green sturgeon would experience a significant reduction in the abundance and availability of food as a result of the burrowing shrimp control program at shellfish culture sites (Dumbauld et al. 2008). Burrowing shrimp are very abundant in the coastal estuaries and the eradication program is limited to a relatively small area (i.e., up to 600 acres in Willapa Bay and 200 acres in Grays Harbor).

Green sturgeon, like juvenile salmon, will be exposed to carbaryl through drinking seawater contaminated with carbaryl and passing it across their gills. We have not found studies of the potential effects thresholds for green sturgeon. However, the USFWS (USFWS 2008) found that certain sturgeon species (Atlantic sturgeon, shortnose sturgeon) have been shown to be very sensitive to chemical exposures relative to other fish species. If so, then the southern DPS of green sturgeon are likely to exhibit similar, if not greater, behavioral effects as experienced by juvenile salmon.

Although the studies presented here are based on research in Willapa Bay, we believe that similar conditions and effects exist for listed salmon and sturgeon in Grays Harbor. Green sturgeon occupy Grays Harbor during the spraying of carbaryl. If Columbia River ESUs enter Grays Harbor, they will also be present when carbaryl is being applied. Carbaryl is applied in the same manner, and exposure pathways would be identical to those in Willapa Bay.

Based on the analysis above, individual Southern DPS green sturgeon will be exposed to the effects of carbaryl application. Some of the exposed fish will respond to exposure making them more vulnerable to predation, and some of those made more vulnerable will be injured or killed as a result of the application of carbaryl in Willapa Bay and Grays Harbor.

To assess the number of Southern DPS green sturgeon that might be injured or killed by the proposed action, NMFS prepared assumptions establishing both the estimated biomass of shrimp removed per acre of application and the number of Southern DPS green sturgeon individuals affected per acre of application for both Willapa Bay and Grays Harbor. The data and sources for these assumptions are presented in Appendix B. Although abundance information is derived in ranges from minimum to maximum, NMFS used the maximum abundance during this consultation to derive a worst possible case of the extent of affect individuals. Based on data from Beamesderfer and Webb (2002) and Adams et al (2002), NMFS assumed the total number subadult and adult Green Sturgeon in Willapa Bay to be as many 6,290 fish. The number of subadult and adult Green Sturgeon in Grays Harbor is as many as 4,831 fish. Based on assumptions about the maximum extent of affected acreage per year, the density of affected Green Sturgeon in Willapa Bay is 0.118 fish per acre, and in Grays Harbor is 0.107 fish per acre. Based on this density of affected fish, the maximum number of fish that might be injured or killed by the application of carbaryl in Willapa Bay is 100 fish per year. The maximum number of fish that might be injured or killed in Grays Harbor is 48 fish per year. Sturgeon vulnerability is also influenced by proximity of carbaryl application relative to seal haul-outs, where predator densities would be higher. Carbaryl applications might render exposed fish to higher risk of predation should exposure to carbaryl occur closer to seal haul outs since the response to exposure is decreased ability to avoid predators. Attempting to account for the fact that applications will not in every instance be co-located with predator populations, mid-point estimations are appropriate surrogates for estimates of injured or killed green sturgeon from this action. The NMFS has also considered these take assumptions in light of our estimate of population for Southern DPS green sturgeon. The appendix work sheets would indicate an estimate of potentially as few as 13,900 and as many as 70,400 subadults and adults in the population. This would mean that sturgeon injury or death associated with this action as an interdependent activity would be approximately 0.105 to 0.532 percent of this subadult and adult population on a yearly basis.

As stated above, the application of carbaryl is not regulated by the COE and is not part of the proposed action. While take is likely to occur, the analysis of the effects of carbaryl is included in the Opinion for purposes of assessing the risk these effects pose for the conservation of the species, and not for the purpose of exempting any incidental take.

Benthic Disturbance. Benthic disturbance for this analysis refers to the various activities that involve a physical interaction with the bottom. Activities that interact with the bottom under the proposed NWP 48 include site and plot preparation, grow-out, and harvest. The issue for each of these activities and the benthic environment is whether and to what extent they influence the functional condition of the nearshore marine bottom environment, and whether any influence is significant enough to impair normal behaviors of listed fish in the action area. Several activities that are part of shellfish aquaculture involve proximal contact with the bottom. This implies some effect on benthic processes; specifically those processes that contribute to the production of food for listed fish. However, the intensity and duration of these disturbances are local, small, and brief. During this consultation we found no evidence that such disturbances interfere with benthic productivity or decrease the availability of forage for salmon, steelhead, or sturgeon to such a degree that would impair normal behavioral patterns of exposed, listed fish. Thus their importance to salmonid and sturgeon life history expression appears to be limited, as will be discussed below. The other results of interactions with the bottom (water quality degraded by increased turbidity) are discussed separately, above.

The primary issue for listed fish caused by benthic disturbance is whether or not bottom interactions from any source change conditions affecting the function of the benthic food web. The effects of those interactions on benthic function to produce forage for listed fish are variously reported. Straus et al. (2008) reported increased benthic species at mussel culture sites, decreased benthic species richness at oyster culture sites, and no significant differences in benthic species (infauna) between mussel farms, oyster farms, and reference sites. Dumbauld (1997), in a review of studies on the impacts of oyster aquaculture, reported that species abundance, biomass, and diversity are often enhanced in areas where oysters are cultured. ENVIRON 2008a, in a review of recent studies found that Fleece et al. (2004) reported that species richness of macroinvertebrates was higher in areas seeded with geoduck than in unseeded areas. ENVIRON 2008a also found that Pearce et al. (2007) reported similar results in species richness of benthic infauna two months after geoduck were seeded in an aquaculture site in British Columbia, Canada. Increased densities of benthic infauna at intertidal geoduck clam aquaculture sites may persist even after removing the protective PVC tubes and netting. For example, at one aquaculture site in Southern Puget Sound, ENVIRON 2008a, found the average number of infaunal benthic organisms per sediment core from an unprotected seeded area was greater than the density of infaunal benthic organisms found in a reference area located outside of the aquaculture site.

Some of the various hand or mechanical harvest methods used in shellfish aquaculture involve a physical disturbance of the bottom that affect sediment and benthic fauna (Johnson 2002). In most cases, bottom disturbance reduces the number and abundance of benthic species in the disturbed area, although the extent of such reductions has been reported variously, including no effect at all. For example, hand raking and digging for various shellfish in Yaquina Bay, Oregon, did not impact infaunal species number and abundance as reported by Straus et al. (2008). Furthermore, while post-harvest reductions of some taxa have been observed at intertidal geoduck aquaculture sites in Southern Puget Sound, sites generally recover after harvest. The recovery rates of benthic communities following physical disturbance depend on a variety of physical, chemical, and biological factors (Dernie et al. 2003), but in general, they recover fairly quickly. Preliminary data developed by Chris Pearce (DFO Canada), as reported by ENVIRON (2008a) suggests that species richness and relative abundance of benthic fauna at a geoduck aquaculture site in British Columbia, Canada were restored to pre-harvest levels within six months.

Straus et al. 2008 cited other research that examined the return to pre-disturbance conditions. For example, a study that assessed sediment grain size as a metric of disturbance found that while bottom patches at which disturbance resulted in reduced or no fauna differed considerably in sediment grain size distribution, sediment grain size distribution returned to ambient levels after about two months at the disturbed sites. Similarly, benthic fauna population abundances for most species returned to ambient levels two to three months after benthic disturbance, and the community structure returned to ambient conditions after four months. In Scotland, suction-dredged intertidal cockle sites had an average of 30 percent fewer benthic species and 50 percent fewer benthic individuals, immediately after harvest (Straus et al. (2008). But within 56 days after harvest, the faunal assemblages at these disturbed sites were not significantly different from control sites. A similar study in southeast England examined the sediment structure and benthic community immediately following and seven months after suction-dredge harvesting for Manila clams at an aquaculture site. Harvest suspended the sandy layer but left the underlying clay substrate and substantially reduced both infaunal diversity and the mean number of individuals per sample. However, after seven months, neither the sediment composition nor the benthic fauna were significantly different from control sites. Straus et al. (2008) report that the authors of these studies concluded that clam cultivation does not have long-term effects on the substrate or the benthic community at that location.

Furthermore, the complex surface area provided by oysters and mussels offers habitat for over 100 different benthic species (as reviewed in CRMC 2008). The CRMC review also found that large biomasses of cultured mussels or oysters and fouling organisms suspended from lines attached to buoys or rafts have a major beneficial effect on phytoplankton, benthic, and hydrographic conditions within the immediate area of culture activities. For example, suspended rope culture in high current waters does not disrupt nutrient balance that would, in turn, create a hypoxic environment diminishing benthic food productivity for listed salmon, steelhead, and sturgeon. However, places with existing pollution and decreased flow rates have increased organic sedimentation under long lines, sometimes up to two times that found in adjacent uncultivated areas, and typically display lower benthic diversity and less food items for listed fish (CRMC 2008).

Additional shellfish aquaculture activities with benthic interactions include bed preparation such as “frosting,” which involves spraying gravel or oyster shell onto the intertidal area to make the bed firmer and to minimize predation for the bottom culture of clams and oysters. Frosting an intertidal region shifts the benthic community from polychaetes to amphipods and copepods. Gammarid amphipods are important prey items for juvenile salmonids (Jamieson et al. 2001), making this a beneficial result for salmonid forage production.

Benthic communities may be temporarily disturbed by geoduck seed nurseries. Containers or pools are planted with geoduck seed and placed in the intertidal zone for a short period in the summer, to protect the seed from predators and wave action. The pools are deployed over the top of benthic habitat, but only at a few locations in Puget Sound. In fact, only Spencer Cove and Cape Horn have nursery pools in any great number. And in those two locations, pools roughly occupy less than an acre each (Fisher, pers. comm.). Other farmers may use pools or other nursery containers placed in the lower intertidal zone during the planting season to provide needed flexibility of geoduck planting operations, but the number of containers used is few relative to the extent of intertidal habitat in the action area such that this form of benthic interaction is not likely to adversely affect prey resources available to listed fish.

As mentioned above, and summarized in Straus et al. (2008), benthic recovery typically follows disturbances for shellfish aquaculture. The stability and recolonization rates of benthic fauna can range dramatically depending on physical conditions (sediment type and stability, wave action, current), season, location, scale of disturbance, and whether recolonization occurs primarily through adult movement or larval settlement. Small benthic invertebrates produce more than one generation per year and thus have rapid recolonization rates. Intertidal species have adapted to habitat changes, and so chronic low intensity or sporadic medium intensity intertidal substrate disturbances are within the range of “behavioral or ecological adaptability” (Jamieson et al. 2001). The best available information on the resilience of benthic populations after geoduck harvest is limited and this subject has not been well-studied in Puget Sound. However, geoducks are harvested once every five or six years, a period of time that is reasonably likely to allow full benthic community recovery in between harvests based on the information presented in the studies cited by Straus, et al. 2008.

In summary, intertidal and nearshore shellfish aquaculture activities cause some disturbance of benthic habitat affecting the availability of benthic food resources for listed fish for a short period of time following disturbance. As stated above, benthic affects are reasonably certain to be irrelevant to listed fish in places with already low benthic diversity. In places with normal benthic diversity, with regular flows and normal nutrient balance, benthic items rapidly recolonize after disturbance, making food available again at the disturbed site. The consultation process revealed no evidence to support the argument that forage productivity is limited in and around managed sites. In fact, based on the currently available evidence, the level of benthic disturbance from existing shellfish aquaculture in Washington State is well within the range of normal benthic processes and effects on productivity are likely to be so limited in space (the footprint of the shellfish bed plus some down drift area to account for current) and duration (from a few hours to days, and certainly less than a year), that they are not likely to adversely affect listed salmon, steelhead, or sturgeon. Therefore, the effects of management activities on benthic communities are unlikely to impact forage productivity to a degree that would impair or even influence normal feeding and rearing behavioral patterns in the action area.

Submerged Aquatic Vegetation (Eelgrass). Although shellfish aquaculture does not prevent eelgrass growth or spread to sites next to or near managed sites, the historic and perennial activities of shellfish aquaculture probably limit the formation of persistent eelgrass beds within some shell fish aquaculture sites. In contrast, there is nothing inherent in shellfish aquaculture that impairs or prevents the growth of eelgrass and formation of functional beds adjacent to or near active shellfish aquaculture sites. In fact, the presence of shellfish beds can aid in enhancing water clarity, benefitting the nearby growth and spread of eelgrass. The presence of shellfish structure has also been credited with attenuating wave velocity thus allowing the eelgrass to gain foothold. Eelgrass growth is likely accelerated in areas where the plants are co-mingled with bottom-growing shellfish (Newell 2006). So the issue for this consultation is whether persistent non-presence or reduced density of eelgrass beds within the footprint of perennial shellfish aquaculture sites that provide limited eelgrass habitat function are likely to adversely affect listed fish.

Eelgrass beds provide cover for juvenile salmonids, and structure for the spawning of species on which juvenile salmonids prey. Eelgrass beds and eelgrass patches are a foundational element in the inter-tidal and sub-tidal environment, throughout the action area, supporting the base of the food web. Throughout most of the Puget Sound region, eelgrass is of primary importance as a herring spawning substrate (Mumford 2007; Blackmon et al. 2006). The presence of perennial vegetation tends to be more important than location for selection of spawning habitat (Pentilla 2007). Eelgrass patches also support feeding and growth of herring (and other forage creatures) (Blackmon 2006) on which juvenile salmon and steelhead feed. In a small fraction of documented herring spawning areas, more atypical spawning substrates are used (Mumford 2007), including shellfish aquaculture apparatus.

The existence of managed shellfish plots impairs the development of beds of eelgrass that provide habitat function for juvenile salmonids. And although eelgrass growth can recover following disturbance, the proposed action is likely to maintain conditions limiting eelgrass beds with the footprint of managed sites. Eelgrass spreads from seed source or from rhizome growth. Where sufficient rhizome nodes remain intact following disturbance, eelgrass can recover (Cabaco et al. 2005), although recovery may take an extended period of time and eelgrass density may be initially lower. Eelgrass regrowth can occur on a shellfish bed following aquaculture activities that have removed existing eelgrass, but cyclical management activities probably limit the functional condition of eelgrass in managed sites. Depletion or decreased function of eelgrass in shellfish beds is also probable for off-bottom culture as well, as it limits conditions favorable to eelgrass growth. However, Rumrill and Poulton (2003) found that at certain spacing of the longlines, eelgrass presence was the equivalent of that in the reference plots. Off-bottom, stake (see Griffin 1997), and rack culture can cause erosion or sedimentation in some places, which appears to be the primary cause of eelgrass depletion in areas where this type of aquaculture is practiced (Everett et al 1995). Various aspects of geoduck culture (presence of tubes and disturbance after harvest, for example), also results in a lower density of eelgrass (Ruesink and Hacker 2005). Since the effects of the action include the persistence of these types of conditions within the footprint of managed sites, the recovery of eelgrass in managed sites in unlikely.

Juvenile salmonids utilize a variety of habitats during their migration through Puget Sound. They commonly use eelgrass because it provides cover, refuge and a prey base for small fish at this vulnerable life stage. The reduction of density and extent of eelgrass within the footprint of perennially-managed shellfish beds would appear to perpetuate their already limited function for the support of forage production and cover at those places. However, the absence of these functionally depressed eelgrass beds within managed sites may be of little consequence to juvenile salmonids as nothing in the proposed action impairs or prevents the presence of eelgrass beds adjacent to, or near actively managed sites. A review of publically available aerial photography (e.g. Google Earth) will show unaffected eelgrass sites immediately adjacent to managed aquaculture sites. Such review will also show that SAV is also present at many aquaculture sites, at least during portions of the production cycle at these sites. Additionally, this review reveals that in the context of the extent of salmonid habitat, inter-tidal habitat occupied by aquaculture sites as well as eelgrass and sub-tidal eelgrass habitat, shellfish aquaculture sites occupy a relatively small proportion of the salmonid habitat that exists in these coastal and estuarine waters.

Though the function of eelgrass beds cannot be artificially replaced by structures used for shellfish aquaculture, managed shellfish sites have been observed to support some habitat function juvenile salmonid rearing. For example, Dumbauld (1997) found that when comparing the function of habitat at oyster bottom culture sites to eelgrass beds and mud bottom habitat, both eelgrass beds and oyster culture sites provide similar species richness and habitat utilization by salmonids in excess of adjacent mud flat habitats. The NMFS notes that eelgrass habitats are very ecologically important and that studies have shown seagrass beds to be among the areas of highest primary productivity in the world (Herke and Rogers 1993; Hoss and Thayer 1993). But contrary to the apparently deductive conclusion that shellfish plots do not provide habitat function because they lack highly functioning eelgrass habitat, stake culture also has a species richness, albeit a different species suite, that compares to eelgrass beds (ENVIRON 2008a). A study of similar comparisons with rack and bag shell fish aquaculture found similar results in a tidal estuary in Southern Rhode Island (DeAlteris et al. 2004). These studies suggest that lower density of eelgrass at culture sites does not ensure a net negative ecological result when it comes to supporting juvenile salmonid rearing.

The proposed action is reasonably certain to maintain existing conditions of limited eelgrass presence within the footprint of management actions covered by the proposed NWP 48. As a result, managed sites are unlikely to support eelgrass beds that functionally support juvenile salmonid rearing at an equivalent level. Managed sites are unlikely to have provided that function historically; at least insofar as the development of eelgrass beds are concerned. But nothing inherent in aquaculture activities prevents bed formation or impairs beds adjacent to or near managed sites. In addition, in some cases, aquaculture sites (or shellfish plots) substitutes for the habitat structural function otherwise provided by eelgrass beds that cannot form at those sites. Therefore, maintaining an existing condition of reduced eelgrass within those plots is not likely to adversely affect ESA-listed fish in the action area.

Relevance of Local Effects on Fish to Affected Populations

The preceding section considered the effects of operations of the shellfish farms that would be covered by the proposed NWP 48. With the exception of the interdependent action of carbaryl application, the effects of shellfish aquaculture that would be covered under the proposed NWP 48 on water quality (turbidity and nutrient balance), benthic productivity, eelgrass bed function have been evaluated and found to be of low environmental consequences that they are not likely to adversely affect listed salmon, steelhead, and green sturgeon. Since these categories of effect are not likely to adversely affect individual listed fish, they cannot be found to bear on population viability. Instead, only carbaryl application, an interdependent action, was found likely to adversely affect listed species, and that activity is limited to small portions of Grays Harbor and Willapa Bay. Of the species considered in this consultation, only LCR Chinook salmon, LCR chum salmon, and Southern DPS green sturgeon co-occur with the effects of carbaryl application, so the relevance of effects on populations from those ESUs and DPS only is discussed below.

Lower Columbia River Chinook Salmon. In terms of characteristics of VSPs, LCR Chinook salmon populations are a concern for all VSP elements, especially abundance and diversity. Eight to ten historic LCR Chinook salmon populations have been extirpated (most of them spring-run populations). Although some natural production currently occurs in 20 or so populations, only one exceeds 1,000 spawners. Most LCR Chinook salmon populations have not seen increases in recent years as pronounced as those that have occurred in many other geographic areas. Recovery planning has defined the limiting factors for this ESU to include: (1) Reduced access to spawning/rearing habitat in tributaries, (2) hatchery impacts, (3) loss of habitat diversity and channel stability in tributaries, (4) excessive fine sediment in spawning gravels, (5) elevated water temperature in tributaries, and (6) harvest impacts (NMFS 2005b).

As determined above, only the application of carbaryl in Willapa Bay and Grays Harbor is likely to adversely affect fish from the populations comprising this ESU. Each of the other elements of

the action is unlikely to adversely affect this or any of the salmonid ESUs or DPS considered in this consultation. Adverse effects to individual LCR Chinook salmon from exposure to carbaryl, such as locomotor effects (endurance and predator avoidance) and olfactory-mediated behaviors (attraction to food and predator avoidance) are likely in the event individual animals co-occur with the effects of carbaryl application at exposure conditions. A very small number of fish that are exposed to carbaryl will respond to exposure in a way that will injure or kill them.
The NMFS has no information, and cannot discern using the best available information how effects on numbers of fish will be spread amongst the 20 populations of LCR Chinook salmon. However, even though abundance is a moderate concern for all LCR Chinook salmon populations, if we assume that each population is affected proportionally, the decrease in abundance would be so small that it would not appreciably influence population viability. Furthermore, diversity would be unlikely to be adversely affected.

Columbia River Chum Salmon. This ESU has showed low productivity for many decades. Recovery planning revealed limiting factors for CR Chum Salmon to include: (1) altered channel form and stability in tributaries, (2) excessive sediment in tributary spawning gravels, (3) altered stream flow in tributaries and mainstem Columbia, (4) loss of some tributary habitat types, and (5) harassment of spawners in tributary and Columbia mainstem (NMFS 2005b).

As for LCR Chinook salmon, CR chum salmon will be affected by carbaryl applications to the extent they are present in Willapa Bay and co-occur with exposure conditions. There is no evidence of CR chum salmon presence in these bays and estuaries as there is for LCR Chinook salmon. However, if we assume they express “dipping in” behavior similar to that of LCR Chinook salmon, then CR chum salmon will be exposed to carbaryl application within the treated acreages described earlier in this Opinion. However, even assuming that individual CR chum salmon are exposed to carbaryl, and respond to exposure with locomotor effects such as decreased endurance and predator avoidance, or olfactory-mediated behaviors such as decreased attraction to food and predator avoidance, the number of affected animals is likely to be small, not exceeding a few individual fish per year.

Spatial structure of Chum salmon populations is the biggest concern amongst characteristic of viable chum salmon populations comprising the ESU. Spatial structure is measured by three main processes: (1) reduced chance of catastrophic losses of the population (i.e., when groups of individuals are spread out in space), (2) greater chance that locally extirpated or dwindling groups will be rescued by recolonization (i.e., when individual groups are close enough together), and (3) a greater opportunity for long-term demographic processes to buffer a population from future environmental changes. None of these metrics is influenced by the injury or death of a few individual fish per year, as unlikely as that outcome appears to be. Therefore, the proposed action is not reasonably to certain to have any effect on CR chum salmon population viability.

Southern Distinct PopulationSegment of Green Sturgeon. The NMFS identified several primary factors for decline of the Southern DPS of green sturgeon, supporting the final listing determination that the DPS is likely to become endangered throughout its range. The principle factor was the reduction of spawning habitat to a small area of the Sacramento River, which is exacerbated by the decline of functional habitat in that area (71 FR 17757; April 7, 2006). The

Willapa Bay and Grays Harbor portions of the action area are identified as supporting summer rearing, feeding, and holding life histories of green sturgeon, but not spawning (NMFS 2008b). Therefore, impacts there cannot be concluded to contribute to the primary risk factor identified during the listing process for the DPS..

Although NMFS is not aware of studies specifically addressing the impacts of carbaryl on green sturgeon, NMFS believes that green sturgeon may be as sensitive or more sensitive (Dwyer et al. 2005) than other fish for which studies have identified adverse effects, including locomotor effects (endurance and predator avoidance) and olfactory-mediated behaviors (attraction to food and predator avoidance). We therefore believe that these effects are likely to occur. However, the total number of these fish exposed to the pesticide to be few (~.01 percent of the number of fish comprising the DPS) in the context of population size, is very small, and the number that actually respond to exposure with decreased performance such that they might be injured or killed is even smaller. These effects are not appreciable to the DPS.

Effects on Designated Critical Habitat

Critical habitat has been designated or proposed for listed salmon and sturgeon species in the action area. Lower Columbia Chinook salmon and CR chum salmon do not have designated CH in the action area. Willapa Bay and Grays Harbor do not contain CH for salmonids. Thus, the CH analysis for this consultation focuses on CH designated for PS Chinook salmon and Hood Canal summer-run chum salmon. In addition, NMFS conducted a conference on the proposed designation of CH for southern DPS green sturgeon.

Salmonid Critical Habitat in Puget Sound and Hood Canal. When designating CH for West Coast salmonids in 2005, NMFS identified the nearshore marine PCE. The nearshore marine PCE was defined as nearshore marine areas free of obstruction and excessive predation with: (i) Water quality and quantity conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation; and (ii) Natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels. The action area contains areas presenting elements of the nearshore marine PCE. As described above, activities that would occur under the proposed NWP 48 have both beneficial and adverse effects on water quality, forage, and aquatic vegetation. As also described above, none of these essential elements are limited in the action area and effects on water quality, food, and places that produce food are likely to be too diffuse and short term to have any meaningful effect on the conservation role of the basins in which the action area lies.

As discussed in the preceding section, aquaculture activities that will be carried out under the proposed NWP 48 consist of various interactions with the bottom within managed plots. These interactions are likely to affect water quality by increasing turbidity. If turbidity increases enough, for a long enough duration, turbidity can lower the functional condition of water quality to support the growth and maturation element of the nearshore marine PCE at the site of the turbid water. However, that result is highly unlikely for this proposed action. Activities causing local turbidity are reasonably certain to occupy very small areas, for a very short period of time. For example, geoduck harvesting is likely to occur for a few hours and up to a tenth of an acre per day. And while modeling the worst case scenario (Environ 2008) revealed that turbidity could persist at an intensity that would cause fish to rear and feed away from affected sites, other research indicates that saltwater clarifies more rapidly than in the freshwater environment for which the model was developed. Therefore, Environ (2008) probably overstates the effects of turbidity in saltwater.

Even if water quality function for growth and maturation is temporarily affected at sites where shellfish management activities interact with the bottom, those effects are reasonably certain to be limited and localized. Since water quality affected by turbidity is not a factor outside of the affected sites, it would be highly unlikely to bear on the conservation role of the fifth field HUCs that include the managed areas covered by the proposed NWP 48. And if locally turbid water does not impair the conservation role of those larger areas containing the managed sites, momentarily increased turbidity will not appreciably reduce the conservation value of designated CH.

The same activities, among others, that interact with the bottom to increase turbidity, are also likely to affect benthic production. Benthic production matters to the nearshore marine PCE because it provides forage in support of the growth and maturation of listed salmon. However, as discussed above, activities covered by the proposed NWP 48 could both diminish and enhance benthic productivity. Furthermore, those places where interactions with the bottom environment are significant enough to disrupt benthic productivity are reasonably certain to recover rapidly to ambient conditions. And similar to the temporal and spatial factors considered for the turbidity analysis, benthic disruptions are certain to be highly localized within managed plots, which are themselves located in larger areas containing fully functional benthic conditions. Therefore short-term, localized disruptions of benthic conditions, in areas that are perennially managed for shellfish aquaculture, are unlikely to influence the conservation role of these larger areas. In turn, the lack of influence of localized disruptions on the larger nearshore environment means the proposed action is unlikely to appreciably reduce the conservation value of designated CH.

The proposed action covers activities in places that likely have reduced eelgrass extent or density, or both. Submerged aquatic vegetation, and eelgrass in particular, supports the spawning of forage fish on which salmon feed and provide cover for juvenile fish, both of which support growth and maturation in the nearshore marine PCE. Despite the decreased density of eelgrass at managed sites, some aquaculture activities have been shown to enhance habitat characteristics for eelgrass colonization or provide alternative eelgrass habitat function (Dumbauld pers. comm. 2008). And since shellfish remove suspended particles, they improve water clarity and therefore light penetration, which can enhance the photosynthesis of eelgrass. Thus, while changing the distribution, density, and biomass of eelgrass can change the suitability of eelgrass to fulfill the functional processes it contributes to fish habitat as a general matter, the extent to which the proposed action affects eelgrass function is low intensity and of little effect to fish because the effects are localized in places where aquaculture activities are already ongoing, and have been for many years. These are places where eelgrass is already sparse and provides little, if any function in support of rearing and migrating salmon and steelhead not provided by the aquaculture habitat. When considered in the context of the Fifth Field HUCs comprising the action area for this consultation, site-level effects on eelgrass and similar SAV are unlikely to diminish the conservation role of the nearshore marine environment in those HUCs. Therefore, effects on SAV are unlikely to diminish the conservation value of designated CH.

Finally, the information reviewed during consultation did not suggest that shellfish aquaculture adversely affects forage fish species; including surf smelt, sand lance, and herring, in Washington State to the detriment of listed salmonids. Surf smelt and sand lance spawn at elevations above those where shellfish culture is generally practiced. Shellfish growers are sensitive to the importance of these species and avoid performing any support activities on beaches during surf smelt and sand lance spawning and incubation. Herring do spawn on eelgrass, anti-predator nets, oyster beds, and hard substrates such as geoduck tubes in areas subject to shellfish culture. Growers practice avoidance of these areas until the herring eggs have hatched as noted in PCSGA's Environmental Codes of Practice. Herring spawn in shellfish culture areas is rare in many shellfish areas (e.g., South Sound) and obvious where it does occur (masses of sticky adhesive eggs (Fisher, pers. comm. 11/19/08). Avoidance is a simple matter that does not inconvenience the growers. Therefore, the proposed action is unlikely to reduce the availability of forage at the local or Fifth Field HUC scales, and is unlikely to appreciably reduce the conservation of designated CH.

Proposed Critical Habitat for Southern Distinct Population Segment Green Sturgeon. The COE and NMFS conferred according to 50 CFR 402.10 on the proposed designation of CH for southern DPS green sturgeon. When conducting the process of proposing designated CH for the southern DPS of green sturgeon, NMFS convened a critical habitat review team (CHART). The CHART performed several functions including, among other things, rating the conservation value of each of the freshwater, bay/estuary, and coastal areas to be included in the proposed designation. The CHART identified two areas in the action area for the proposed action in which to propose designating CH: Willapa Bay and Grays Harbor. The CHART rated Willapa Bay as having "high" conservation value, important for summer rearing, feeding, aggregations, and holding of multiple year classes of Southern DPS subadults and adults. Grays Harbor was similarly rated as having "high" conservation value, also important for summer rearing, feeding, aggregations, and holding of multiple year classes (NMFS 2008b).

The CHART also identified the PCEs within the specific areas considered for designation, including Willapa Bay and Grays Harbor. The PCEs of proposed CH in estuarine areas include sufficient food resources, water flow, water quality, migratory corridor, water depth, and sediment quality. Food, water quality, and sediment quality are the PCEs of proposed CH reviewed in this consultation as the use of carbaryl to control burrowing shrimp in Willapa Bay and Grays Harbor may affect each of these PCEs. The proposed action is not likely to affect any of the other three PCEs.

As discussed above, carbaryl is used to control burrowing shrimp on aquaculture sites and is sprayed on less than 600 of 25,565 farmed acres per year in Willapa Bay and 200 of about 4,000 farmed acres per year in Grays Harbor. Carbaryl also affects several other species within these treated acreages, on which green sturgeon feed in Willapa Bay and Grays Harbor (burrowing ghost shrimp, mud shrimp, crangonid shrimp, amphipods, isopods, juvenile Dungeness crab). While the control program affects food items within these treated acreages, burrowing shrimp are so prolific in Willapa Bay that the control program is unlikely to affect their availability as a food resource for green sturgeon (Dumbauld et al. 2008). Furthermore, Dumbauld (pers. comm. 2008) did not observe green sturgeon feeding on the tide flats targeted by the control program. Therefore, NMFS does not expect appreciable decreases in the food resources PCE in these two estuaries in the action area.

Carbaryl application is also likely to adversely affect water and sediment quality. While the area of application is quite limited relative to both the number of farmed and total acres in each estuary, carbaryl can persist in the environment for several hours (in the water column) and weeks (in the sediment) after application, and drift hundreds of feet from application sites. Carbaryl has been detected in water samples as many as 50 hours after spraying, and up to 1,700 feet from spray sites after spraying. Carbaryl has been detected in sediment samples as many as 60 days after spraying. Therefore, application of carbaryl in Willapa Bay and Grays Harbor will bear on the functional condition of water and sediment quality PCEs, adversely affecting proposed CH in the action area.

To determine whether or not changes in PCE function in these two estuaries in the action area appreciably reduce the conservation value of proposed CH, NMFS assessed the action area in context. As already stated above, the decrease in food item abundance at treated sites, in places where green sturgeon have not been observed foraging, is not likely to adversely affect green sturgeon CH. As to water and sediment quality, the area treated is quite small relative to the extent of area in each estuary proposed for designation, even when drift of the product is considered. Proposed CH in Willapa Bay includes 45,000 acres of tidelands, of which 25,565 acres are managed for shellfish. Of that acreage, less than 600 acres are sprayed to control burrowing shrimp, and water and sediment quality are properly functioning in the rest of Willapa Bay, as a whole. Effects lasting up to 60 days are short-termed, and the treated area (600 acres plus possible drift of a radius less than 1,700 feet from spray sites) are unlikely to be appreciable at a Bay-wide scale. Therefore, effects in the action area on these two PCEs will not influence the conservation role or decrease the conservation value of proposed CH in the estuary.

Similar to the assessment for Willapa Bay, the area treated in Grays Harbor is quite small relative to the extent of area in each estuary proposed for designation, even when drift of the product is considered. Proposed CH in Grays Harbor includes 34,460 acres of tidelands, of which 3,995 acres are managed for shellfish. Of that acreage, less than 200 acres are sprayed to control burrowing shrimp, and water and sediment quality are affected by factors other than shellfish aquaculture but functioning nonetheless. Effects lasting up to 60 days are short-termed, and the treated area (200 acres plus possible drift of a radius less than 1,700 feet from spray sites) are unlikely to be appreciable at an estuary-wide scale. Therefore, effects in the action area on these two PCEs will not influence the conservation role or decrease the conservation value of proposed CH in the estuary.

Cumulative Effects

Cumulative effects are those effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur (50 CFR 402.02). Cumulative effects that reduce the ability of a listed species to meet its biological requirements may increase the likelihood that the proposed action will result in jeopardy to that listed species or in destruction or adverse modification of a designated CH. The present consultation was conducted at a large scale, covering Puget Sound, Hood Canal, Willapa Bay, Grays Harbor, and the Straits of Juan de Fuca. For such a large scale consultation, actions considered within the cumulative effects definition is somewhat coarse grained. For this consultation, NMFS identified two general groups of actions to conduct the cumulative effects analysis. These groups include the environmental results of climate change and tribal, state, and local government actions related to salmon recovery planning.

Climate Change

One of the likely cumulative effects on salmon and their associated aquatic habitat throughout the action area is ongoing and future climate change. Fluctuations in climate and sea level play a role in determining the suitability of nearshore and estuarine aquatic habitats through their influence on circulation and water properties. Given the increasing certainty that climate change is occurring and is accelerating, climate conditions in the future will not resemble those in the past. The following discussion is based on "Uncertain Future: Climate Change and its Effects on Puget Sound," prepared for the Puget Sound Action Team by the Climate Impacts Group (Snover et al. 2005). This discussion is focused on Puget Sound, but the findings are also appropriate for Willapa Bay and Grays Harbor.

Climate warming will shape the Puget Sound ecosystem from both the bottom-up (via impacts on phytoplankton and other marine plants that comprise the base of the food web) and the top-down (via direct impacts on top predators such as salmon and marine mammals). Taken together, these changes can be dramatic. In the coastal ocean, for example, broad reorganizations of the marine ecosystem have been associated with the subtle decade-to-decade changes in climate associated with the Pacific Decadal Oscillation (PDO). This has resulted in salmon in the coastal waters of Washington, Oregon, California, British Columbia and Alaska returning in relatively large or small numbers, depending on the phase of the PDO.

Future climate-related changes in the environment will be accompanied by changes in other factors such as human activities that are also very difficult to predict. The ultimate impact on each individual species that calls Puget Sound home will depend on how each of these changes reverberates across the food web, how each change interacts with every other change, and on the ecosystem's ability to adapt to a rapidly changing chain of estuarine and oceanic conditions.

Fish and other animals will be affected by climate change in many ways—directly via changes in habitat and indirectly via changes in the availability of food. Temperature is a dominant controlling factor of growth rates of most cold-blooded marine organisms. Increasing water temperatures can increase growth rates, providing many benefits, but only to a certain point. Temperatures that are too warm can stress an organism, causing decreased growth and survival and weakened immune systems, which have been linked to disease epidemics in marine populations (e.g., sea urchins) and seabirds and disease-related marine mammal strandings.

The consequences of warmer temperatures may be especially severe for species unable to seek out cooler temperatures, especially at vulnerable life stages. For this reason, increasing water temperatures above the optimum level for stationary shellfish, for example, could have more severe impacts than increasing water temperatures above the optimum level for salmon that could presumably move to pockets of cooler water.

The Shared Strategy for Puget Sound and the Puget Sound Partnership

The Puget Sound community has a rich history of success in addressing natural resource challenges, and the people of the Puget Sound region are committed to protect and restore the land and waters that define their quality of life. This was demonstrated by the development of The Shared Strategy for Puget Sound, a collaborative initiative built on the foundation of local efforts, supported by leaders from all levels of government and community sectors, and guided by the Puget Sound Technical Recovery Team's regional recovery criteria. Despite the fact that warmer temperatures are predicted for Puget Sound and over a million more people are projected to live in Puget Sound in the next 15 years, the Shared Strategy (Shared Strategy Development Committee, 2007) aspires to increase salmon abundance by twenty percent.

To accomplish that goal the Shared Strategy outlines the following strategies for the next ten years:

- Gaining a better understanding of how protection programs protect identified key habitats and processes into the future;

- Specifically understanding the results that can be expected from existing land-use programs and identifying and resolving gaps;

- Encouraging management at the scale of the processes that support key habitats (sub-basin, drift cell, etc.);

- Protecting water quality in areas susceptible to degradation and where there is high population use;

- Integrating information generated through the salmon recovery planning process into oil response plans, Critical Area Ordinances, Shoreline Master Programs and instream flow updates;

- Ensuring an adequate quantity of freshwater exists to support nearshore and marine systems; and

- Containing existing invasive species and preventing introductions of new species.

Similar long-range planning efforts are underway in coastal communities along the Washington coast. Future tribal, state and local government actions will likely to be in the form of legislation, administrative rules, or policy initiatives and fishing permits. These actions may include changes in policy and increases and decreases in the types of activities currently seen in the action area, including changes in fishery management, land use regulations, vessel traffic, dredging and disposal, submarine cable/pipeline installation and repair, oil and gas exploration, pollutant discharge, oil spill prevention and response, military operations, research, or designation of marine protected areas, any of which could impact listed species or their habitat.

Government actions are subject to political, legislative, and fiscal uncertainties. These realities, added to the geographic scope of the action area, which encompasses numerous cities and counties exercising various authorities, and the changing economies of the region, make any analysis of cumulative effects speculative.

In December 2008, the Puget Sound Partnership released the 2020 Action Agenda to help identify threats to the health of Puget Sound and actions to address those threats. The Action Agenda states five strategic goals for actions: protecting intact ecosystem processes and functions; restoring degraded ones; preventing water pollution at its sources; local and regional coordination and cooperation; and creating a system of implementation and accountability based on stable funding, performance management, monitoring, and accounting. Among the several strategic actions listed in the action agenda is "implement the regional salmon recovery plans as an integral part of Puget Sound restoration." The Puget Sound Partnership is responsible for implementing the regional salmon recovery plans for Chinook and summer chum salmon that have been approved by NMFS. Salmon recovery plans have been prepared by local groups in all 14 watershed areas of Puget Sound and include detailed actions for protecting and improving habitat, restoring river deltas and estuaries, re-vegetating stream corridors, removing barriers, conserving instream flows, and upgrading hatchery operations (Puget Sound Partnership, 2008).

When considered together, these cumulative effects are likely to have a small negative effect on salmon and sturgeon population abundance and productivity, and some short-term negative effects on spatial structure (short-term blockages of fish passage). Similarly, the condition of CH PCEs will be slightly degraded by the cumulative effects.

<u>Conclusion</u>

To determine whether or not the proposed action jeopardizes listed species or adversely modifies or destroys designated CH, NMFS reviews the effects of the action, including those of interdependent actions (like the application of carbaryl in Willapa Bay and Grays Harbor), along with those in the baseline and cumulative effects. These are reviewed against existing risk to the species described in terms of their present status.

Listed Species

Each of the species considered in this consultation is a threatened species with compromised abundance and productivity. The effects of the proposed action are unlikely to injure or kill individual listed salmon or steelhead, and are therefore unlikely to bear on the continuing status of the species. Furthermore, the effects in the baseline and cumulative effects are likely to persist at present conditions, moderated by recovery actions undertaken specifically for salmon or under the Puget Sound Partnership. Thus, the proposed action will not influence any of the characteristics of salmonid population viability even in the context of persistent baseline and cumulative effects for PS Chinook salmon and Hood Canal summer-run chum salmon. The same is true for LCR Chinook salmon and Southern DPS green sturgeon, even though the effect of carbaryl applications will injure or kill a small number of these fish every year. The number of exposed fish relative to the abundance and spatial structure of the populations comprising these two species, even in the worst case, is so small that this effect will not bear of the number, distribution, or reproduction of these fish. Therefore, the proposed action will not jeopardize the continued existence of PS Chinook salmon, Hood Canal summer-run chum salmon, LCR Chinook salmon, or Southern DPS green sturgeon in the wild.

Critical Habitat

Presently, the action area contains proposed CH for Southern DPS green sturgeon and designated CH for PS Chinook and HC summer-run chum. The only portions of the action area containing CH designated for listed salmon are Puget Sound and Hood Canal. These areas consist of approximately 532 non-contiguous farmed parcels covering about 8,000 total acres along 2,500 miles of Puget Sound and Hood Canal shoreline.

The proposed action may affect the condition of the elements of the nearshore marine PCE of salmonid CH within the action area. Those effects could be both adverse and beneficial, but taken together with those in the baseline and in cumulative effects, are not likely to adversely affect the conservation role of the fifth field HUCs comprising CH in the action area. Despite localized effects, the proposed action will neither impair the function of the nearshore marine PCE at those sites, nor prevent that PCE from becoming established, even when considered with the condition of the baseline and cumulative effects. Because the combined effects of the action, baseline, and cumulative effects will not bear on the conservation role of the CH, the proposed action is not likely to adversely modify or destroy CH.

The NMFS CHART that assisted the process to propose designating CH for southern DPS green sturgeon rated proposed CH in the Willapa Bay and Grays Harbor portions of the action area as having "high" conservation value. The interdependent action of applying carbaryl in these estuaries will affect the abundance of food items at sprayed sites where no foraging activity has been observed. Furthermore, the application of carbaryl will affect water and sediment quality only in a minute portion of these estuaries within the action area. Therefore, NMFS concludes that the action is not likely to appreciably diminish the "high" conservation value of each of these two estuaries and is therefore not likely to adversely modify or destroy proposed CH for southern DPS green sturgeon.

Conservation Recommendations

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. The following recommendations are discretionary measures that NMFS believes are consistent with this obligation and therefore should be carried out by the COE:

- The NMFS, along with co-managers, and local groups, has developed or is currently developing recovery plans for ESA-listed salmon and sturgeon. Plans for salmon are currently available in adopted or proposed form at: http://www.nwr.noaa.gov/Salmon-Recovery-Planning/ESA-Recovery-Plans/Index.cfm. The NMFS encourages the COE to consider the recommended actions and prioritization plans found in current draft and forthcoming recovery plans when planning, conducting, or permitting actions that may affect listed species.

- The COE should support the shellfish growers in Willapa Bay and Grays Harbor in their efforts to find an alternative IPM to control burrowing shrimp infestations on shellfish beds. While NMFS recognizes that current applications are applied under the authority of a NPDES permit NMFS encourages the COE and the growers to move to an alternative non-toxic IPM methodology.
- The COE should support the prevention of introductions of aquatic nuisance species and populations.
- Newly positioned aquaculture racks and stakes within an existing aquaculture tract authorized under NWP 48 should not be placed within a buffer distance of three meters of existing native eelgrass, *Z. marina*.
- Newly positioned on-bottom aquaculture operations within an existing aquaculture tract authorized under NWP 48 should not be located within existing stands of native eelgrass or within a buffer distance of three meters of existing native eelgrass.
- Newly positioned shellfish long-lines within an existing aquaculture tract authorized under NWP 48 that are spaced closer than five feet should not be located above existing native eelgrass or within a buffer distance of three meters of existing native eelgrass. Alternate spacing e.g. two to four lines spaced at one foot to 2.5 feet and an open row of 10 feet and then repeated may also be considered.
- Newly positioned shellfish rafts within an existing aquaculture tract authorized under NWP 48 should not be located above existing aquatic vegetation (native eelgrass or kelp).
- The COE's District Engineer should collaborate with the Services to develop criteria for determining which PCN activities have more than "minimal effects" and thus require an Individual Permit.
- Growers should not use intertidal areas as storage areas for bags, marker stakes, rebar, nets, etc. Growers should move all aquaculture materials that are not immediately needed to an off-site storage area. Growers should periodically remove all aquaculture debris from the leasehold. This conservation recommendation is not meant to apply to the wet storage of harvested shellfish.
- Growers should strictly adhere to their code of practice to ensure minimized effects to listed species.
- Growers should continue to minimize disturbance of inter-tidally spawned forage fish eggs when accessing their culture sites.

Please notify NMFS if the COE carries out these recommendations so that we will be kept informed of actions that minimize or avoid adverse effects and those that benefit listed species or their designated CHs.

<u>Reinitiation of Consultation</u>

Reinitiation of formal consultation is required and shall be requested by the Federal agency or by NMFS where discretionary Federal involvement or control over the action has been retained or is authorized by law and: (a) If the amount or extent of taking specified in the ITS is exceeded; (b) if new information reveals effects of the action that may affect listed species or designated CH in a manner or to an extent not previously considered; (c) if the identified action is subsequently modified in a manner that has an effect to the listed species or designated CH that was not considered in the biological opinion; or (d) if a new species is listed or CH is designated that may be affected by the identified action (50 CFR 402.16). In addition to these specific reinitiation criteria, NMFS has considered information gained from past programmatic consultations; the potential for new information to further refine and inform the effects of the activities covered in this consultation, e.g., ongoing data collection in the estuarine environment; and listed salmon recovery planning efforts, most notably in Puget Sound. These factors, collectively, provide reason for NMFS to place a terminus date on this programmatic biological opinion of December 31, 2018 to ensure current assumptions remain valid in the future. The Corps will need to reintiate consultation with NMFS on or before that date to continue programmatic coverage for the activities considered in this programmatic biological opinion. To reinitiate consultation, contact the Washington State Habitat Office of NMFS and refer to the NMFS Tracking Number assigned to this consultation.

Incidental Take Statement

Section 9(a)(1) of the ESA prohibits the taking of endangered species without a specific permit or exemption. Protective regulations adopted pursuant to section 4(d) extend the prohibition to threatened species. Among other things, an action that wounds or kills an individual of a listed species, modifies its habitat in a way that significantly impairs essential behavioral patterns, is a taking (50 CFR 222.102). Incidental take refers to takings that result from, but are not the purpose of, carrying out an otherwise lawful activity conducted by the Federal agency or applicant (50 CFR 402.02). Section 7(o)(2) exempts any taking that meets the terms and conditions of a written ITS from the taking prohibition.

Based on the analysis in the Opinion above, NMFS determined that while the activities covered by the proposed NWP 48 affect the environment in or near places that support salmonid and green sturgeon life histories, those effects are unlikely to impair normal behavioral patterns of those listed fish, and are therefore unlikely to adversely affect such fish. This determination is based on finding that each of the effects of the action either do not co-occur with the presence of listed fish, or are too small, too short-lived and diffuse to elicit a fish behavioral response. Furthermore, effects on water quality from carbaryl applications are not within the scope of the proposed action as they are not authorized or prescribed by the NWP 48. Therefore, issuance of the proposed NWP 48 is not reasonably certain to cause the incidental take of listed species.

Since incidental take of listed species is not reasonably certain to occur, this statement does not quantify an extent of anticipated take nor does it exempt any extent of incidental take from the prohibition against take. Consequently, this statement does not contain any reasonable and prudent measures for the minimization of take, nor does this statement provide any mandatory terms and conditions to implement reasonable and prudent measures. Should any taking occur whatsoever, as a result of the activities considered in this consultation, the reinitiation provisions of the Opinion would be triggered.

NOTICE: If a sick, injured or dead specimen of a threatened or endangered species is found, the finder must notify NMFS through the contact person identified in the transmittal letter for this Opinion, or through the NMFS Office of Law Enforcement at 1-800-853-1964. If the proposed action may worsen the fish's condition before NMFS can be contacted, the finder should attempt to move the fish to a suitable location near the capture site while keeping the fish in the water and reducing its stress as much as possible. Do not disturb the fish after it has been moved. If the fish is dead, or dies while being captured of moved, report the following information: (1) NMFS consultation number; (2) the date, time and location of discovery; (3) a brief description of circumstances and any information that may show the cause of death; and (4) photographs of the fish and where it was found. The NMFS also suggests that the finder coordinate with local biologists to recover any tags or other relevant research information. If the specimen is not needed by local biologists for tag recovery or by NMFS for analysis, the specimen should be returned to the water in which it was found, or otherwise discarded.

MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT

The Magnuson-Stevens Act, as amended by the Sustainable Fisheries Act of 1996 (Public Law 104-267), established procedures designed to identify, conserve, and enhance EFH for those species regulated under a federal Fisheries Management Plan. The Magnuson-Stevens Act requires consultation with NMFS on all actions, or proposed actions that may *adversely affect* EFH (MSA §305(b)(2)). To *adversely affect* means any impact that reduces the quality and/or quantity of EFH, and may include direct (e.g., contamination or physical disruption), indirect (e.g., loss of prey or reduction in species fecundity), site-specific or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810).

Under Section 305(b)(4) of the Magnuson-Stevens Act, NMFS is required to provide EFH conservation and enhancement recommendations to Federal and state agencies for actions that adversely affect EFH. Wherever possible, NMFS uses existing interagency coordination processes to fulfill EFH consultations with Federal agencies. For the proposed action, this goal is being met by incorporating EFH consultation to the ESA Section 7 consultation, as represented by this biological opinion.

Designated Essential Fish Habitat

The EFH mandate applies to all species managed under a Federal Fisheries Management Plan. For the Pacific West Coast (excluding Alaska), there are three Fisheries Management Plans covering Pacific salmon, coastal pelagic species, and groundfish. Impacts of the proposed action on EFH for any species managed under the three Fisheries Management Plans must be considered. A brief description of EFH identified in each Fisheries Management Plan follows.

Pacific salmon – Chinook, Coho, and Pink salmon: Essential Fish Habitat for the Pacific Coast salmon fishery means those waters and substrate necessary for salmon production needed to support a long-term sustainable salmon fishery and salmon contributions to a healthy ecosystem. To achieve that level of production, EFH includes all those streams, lakes, ponds, wetlands, and other currently viable water bodies and most of the habitat historically accessible to salmon in Washington, Oregon, Idaho, and California. In the estuarine and marine areas, in which this action occurs, salmon EFH extends from the nearshore and tidal submerged environments within state territorial waters out to the full extent of the exclusive economic zone (EEZ; 200 miles) offshore of Washington, Oregon, and California north of Point Conception.

Coastal pelagic species: Amendment 8 to the Coastal Pelagic Species Fishery Management Plan describes the habitat requirements of five pelagic species: northern anchovy, Pacific sardine, Pacific (chub) mackerel, jack mackerel and market squid. These four finfish and market squid are treated as a single species complex because of similarities in their life histories and habitat requirements. The east-west geographic boundary of EFH for coastal pelagic species is defined to be all marine and estuarine waters from the shoreline along the coasts of California, Oregon, and Washington offshore to the limits of the EEZ and above the thermocline where sea surface temperatures range between 10 degrees and 26 degrees C. The southern boundary is the U.S.-Mexico maritime boundary. The northern boundary is more dynamic, and is defined as the position of the 10 degrees C isotherm, which varies seasonally and annually.

Groundfish: Essential fish habitat for Pacific Coast groundfish is defined as the aquatic habitat necessary to allow for groundfish production to support long-term sustainable fisheries for groundfish and for groundfish contributions to a healthy ecosystem. Descriptions of groundfish EFH for each of the 83 species and their life stages result in more than 400 EFH identifications. Taken together, the groundfish EFH includes all waters from the mean higher high water line, and the upriver extent of saltwater intrusion in river mouths, along the coasts of Washington, Oregon and California seaward to the boundary of the EEZ.

Table 8 presents the life-history stages and habitat preferences for species with designated EFH in the action area. Information contained in the table is drawn from a habitat use database developed by the PFMC (2005) to designate EFH for Pacific goundfishes and the Pacific coast salmon (PFMC 1999) and Coastal Pelagic Species (PFMC 1998) fishery management plans.

Table 8. Life History Stage and Habitat Use for Fish Species with Designated EFH Potentially in the Action Area (PFMC 2005)

Species		Lifestage	Activity
Pacific Groundfishes			
Spotted ratfish	*Hydrolagus colliei*	Adults	All
Spotted ratfish	*Hydrolagus colliei*	Juveniles	Feeding
Soupfin shark	*Galeorhinus galeus*	Adults	All
Soupfin shark	*Galeorhinus galeus*	Juveniles	Growth to Maturity
Spiny dogfish	*Squalus acanthias*	Adults	All
Spiny dogfish	*Squalus acanthias*	Juveniles	Feeding
Spiny dogfish	*Squalus acanthias*	Juveniles	Growth to Maturity
Leopard shark	*Triakis semifasciata*	Adults	All
Leopard shark	*Triakis semifasciata*	Juveniles	
Big skate	*Raja binoculata*	Adults	All
California skate	*Raja inornata*	Adults	All
California skate	*Raja inornata*	Eggs	
Longnose skate	*Raja rhina*	Adults	All
Kelp greenling	*Hexagrammos decagrammus*	Adults	All
Kelp greenling	*Hexagrammos decagrammus*	Larvae	
Lingcod	*Ophiodon elongatus*	Adults	Feeding
Lingcod	*Ophiodon elongatus*	Eggs	
Lingcod	*Ophiodon elongatus*	Juveniles	Feeding
Lingcod	*Ophiodon elongatus*	Larvae	Feeding
Sablefish	*Anoplopoma fimbria*	Adults	All
Sablefish	*Anoplopoma fimbria*	Eggs	
Sablefish	*Anoplopoma fimbria*	Juveniles	Feeding
Sablefish	*Anoplopoma fimbria*	Larvae	
Cabezon	*Scorpaenichthys marmoratus*	Adults	All
Brown rockfish	*Sebastes auriculatus*	Adults	Feeding
Brown rockfish	*Sebastes auriculatus*	Larvae	Feeding
Copper rockfish	*Sebastes caurinus*	Adults	
Copper rockfish	*Sebastes caurinus*	Larvae	Feeding
Splitnose rockfish	*Sebastes diploproa*	Juveniles	Feeding
Splitnose rockfish	*Sebastes diploproa*	Larvae	Feeding
Yellowtail rockfish	*Sebastes flavidus*	Adults	All
Quillback rockfish	*Sebastes maliger*	Adults	All
Black rockfish	*Sebastes melanops*	Adults	All
Black rockfish	*Sebastes melanops*	Juveniles	Feeding
Blue rockfish	*Sebastes mystinus*	Adults	Feeding

Blue rockfish	*Sebastes mystinus*	Juveniles	Feeding
Blue rockfish	*Sebastes mystinus*	Larvae	Feeding
China rockfish	*Sebastes nebulosus*	Adults	Feeding
Tiger rockfish	*Sebastes nigrocinctus*	Adults	Feeding
Bocaccio	*Sebastes paucispinis*	Juveniles	Feeding
Redstripe rockfish	*Sebastes proriger*	Larvae	Feeding
Pacific sanddab	*Citharichthys sordidus*	Adults	Growth to Maturity
Pacific sanddab	*Citharichthys sordidus*	Larvae	Feeding
Petrale sole	*Eopsetta jordani*	Adults	All
Petrale sole	*Eopsetta jordani*	Eggs	
Petrale sole	*Eopsetta jordani*	Larvae	Feeding
Pacific cod	*Gadus macrocephalus*	Larvae	
Rex sole	*Glyptocephalus zachirus*	Adults	Feeding
Flathead sole	*Hippoglossoides elassodon*	Adults	All
Flathead sole	*Hippoglossoides elassodon*	Eggs	
Flathead sole	*Hippoglossoides elassodon*	Juveniles	Feeding
Flathead sole	*Hippoglossoides elassodon*	Larvae	Feeding
Butter sole	*Isopsetta isolepis*	Adults	All
Rock sole	*Lepidopsetta bilineata*	Adults	All
Rock sole	*Lepidopsetta bilineata*	Eggs	
Rock sole	*Lepidopsetta bilineata*	Larvae	Feeding
Pacific hake	*Merluccius productus*	Adults	All
Pacific hake	*Merluccius productus*	Juveniles	Feeding
Pacific hake	*Merluccius productus*	Juveniles	Growth to Maturity
Dover sole	*Microstomus pacificus*	Eggs	
English sole	*Parophrys vetulus*	Adults	All
English sole	*Parophrys vetulus*	Eggs	
English sole	*Parophrys vetulus*	Juveniles	Feeding
English sole	*Parophrys vetulus*	Larvae	Feeding
Starry flounder	*Platichthys stellatus*	Adults	All
Starry flounder	*Platichthys stellatus*	Eggs	
Starry flounder	*Platichthys stellatus*	Juveniles	Feeding
Starry flounder	*Platichthys stellatus*	Larvae	
Sand sole	*Psettichthys melanostictus*	Adults	All
Sand sole	*Psettichthys melanostictus*	Eggs	
Sand sole	*Psettichthys melanostictus*	Juveniles	Feeding
Sand sole	*Psettichthys melanostictus*	Juveniles	Growth to Maturity
Pacific Salmon			

Chinook salmon	*Oncorhynchus tsawytscha*	Juveniles	Feeding
Chinook salmon	*Oncorhynchus tsawytscha*	Adults	
coho salmon	*O. kisutch*	Juveniles	Feeding
coho salmon	*O. kisutch*	Adults	
Puget Sound pink salmon	*O. gorbuscha*	Juveniles	Feeding
Puget Sound pink salmon	*O. gorbuscha*	Adults	

Coastal Pelagic Species	
Northern Anchovy	*Engraulis mordax*
Jack Mackerel	*Trachurus symmetricus*
Pacific Sardine	*Sardinops sagax*
Pacific (Chub) Mackerel	*Scomber japonicus*
Market Squid	*Loligo opalescens*

Habitat Areas of Particular Concern

Essential Fish Habitat guidelines published in Federal regulations identify habitat areas of particular concern as types or areas of habitat within EFH that are identified based on one or more of the following considerations:

- The importance of the ecological function provided by the habitat.
- The extent to which the habitat is sensitive to human-induced environmental degradation.
- Whether, and to what extent, development activities are or will be stressing the habitat type.
- The rarity of the habitat type.

Based on these considerations, the Council has designated both areas and habitat types as Habitat Areas of Particular Concern (HAPCs). In some cases, HAPCs identified by means of specific habitat type may overlap with the designation of a specific area. The HAPC designation covers the net area identified by habitat type or area. Designating HAPCs facilitates the consultation process by identifying ecologically important, sensitive, stressed or rare habitats that should be given particular attention when considering potential nonfishing impacts. Their identification is the principal way in which the Council can address these impacts.

Designated Habitat Areas of Particular Concern

Estuaries. Estuaries are protected nearshore areas such as bays, sounds, inlets, and river mouths, influenced by ocean and freshwater. Because of tidal cycles and freshwater runoff, salinity varies within estuaries and results in great diversity, offering freshwater, brackish and marine habitats within close proximity (Haertel and Osterberg 1967). Estuaries tend to be shallow, protected, nutrient rich, and are biologically productive, providing important habitat for marine organisms, including groundfish.

Seagrass. Seagrass species found on the West Coast of the U.S. include eelgrass species (*Zostera spp.*), widgeongrass (*Ruppia maritima*), and surfgrass (*Phyllospadix spp.*). These grasses are vascular plants, not seaweeds, forming dense beds of leafy shoots year-round in the lower intertidal and subtidal areas. Eelgrass is found on soft-bottom substrates in intertidal and shallow subtidal areas of estuaries and occasionally in other nearshore areas, such as the Channel Islands and Santa Barbara littoral. Studies have shown seagrass beds to be among the areas of highest primary productivity in the world (Herke and Rogers 1993; Hoss and Thayer 1993).

Description of Proposed Activities

The proposed action and covered area are detailed above in the Introduction Section of this document. The COE is the action agency for the proposed NWP 48 in Washington.

Effects to Essential Fish Habitat

The proposed action is issuance of an NWP 48 permit that will enable the continuation of ongoing shellfish aquaculture activities whose past effects already inform, in part, the condition of EFH throughout the affected area. Review of the literature during consultation revealed divergent findings on many relevant issues such that there remains some uncertainty regarding the likelihood of the effects of these activities on the environment and whether or not likely effects would bear on EFH and managed fish. In cases of such uncertainty, NMFS considers the breadth of findings in the literature before concluding consultation.

The NMFS believes the proposed action will affect EFH within the action area via the following mechanisms:

- Water quality – Harrowing on oyster grounds and dredge harvest of oysters creates sediment inputs to the water column. Hand racking for the harvest of hard shell calms also has the potential for a minor pulse of turbidity upon tidal inundation. Geoduck harvest when accomplished in the intertidal with the aid of pumping waters into the substrate to facilitate removing the geoduck may also produce a sediment pulse to the adjacent waters.
- Water quality – the application of the pesticide 'Sevin' or carbaryl to oyster beds in Willapa Bay and Grays Harbor also affects the water column and EFH on and near the spray sites.
- Temporary Reduction in prey resources – The application of carbaryl in Willapa Bay and Grays Harbor has at least a localized affect on prey resources for a number of EFH species.
- Temporary Reduction in prey resources – Localized and temporal affects to HAPC designated eelgrass beds and to benthic communities can be caused by bed preparation and harvest activities of shellfish species.
- Altered substrate of EFH can be caused by graveling or 'frosting' for clam culture, spreading of shell to harden oyster beds, impacts to eelgrass from frosting and shell disbursements.
- Placement of raft and suspended culture anchors on subtidal estuarine bottoms and the impacts to substrate beneath raft culture operations.

Water Quality – Turbidity

The harrowing of bottom culture beds may occur at approximately annual increments. Harrowing normally involves work boats dragging a short tooth rake across the oyster beds, disturbing not more than two inches of the surface substrate. This activity normally occurs on beds softer sediments or burrowing shrimp infestations to ensure that the oyster crop stays on the surface. The mechanical or dredge harvest on bottom culture beds also may occur at an interval of one to four years. Dredge harvest is done at high tide and typically occurs on beds with a sandy bottom thus producing less turbidity plume when compared to beds with finer substrates that are more typically hand-picked during low tides. (Dumbauld, Pers. Comm. 12/09/08) Dumbauld also related that when dredge harvesting, operators attempt to keep the dredge from engaging deeply into the substrates, creating more sediment, preferring to operate as efficiently as possible by just skimming the surface and harvesting the oyster crop. An additional element of this operational method is the effect on SAV as will be discussed below.

During the harvest of bed reared hard shell clams, the beds are raked with hand-held rakes, or occasionally a mechanical harvester. Rakes extend a few inches into the surface substrate but do not penetrate the gravels into the more fine-grained sediments below. A small amount of turbidity may be generated on the subsequent tidal inundation, but habitat effects are small and generally contained to the immediate vicinity of the harvest site.

The harvest of geoduck sites also has the potential to generate a turbidity pulse to the aquatic environment. Harvesting of geoducks by pumping sea water into the substrates to loosen and allow the geoduck to be removed has the surface appearance of creating a considerable sediment plume to adjacent waters. To test this effect Entrix, Inc. (2004) collected water samples during a harvest operation. Harvesting was conducted at different distances from the water's edge and samples were collected up current, at water's edge, and down current from the harvest site. There was a definite increase in TSS or NTU measurements immediately adjacent to the harvest sites when harvest was measured at five feet from the water's edge. When harvest occurred further landward or samples were collected as little as 50 feet down current, however, TSS/NTU measurements were found to be at or near to background (up current) levels.

Each of these activities is likely to produce a short-term increase in turbidity and to resuspend some sediments, including particulate nutrients into the water column. Because these activities are performed infrequently at any particular site, they have limited potential to impair water quality and effects are typically observed only within the footprint of the activity and immediately adjacent waters. (Jones and Stokes, COE BA, 2007)

These short-term affects to water quality as a measurement of turbidity, need also to be measured in contrast to the effects on water clarity that is occurring as a result of filter-feeding activity of the cultured mollusks. Phytoplankton and other water column particulates are being filtered from the water in the vicinity of the various mollusk aquaculture sites contributing to improved water clarity and to increased opportunity for SAV (eelgrass) to establish. The ammonia released by the shell fish is taken up by phytoplankton, renewing the cycle. These biodeposits provide support to invertebrates, macroalgae, and seagrasses, including eelgrass (Newell et al. 2005). A net removal of a portion of the nutrients consumed by the shellfish occurs when they are harvested.

Water Quality – Carbaryl

The application of the pesticide 'Sevin' or carbaryl to oyster beds in Willapa Bay and Grays Harbor also affects water quality and EFH on and near the spray sites.

Chinook salmon and coho salmon use the estuarine habitat in Willapa Bay and Grays Harbor where carbaryl is applied. Pacific groundfishes and coastal pelagic also have life history strategies that touch on the estuarine habitats of Willapa Bay and Grays Harbor where carbaryl is applied. Effects of the proposed carbaryl applications include potential reduction of the prey base, and waterborne exposure through drinking and across gills.

Numerous monitoring studies have been conducted in coordination with applications of carbaryl to control burrowing shrimp in commercial oyster beds in Washington State. The results of the studies are quite variable, as are the study designs and objectives. Several investigations have documented water column concentrations exceeding several mg/L (which is substantially higher than the µg/L concentrations observed in freshwater aquatic habitats) following the first flood tide post-application (Hurlburt 1986; Creekman and Hurlburt 1987; Tufts 1989; Tufts 1990). Water column concentrations measured at Willapa Bay in 1984 detected a mean concentration of 10.6 mg/L upon initial flooding of the treated area (Hurlburt 1986). Concentrations were monitored at varying depths for several hours following flooding. The concentrations decreased rapidly but were detectable in the low µg/L range throughout sampling. In 1985 samples were collected along transects from treated areas following the direction of the tide to monitor the dispersal of carbaryl (Creekman and Hurlburt 1987). The data indicate that carbaryl is transported off the treated area by the tide. Average concentrations measured above the treated area ranged from 2.4 – 5.5 mg/L. The highest average concentration (7.9 mg/L) was collected 510 feet from the treated area. Average concentrations at the most distant sampling point (650 feet from initial treated area) were 2.5 mg/L. In 1996, further study was taken to evaluate carbaryl movement off the treated spray area (Tufts 1989). Samples were collected along a transect corresponding to the direction of the incoming tide. The peak concentration measured was 27.8 mg/L. Over one treated area, the concentration of carbaryl decreased from 13.2 mg/L to 9.3 mg/L as the water depth increased from 1.5 to 10 inches. The concentration further decreased to 600 µg/L when the water rose to 16 inches. The monitoring indicated concentrations of carbaryl decreased with increasing distances along the transect, but concentrations greater than 1 mg/L were detected in several instances at distances several hundred feet from treated plots. Carbaryl was found in the water column at the detection limit (0.1 mg/L) as far as 1,725 feet from the treated area.

The dilution pattern and concentrations of carbaryl in shallow pools and streams were monitored in 1987 (Tufts 1990). Peak concentration for one sample site was 18.8 mg/L upon initial flooding. The concentrations decreased to 0.2 mg/L when covered by 18 inches of water. Results were somewhat variable among sites. For example, another sample site showed no detections of carbaryl upon initial flooding. Peak concentrations of 8.4 mg/L were detected at a depth of 11 inches. This sample station was located 300 feet from treated area. Maximum carbaryl concentrations detected at other sites were 17.4, 7.8, and 4 mg/L with samples collected at depths of 6, 4, and 13 inches from the bottom. Average concentrations of carbaryl detected in tide pools and small streams ranged from 3.6 to 11.2 mg/L. The 11.2 mg/L detection was associated with application of 5 lbs carbaryl/acre. An average concentration of 7.8 mg/L in tidepools and streams was associated with an application rate of 4 lbs carbaryl/acre. Similarly, a more recent study found a peak of 820 ug/L in the water column 50 feet from the application site following a typical treatment application of 8 lbs/acre (n=3) (Weisskopf and Felsot 1998).

Several studies demonstrate that carbaryl dissipates rapidly from over the treatment site due to degradation, metabolism, dilution, and off-site transport (Hurlburt 1986; Creekman and Hurlburt 1987; Tufts 1989; Tufts 1990; Weisskopf and Felsot 1998). In 2006 and 2007, samples collected at the mouth of channels adjacent to treated oyster beds in Willapa Bay had maximum concentrations of 29.1 µg/L after 6 h (high tide), 38 µg/L after 12 h (low tide), and 21.1 µg/L after 24 h (low tide) (Major et al. 2005)

The NPDES permit for Willapa Bay and Grays Harbor requires annual monitoring of water column concentrations in treated areas. It specifies an acute effluent limit of 3 µg/L and a chronic limit of 0.06 µg/L. However, data associated with this monitoring are of questionable value because the monitoring plan specifies that monitoring is suspended for the first 48-hours following application to assess the acute effluent, and further suspends monitoring for 30 days from the last application to assess the chronic limit. We expect that most of the carbaryl will be degraded and transported to other locations by the time carbaryl monitoring is initiated.

Carbaryl sprayed on mud flats can be transported substantial distances at concentrations that may have ecological impacts. Researchers found that close to 100 percent of Dungeness crabs were killed up to 100 m off the carbaryl application area (Doty, Armstrong et al. 1990). Levels decrease to below 1 mg/L when transported more than 200m or more. The WDOE reports that carbaryl concentrations in the “potential effects threshold range” of 0.1-0.7 ug/L have been detected at locations several miles from oyster beds soon after large areas were treated (Johnson 2001).

Carbaryl is not a persistent bioaccumlative toxicant (IARC 1976). However, longer-term persistence has been observed in the treated sediments relative to the overlying waters where treatment occurs. The Washington State Department of Ecology study (WDOE 2001) found an average carbaryl concentration of 105 µg/Kg (parts per billion) in sediment from treated sites 60 days after application, and carbaryl was detected in sediment pore water at 0.57-1.2 µg/L (parts per billion) on day-60 (Stonick, 1999). Dumbauld et al. (1997) reported shorter persistence in the sediments, 40-45 days or less, and that the rate of initial decline after application is rapid (WDOE 2001). Carbaryl persists for a short time in sediments because it binds tightly to sediment and this characteristic facilitates its efficacy against burrowing shrimp In 2003, Major et al. (2005) assessed the use of waters above oyster beds by fishes before and after applications of carbaryl. The only salmonids captured before and after treatment were juvenile Chinook salmon. Concentrations of carbaryl before each of the spray events were less than 1 ppb (parts per billion, below detection limits). Concentrations of carbaryl after spray ranged from below detection limits to 11.3 ppb. These levels are two to three orders of magnitude below levels lethal to Chinook salmon.

There have been concerns that carbaryl applications in Willapa Bay and Grays Harbor may have adverse effects to the commercial Dungeness crab fishery (Feldman, Armstrong et al. 2000). Consequently, Washington Department of Fisheries conducted several surveys to estimate the number of crabs killed (Hurlburt 1986; Creekman and Hurlburt 1987; Tufts 1989; Tufts 1990). Transect surveys conducted on treatment beds the day following applications indicate large numbers of crabs are killed by the applications (Table 6). Other acute mortalities to nontarget organisms were generally not reported. However, transect surveys were conducted during 1986 and 1987 due to concerns over potential impacts to fish given staff observations from the WDF reported that fish mortality was "routinely" noted, but not quantitatively assessed following applications of carbaryl (Tufts 1989). Mortalities were characterized as small fish apparently trapped in shallow pools during low tide and directly exposed during carbaryl treatments. The surveys indicate several thousand fish were killed each year from carbaryl applications to approximately 400 acres at rates of ≤ 7.5 lbs a.i./acre. Currently, the NPDES permit allow for treatment of up to 600 acres. The current 24 (C) label does not specify acreage restrictions and allows for applications of carbaryl up to 8 lbs a.i./acre.

Table 6. Estimated Dungeness crab mortalities resulting from carbaryl applications in Willapa Bay and Grays Harbor, Washington

Year	Maximum Application Rates*	Total Acres Treated**	Dungeness Crab Killed
1984	≤ 10 lbs a.i. / acre	490	38,410
1985	≤ 7.5 lbs a.i./acre	391	59,933
1986	≤ 7.5 lbs a.i./acre	398	16,286
1987	≤ 7.5 lbs a.i./acre	434	44,053

* Current 24(c) label allows for application of up to 8 lbs a.i./acre
** Current NPDES permit allows for a total of 600 hundred acres to be treated in Willapa Bay and Grays Harbor, Washington. The Label places no restrictions on acres or geographic restrictions for use of carbaryl on Oyster beds in Washington.

Given that the fish that reside in standing water on mud flats are likely to be the most vulnerable to carbaryl exposure, staff from the Washington Department of Fisheries also estimated the available marine fish habitat that existed on exposed mudflats of treated areas. This was characterized as water that was at least 2 inches in depth, a depth that is adequate for salmon fry. This habitat comprised substantial portions of the treated areas. In 1986, surveys indicate 135 acres of the 398 of the treated area (approximately 34 percent) were marine fish habitat (Tufts 1989). In 1987, 67 of the 434 (15 percent) acres were characterized as marine fish habitat. The current NPDES specifies that there be a 200 foot buffer zone for sloughs and channels when carbaryl is applied by helicopter. A 50 foot buffer is required for those aquatic habitats when carbaryl is applied by hand sprayer. AgDrift estimates for aerial application at an application rate of 8 lbs a.i./acre with a 200 foot buffer indicate the average initial concentration from drift to a body of water that is 2 inches deep (~ 5 cm) and 10 meters wide would be 771 µg/L. A direct overspray of 2 inches of water would result in an average initial concentration of approximately 18 mg/L, a concentration comparable to measured concentrations associated with initial tidal inundation of treated mud flats (see surface water detections above). Acute exposure to these concentrations are expected to kill a portion of exposed salmonids in a matter of hours i.e., 24 h-LC50s for carbaryl range from 948-8000 ug/L, n= 60 (Mayer and Ellersieck 1986), and significantly reduce AChE activity that will lead to myriad sublethal effects such as impaired swimming. The AChE activity is reported to be affected, 20 percent inhibition, when exposure is around 23 µg/l for six hours.

Table 7. Estimated fish mortalities resulting from carbaryl applications in Willapa Bay and Grays Harbor, Washington

Year	Maximum Application Rates*	Total Acres Treated**	Fish Killed
1986	≤ 7.5 lbs a.i./acre	398	14, 954
1987	≤ 7.5 lbs a.i./acre	434	8,041

* Current 24(c) label allows for application of up to 8 lbs a.i./acre
** Current NPDES permit allows for a total of 600 hundred acres to be treated in Willapa Bay and Grays Harbor, Washington. The Label places no restrictions on acres or geographic restrictions for use of carbaryl on Oyster beds in Washington.

Salmonids were not reported in the sampling data which occurred over 2 seasons. The authors report that the fish kills were extremely variable and unpredictable. The fish mortality reported for transect surveys included only 4 species in 1986: saddleback gunnel, threespine stickleback, staghorn sculpin, and arrow goby. In 1987, mortalities included English sole, sand sole, kelp greenlings, shiner perch, saddleback gunnels, staghorn sculpin, and arrow goby. Thom Hooper, pers. comm., a WDF employee at the time surmises that fish with swim bladders may not have been found on the next low tide survey as they would have floated off and/or been consumed by avian species that were readily observed feeding on the nekton. Another observer does report collecting one Chinook salmon of approximately 100 plus mm on the day of a spray monitoring exercise in the late 1980s.
Due to drift, a larger area is being treated with carbaryl then the allowable acreage. Stonick (1999) mentioned several reports that documented drift in floodwaters. One study found measurable levels of carbaryl 1,700 feet from the sprayed tract. Another study detected carbaryl in floodwater 217 yards away from a sprayed area at concentrations of 2,500 parts per billion (ppb) on the day of treatment. Wind velocity, depth of water sampled, and current directions (including surface and bottom currents) are variables that can affect concentrations at any given location in the water. Also, on day-2 the same study found dead animals on the sprayed site as well as its adjacent unsprayed site.

An important issue for listed fish exposed to carbaryl is the effect on performance in response to exposure. Behavior such as swimming and predator avoidance can be impaired when the brain chemical AChE is inhibited, as occurs after carbaryl exposure. The extent to which exposure to carbaryl inhibits AChE is unclear. Major (2005) found that brain AChE assays showed statistically significant levels of inhibition during the first tide post treatment on one spray event with recovery to pre-spray levels of AChE by the second tide post-treatment. Both spray events showed significant increases in AChE levels by the third tide post treatment. The results suggest that juvenile Chinook salmon are being exposed to low levels of carbaryl over at least 50 hours, but are not exhibiting levels of AChE inhibition associated with mortality or overt behavioral effects (lethargy, erratic swimming, or on-bottom gilling) (Major et al. 2005). However, Major et al. (2005) caution that enzyme inhibition thresholds for locomotor effects (endurance and predator avoidance) and olfactory-mediated behaviors (attraction to food and predator avoidance) cannot be ruled out.

Other studies considered whether despite low AChE inhibition from carbaryl exposure seen in the studies like Major 2005, some animals might still be vulnerable to lowered performance in terms of predator avoidance. Scholz et al. (2006) found that organophosphates and carbamates are likely to have additive effects on the neurobehavior of salmon under natural exposure conditions. They concluded that ecological risk assessments that focus on individual AChEs might underestimate the actual risk to salmon in watersheds in which mixtures of these chemicals occur.

Based on reviews of multiple years of water quality monitoring data that has been compiled as part of the NPDES program for carbaryl use, and fisheries data showing the use of nearshore aquaculture areas by Chinook salmon, ENVIRON (2008b), concluded that acute carbaryl exposure to Chinook salmon in Willapa and Grays Harbor could be adverse but chronic exposure conditions were not considered likely and thereby significant through waterborne exposure. As oral ingestion has not been shown to elicit significant toxicity; the concluded that dietary exposure through sediment and sediment-associated benthos was not considered to represent an acute or chronic hazard or potential adverse effect. The NMFS, concurs that these findings are evidence that the application of carbaryl to Willapa Bay and Grays Harbor tide flats has the potential to exert acute ecological exposure conditions through water-borne exposure and that the effects to salmonids are likely to be adverse.

A study cited by Stonick (1999) noted after a carbaryl spray that sole were present on beds where they had previously been absent, suggesting fish were attracted to sprayed beds abundant with killed prey. The direct and indirect effects of this opportunistic foraging on carbaryl-killed prey have not been studied. However, potential mutagenicity and endocrine disruption may contribute population impacts to species, especially where repeated exposure occurs year after year. Little is understood about the metabolites of carbaryl or 1-napthonal in fish, birds, and invertebrates (Stonick 1999). Given the effects of carbamates on the neurobehavior of salmonids, and the likelihood of exposure for salmonids, ground fish and pelagics we believe that the effects could be significant.

Although the assumptions presented here are based on research in Willapa Bay, we believe that similar conditions and effects exist for EFH in Grays Harbor. The EFH species occupy Grays Harbor during the spraying of carbaryl. Carbaryl is applied in the same manner, and exposure pathways are identical to those in Willapa Bay.

The application of carbaryl also has the effect of temporarily reducing prey resources for EFH species in Willapa Bay and Grays Harbor. As reported in the BA addendum carbaryl is highly toxic to most species of shrimp. Dungeness crab, crab larvae, are also reported particularly sensitive to the pesticide. Carbaryl, in fact is very effective in its application to crustacean species in general. This means that various important prey resources for Pacific salmon, e.g. amphipods, harpacticoid copepods and other arthropods are at least temporarily reduced in number when they are trapped in sea water pools on sprayed plots or exposed to carbaryl concentrations on the incoming tide before adequate dilution/flushing has occurred.

Impacts to Food Resources--Carbaryl

Carbaryl is applied to roughly 600 acres annually in Willapa Bay and 200 acres in Grays Harbor. This represents less than 1 percent of the intertidal areas of Willapa and Grays Harbor. While the relative size of application area is small compared to the prey resource areas of the two water bodies, the application of carbaryl and its affects to important prey resources of EFH species is an effect that needs to be reported.

Impacts to Food Resources—Submerged Aquatic Vegetation

Localized and temporal affects to SAV (eelgrass), a HAPC designated habitat and to benthic communities can be caused by bed preparation and harvest activities of shellfish species. Various aquaculture activities allowed under the proposed NWP 48 can directly interact with eelgrass by decreasing its extent or density within estuarine shellfish beds. However, interactions with eelgrass are generally going to occur in areas of perennial shellfish aquaculture that were providing previously impacted eelgrass habitat function prior to the proposed issuance of the NWP 48. Furthermore, some aquaculture activities have been shown to enhance habitat characteristics for eelgrass colonization through water clarifying filtration or provide a substitute or replacement of eelgrass habitat function. (Dumbauld et al. 2001) Additionally, through the removal of suspended particles, shellfish improve water clarity and therefore light penetration, which can enhance the photosynthesis of eelgrass (Newell 2004). Thus, while changing the distribution, density, and biomass of eelgrass can change the suitability of eelgrass to fulfill the functional processes it contributes to fish habitat, the extent to which the proposed action affects eelgrass function is inconclusive.

Eelgrass beds provide cover for juvenile salmonids, and structure for the spawning of species on which juvenile salmonids prey. Eelgrass and eelgrass patches are a foundational element in the inter-tidal environment, throughout the action area, supporting the base of the food web. Throughout most of the Puget Sound region, eelgrass is of primary importance as a herring spawning substrate (Mumford 2007; Blackmon et al. 2006). The presence of perennial vegetation tends to be more important than location for selection of spawning habitat (Pentilla 2007). Eelgrass patches also support feeding and growth of herring (and other forage creatures) (Blackmon 2006) on which juvenile salmon and steelhead feed. In a small fraction of documented herring spawning areas, more atypical spawning substrates are used (Mumford 2007), including shellfish aquaculture apparatus.

The existence of managed shellfish plots impairs the development of beds of eelgrass that provide habitat function for juvenile salmonids. And although eelgrass growth can recover following disturbance, the proposed action is likely to maintain conditions limiting eelgrass beds with the footprint of managed sites. Eelgrass spreads from seed source or from rhizome growth. Where sufficient rhizome nodes remain intact following disturbance, eelgrass can recover (Cabaco et al. 2005), although recovery may take an extended period of time and eelgrass density may be initially lower. Eelgrass regrowth can occur on a shellfish bed following aquaculture activities that have removed existing eelgrass, but cyclical management activities probably limit the functional condition of eelgrass in managed sites. Depletion or decreased function of eelgrass in shellfish beds is also probable for off-bottom culture as well, as it limits conditions favorable to eelgrass growth. Off-bottom, stake (see Griffin 1997), and rack culture can cause erosion or sedimentation in some places, which appears to be the primary cause of eelgrass depletion in areas where this type of aquaculture is practiced (Everett et al 1995). Various aspects of geoduck culture (presence of tubes and disturbance after harvest, for example), also results in a lower density of eelgrass (Ruesink and Hacker 2005). Since the effects of the action include the persistence of these types of conditions within the footprint of managed sites, the recovery of eelgrass in managed sites in unlikely.

Rumrill and Poulton (2003), in Arcata Bay, investigated the effects of long-line culture on eelgrass. The results are represented in the BA. Generally, when line spacing reached 5 feet they found an increase in cover and density of eelgrass. They did caution that a longer study period should be considered to understand the differences in interannual and monthly variability. Off-bottom, stake (see Griffin 1997), and rack culture may cause erosion or sedimentation in some places, which appears to be the primary cause of eelgrass depletion in areas where this type of aquaculture is practiced (Everett et al 1995). Various aspects of geoduck culture (presence of tubes and disturbance after harvest, for example), have also been reported to result in a lower density of eelgrass (Ruesink and Hacker 2005).

Juvenile salmonids utilize a variety of habitats during their migration through Puget Sound. They commonly use eelgrass because it provides cover, refuge and a prey base for small fish at this vulnerable life stage. The reduction of density and extent of eelgrass within the footprint of perennially-managed shellfish beds would appear to perpetuate their already limited function for the support of forage production and cover at those places. The absence of functional eelgrass beds within managed sites may be of little consequence. Nothing about the proposed action impairs or prevents the presence of eelgrass beds adjacent to, or near actively managed sites.

But it seems unlikely that juvenile salmon would seek these functions at locations of limited function when they are surrounded by otherwise highly functioning habitat off the beds themselves. Furthermore, Dumbauld et al (2001) found that when comparing oyster bottom culture to eelgrass beds and mud bottom habitat, both eelgrass and oyster culture provide species richness and habitat utilization by salmonids at an equivalent scale. Contrary to the deduction that shellfish plots do not provide habitat function because of the absence of highly functioning eelgrass habitat, the BA supported by cited works concludes that stake culture also has a species richness that compares favorably with eelgrass beds. These studies suggest that decreased extent or density of eelgrass at culture sites does not ensure a net negative ecological result. NMFS notes that eelgrass habitats are very ecologically important and that studies have shown seagrass beds to be among the areas of highest primary productivity in the world (Herke and Rogers 1993; Hoss and Thayer 1993) Dumbauld, Armstrong, and McDonald, (1993) also found that oyster shell when spread for its crab nursery habitat value generally exceeded on an spatial basis the crab nursery value of eelgrass. While it is reasonable to presume some reduction in the ecological value of EFH from aquaculture at the site and immediate vicinity, it is less obvious to presume EFH impacts, positive or negative, beyond such a scale.

Benthic disturbance generally refers to the various activities that lead to physical interaction with the bottom. Activities that interact with the bottom under the proposed NWP 48 include site and plot preparation, grow-out, and harvest. The issue for each of these activities and the benthic environment is whether and to what extent they influence the functional condition of the nearshore marine bottom environment, and whether any influence is significant enough to impair normal EFH utilization. These activities have proximal contact with the bottom, which at least implies some effect on benthic processes; specifically those processes that contribute to the productions of food for EFH species, salmonids, groundfish, and coastal pelagics. In addition to contact with the bottom, the presence of managed shellfish aquaculture at a site can affect the chemistry in the water and bottom sediments (Straus et al. 2008) in ways that imply effects on benthic communities. Despite interaction with the bottom environment, there is no evidence that such disturbance interferes with benthic productivity or decreases the availability of forage for EFH species on such a temporal and spatial scale to allow for a determinant conclusion of the effects.

The primary issue for EFH concerning the effects of shellfish aquaculture on benthic communities is whether or not bottom interactions from any source change conditions affecting the availability food. The effects of those interactions on benthic function to produce forage for listed fish are variously reported. Straus et al. (2008) reported increased benthic species at mussel culture sites, decreased benthic species richness at oyster culture sites, and no significant differences in benthic species (infauna) between mussel farms, oyster farms, and reference sites. Dumbauld (1997) in a review of studies on the impacts of oyster aquaculture reported that species abundance, biomass, and diversity are often enhanced in areas where oysters are cultured. The ENVIRON 2008a, in a review of recent studies found that Fleece et al. (2004) reported that species richness of macroinvertebrates was higher in areas seeded with geoduck than in unseeded areas. The ENVIRON 2008a also found that Pearce et al. (2007) reported similar results in species richness of benthic infauna two months after geoduck were seeded in an aquaculture site in British Columbia, Canada. Increased densities of benthic infauna at intertidal geoduck clam aquaculture sites may persist even after removing the protective PVC tubes and netting. For example, at one aquaculture site in Southern Puget Sound, ENVIRON 2008a, found the average number of infaunal benthic organisms per sediment core from an unprotected seeded area was greater than the density of infaunal benthic organisms found in a reference area located outside of the aquaculture site.

Some of the various hand or mechanical harvest methods used in shellfish aquaculture each involve a physical disturbance of the bottom that effect sediment and benthic fauna (Johnson 2002). In most cases, bottom disturbance reduces the number and abundance of benthic species in the disturbed area, although the extent of such reductions has been reported variously, including no effect at all. For example, hand raking and digging for various shellfish in Yaquina Bay, Oregon, did not impact infaunal species number and abundance (Straus et al. 2008). Furthermore, while post-harvest reductions of some taxa have been observed at intertidal geoduck aquaculture sites in Southern Puget Sound, sites generally recover after harvest.
The recovery rates of benthic communities following physical disturbance depend on a variety of physical, chemical, and biological factors (Dernie et al. 2003), but in general, they recover fairly quickly. Preliminary data from Chris Pearce, of Canada's DFO, suggests that species richness and relative abundance of benthic fauna at a geoduck aquaculture site in British Columbia, Canada were restored to pre-harvest levels within six months (*as cited in* ENVIRON 2008a).

Straus et al. 2008 also cited other research that examined return to pre-disturbance conditions. For example, a study that assessed sediment grain size as a metric of disturbance found that while disturbed bottoms patches resulting in reduced or no fauna differed considerably in sediment grain size distribution, sediment grain size distribution returned to ambient levels after about two months at the disturbed cites. Similarly, benthic fauna population abundances for most species returned to ambient levels two to three months after benthic disturbance, and the community structure returned to ambient conditions after four months. In Scotland suction-dredged intertidal cockle sites had an average of 30 percent fewer benthic species and 50 percent fewer benthic individuals, immediately after harvest (Straus et al. (2008). But within 56 days after harvest, the faunal assemblages at these disturbed sites were not significantly different from control sites. A similar study in southeast England examined the sediment structure and benthic community immediately following and seven months after suction-dredge harvesting for Manila clams at an aquaculture site. Harvest suspended the sandy layer but left the underlying clay substrate. It substantively reduced both infaunal diversity and the mean number of individuals per sample. However, after seven months, neither the sediment composition nor the benthic fauna were significantly different from control sites. Straus et al. (2008) report that the authors of these studies concluded that clam cultivation does not have long-term effects on the substrate or the benthic community at that location.

The complex surface area provided by oysters and mussels offers habitat for over 100 different benthic species (CRMC 2008). The CRMC review also found that large biomasses of cultured mussels or oysters and fouling organisms suspended from lines attached to buoys or rafts have a major beneficial effect on phytoplankton, benthic, and hydrographic conditions within the immediate area of culture activities. For example, suspended rope culture in high current waters does not promote accumulation of pseudofeces. As a result, that allows for favorable increase in macrofaunal biomass in the vicinity of the culture operation. However, areas with low diversity (usually due to pollution) and decreased flow rates demonstrate organic sedimentation under long lines up to two times that found in adjacent uncultivated areas (CRMC 2008).

Still other shellfish activities with benthic interactions include bed preparation like “frosting” which involves spraying gravel or oyster shell onto the intertidal area to make the bed firmer and to minimize predation for the bottom culture of clams and oysters. Frosting an intertidal region shifts the benthic community from polychaetes to amphipods and copepods. Gammarid amphipods are important prey items for juvenile salmonids (Jamieson et al. 2001), making this a beneficial result for forage production.

Benthic communities may be temporarily disturbed by geoduck seed nurseries. These structures are planted with geoduck seed and placed in the intertidal zone for a short period in the summer. These containment vessels protect the seed from predators and wave action. The containers are deployed over the top of benthic habitat, but only at a few locations in Puget Sound. In fact, only Spencer Cove and Cape Horn have geoduck nurseries in any great number. And in those two locations, the containment vessels occupy less than an acre each (Jeff Fisher, pers. comm.).

As mentioned above, benthic recovery typically follows disturbances for shellfish aquaculture. The stability and recolonization rates of benthic fauna can range dramatically depending on physical conditions (sediment type and stability, wave action, current), season, location, scale of disturbance, and whether recolonization occurs primarily through adult movement or larval settlement (Straus et al. 2008). Small benthic invertebrates produce more than one generation per year and thus have rapid recolonization rates. Intertidal species have adapted to habitat changes, and so chronic low intensity or sporadic medium intensity intertidal substrate disturbances are within the range of “behavioral or ecological adaptability”

(Jamieson et al. 2001). The best available information on the resilience of benthic populations after geoduck harvest is limited and has not been well-studied in Puget Sound. However, geoducks are harvested once every five or six years, a period of time that is reasonably likely to allow full benthic community recovery in between harvests based on the information presented in the studies cited by Straus, et al. 2008.

Intertidal and nearshore shellfish aquaculture activities cause some disturbance of benthic habitat and mortality of non-target species. The factors that may have the greatest effect on benthic invertebrates relate to the timing and duration of the disruption, the shift in community structure, and the availability of other foraging habitat within migrating distance. Based on the currently available evidence, the level of benthic disturbance from existing shellfish aquaculture in Washington State is well within the range of normal sediment disturbing processes (e.g. storm/wave activity) and that adverse effects are likely to be limited in space (the footprint of the shellfish bed plus some buffer to account for current) and duration (from a few hours to a few days to a few months depending on the benthic assemblages in question. Therefore, NMFS believes that the effects of these existing aquaculture activities on benthic communities unlikely to cause large scale impacts to EFH. Impacts to prey resources of EFH species would be limited in time and space.

Altered Substrate

Altered substrate of EFH can be caused by graveling or 'frosting' for clam culture or spreading of shell to harden oyster beds. "Frosting" which involves spraying gravel or oyster shell onto the intertidal area, in thin layers to reduce impacts to the benthic community, to make the bed firmer and to minimize predation for the bottom culture of clams and oysters. Frosting an intertidal region shifts the benthic community from polychaetes to amphipods and copepods. Gammarid amphipods are important prey items for juvenile salmonids (Jamieson et al. 2001), making this a beneficial result for forage production relative to EFH for Pacific salmon but a less certain impact to prey resources for groundfishes or the pelagic life history stages that utilize the nearshore estuarine environments.

As further evidence, Thom et al. (1994) studied the effect of graveling for clam culture at two Puget Sound beaches, one in a relatively sheltered site and one at a relatively exposed site. They measured productivity and respiration for both autotrophic (plant) and heterotrophic (animal) elements of the benthic community. They found that "[g]raveled plots contained more surface coverage of sessile animals and seaweeds." At these sites, respiration and heterotrophic productivity was greater than in adjacent ungraveled plots. It would appear that these graveled sites provide a more rich and diverse habitat than adjacent sites. It should also be noted that 'rich and diverse' for some species, e.g. salmonids, does not necessarily translate to all EFH species. It is again important to note that the COE action is to permit existing graveled sites and the continued frosting of those sites. The conversion of existing mud flats to graveled sites is not authorized here.

Raft culture for mussels and scallops and the associated three dimensional impacts on water circulation and sediment effects has also been addressed in the BA for NWP 48. Several studies have shown potential effects on water circulation from aquaculture when examining dense three dimensional suspended raft systems of scallops and kelp (Grant and Bacher 2001) and mussels

(Saxby 2002). Water circulation and sediment effects depend on the density of the culture system, ambient currents, tidal flows, wave energies, bottom topography and elevations, and sediment type and deposition characteristics. In west coast estuaries some limited sediment accumulation has been observed; but no adverse effects have been documented. Thus the effects of mussel rafts on geomorphology and on water circulation are probably not adverse. This expectation has recently been borne out by fluid dynamic models of water circulation around and through mussel rafts at various locations in Maine, Washington, and British Columbia developed by Carter Newell (2007) and presented at the Northwest Work Shop on Bivalve Aquaculture and the Environment, 2007. Those models indicate that when mussel rafts are sited to optimally forage phytoplankton in tidal current areas, effects on both current and nutrients are confined to the immediate vicinity of the mussel raft, extending downstream a distance roughly equal to the size of the structure.

Mussel rafts also affect turbidity and shading in two ways. By consuming phytoplankton, they reduce turbidity and increase water clarity. However, as noted above, measurable changes in phytoplankton concentrations only occur in the immediate vicinity of the mussel rafts. Second, the mussel raft shades the substrate. Because rafts are sited in waters too deep to support eelgrass growth, this results in, at most, a highly localized effect on macroalgae populations. The resulting potential decrease in macroalgae populations is compensated by increased benthic production due to feces and pseudofeces[3] inputs from the mussel rafts.

Mussel rafts are often sited in areas with tidal currents that can deliver a steady supply of phytoplankton to the mussels. In such cases, feces and pseudofeces produced by the mussels are carried away by the currents and the rafts have little effect on the underlying sediments apart from the occasional fall of mussel shells. Rafts in more quiescent waters may also deliver nutrients to the underlying sediments. This issue has primarily been studied in areas with extremely high density mussel culture and relatively warm, eutrophic waters, a situation not comparable to that of mussel farming in the action area. In New England and eastern Canada, mussels are cultured with techniques and in settings comparable to those in the action area. A study of suspended mussel culture in Nova Scotia (Grant et al. 1995), in water 7m (about 23 feet) deep, found that there was a slight thickening of the anaerobic stratum beneath the mussel lines, but that "[a]lthough there is a shift toward anaerobic metabolism at the mussel lines, the impact of mussels falling to the sediments was more noticeable in benthic community structure than was any impact due to organic sedimentation or hypoxia. In general the impact of aquaculture on the benthos appeared to be minor." Similar evidence was derived during inspection of the area beneath a mussel raft in Totten Inlet, which found that "the bottom seemed to flourish with crab and sea stars" (WDNR 2006). Anecdotal evidence of bacterial mats and tunicate colonies developing on hydrogen-sulfide containing sediments under mussel rafts in south Puget Sound (APHETI 2006) provides evidence that increased anaerobic activity may occur beneath mussel rafts in the action area as well. Such conditions indicate that benthic conditions beneath mussel rafts sited in quiescent waters are unlikely to provide appropriate habitat for EFH species. These effects have been observed within the footprint of the mussel farm, but not beyond the immediate vicinity. It would appear important that locating raft cultured species can have an impact on EFH and that locating in areas with sufficient current and

[3] Pseudofeces are composed of materials consumed but not digested by shellfish, such as mineral material. Along with feces, they are discharged via the excurrent siphon.

depth is important to the efficient production of the cultured animal as well as providing protection to EFHs.

Although these effects may include the localized removal of eelgrass, the proposed action is not likely to result in any long-term change in eelgrass cover in these pre-existing aquaculture sites. The other itemized effects may also alter but do not adversely affect habitat condition.

Of the 91 species managed under the PFMC/MSA, 41 have life history stages potentially present in the action area (Table 8).

Prey resources important to groundfish include crustaceans, mollusks, polychaete, and small fish. Crustacean habitat was discussed above. Mollusks are primarily associated with sand, mud and rock although they are also associated with structures such as piling. Polychaetes are associated primarily with mud and sand habitats and to a lesser extent rocks. Small fish are found throughout the action areas, associated with various habitat types. Juvenile stages of many species of fish use eelgrass and other areas that provide refugia and prey resources (e.g. oysters, woody debris, and interstitial spaces in rocky habitat); however, the value of bottom culture oyster habitat and oyster reef habitat has been established for many species of adult and juvenile fin fish. The importance of the action and potential effects to Pacific salmon has also been discussed in several of the above sections.

Conservation Recommendations

Pursuant to Section 305(b)(4)(A) of the MSA, NMFS is required to provide EFH conservation recommendations to Federal agencies regarding actions that would adversely affect EFH. The NMFS recommends that the COE implement the following conservation measures to minimize the potential adverse effects to the EFH of those species indicated above:

1. Water Quality – The COE/applicants should utilize the BMPs as needed to minimize TSS/turbidity contributions to the water column. Examples would be: to ensure that dredge harvest activities minimize sediment contributions by adjusting the bag to ‘skim’ the surface; Prevent excessive TSS contribution from geoduck harvest by maintaining separation from water injection sites to the tide line, allowing sufficient distance for runoff from the stinger to largely infiltrate. Update the grower’s “Environmental Codes of Practice” to include best management practices for the above and other sediment minimizing actions.

2. Water Quality – The COE should support the shellfish growers in Willapa Bay and Grays Harbor in their efforts to find an alternative IPM to control burrowing shrimp infestations on shellfish beds. While NMFS recognizes that current applications are applied under the authority of a NPDES permit NMFS encourages the COE and the growers to move to an alternative non-toxic IPM methodology. NOTE: The NMFS understands that the COE does not regulate the application of carbaryl to the aquatic environment but notes that this interdependent activity to this action has perhaps the greatest effect to EFH at a temporal scale and is contributing to the indirect mortality of EFH species.

3. Impacts to Prey Resources – See Above.

4. Impacts to Prey Resources - Similar to number 1 above the COE/applicants should minimize negative impacts to important HAPC habitats of native eelgrass (forage producing and foraging area) by locating operations to avoid native eelgrass beds or patches. The

COE/applicants can also minimize impacts by avoiding activities, during full foliage growth (spring and summer) or in a manner that destroys foliage or severely impacts eelgrass rhizomes. Additionally, the COE/applicants can minimize impacts to the benthic communities that support the food web by minimizing the intrusions upon the substrates of aquaculture sites. These activities include tilling, harrowing, dredge harvesting of oysters, geoduck harvest by hydroflushing. NOTE: NMFS recognizes the "existing and ongoing" nature of these operations as part of the baseline.

5. Altered Substrates – As NWP 48 allows the continuation and resumption of activities within a permitted site, the conversion of mud flat habitats to 'graveled' sites for clam aquaculture may occur. The COE should not permit this expansion without adequate analysis of the impacts to EFH.

6. Raft culture of mussels, scallops, and oysters has the potential to shade important HAPC, eelgrass, and contribute to a buildup of anaerobic sediments below the raft. The COE/applicants should avoid these negative EFH impacts by ensuring the siting of raft structures in waters deep enough to avoid shading eelgrass and waters with adequate flow and energy to avoid excessive buildup of feces and pseudofeces.

Federal agencies are required to provide a detailed written response to NMFS' EFH conservation recommendations within 30 days of receipt of these recommendations (MSA (§305(b)(4)(B)) and 50 CFR 600.920(k)). The response must include a description of measures proposed to avoid, mitigate, or offset the adverse impacts of the activity on EFH. In the case of a response that is inconsistent with the EFH conservation recommendations, the response must explain the reasons for not following the recommendations, including the scientific justification for any disagreements over the anticipated effects of the proposed action and the measures needed to avoid, minimize, mitigate, or offset such effects.

If the proposed action is modified in a manner that may adversely affect EFH, or if new information becomes available that affects the basis for NMFS' EFH conservation recommendations, the COE will need to reinitiate consultation in accordance with the implementing regulations for EFH at 50 CFR 600.920(l). After reviewing information gained from past programmatic consultations, analyzing the potential for new information and scientific findings to further refine and inform the effects of these activities, and considering the potential for cumulative effects from activities in estuarine HAPCs, NMFS has determined that an appropriate terminus date for this EFH consultation is December 31, 2018. The Corps will need to reintiate consultation with NMFS on or before that date to continue programmatic coverage for the activities considered in this programmatic EFH consultation.

DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

Section 515 of the Treasury and General Government Appropriations Act of 2001 (Public Law 106-554) (Data Quality Act) specifies three components contributing to the quality of a document. They are utility, integrity, and objectivity. This section of the Biological Opinion addresses these Data Quality Act (DQA) components, documents compliance with the DQA, and certifies that this Opinion has undergone pre-dissemination review.

Utility: Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users.

This ESA consultation concludes that the proposed programmatic actions will not jeopardize the affected listed species or adversely modify or destroy designated CH. Therefore, the COE can carry out these actions in accordance with their authorities under various Federal statutes.

Individual copies were provided to the COE. This consultation will be posted on the NMFS Northwest Region website (http://www.nwr.noaa.gov). The format and naming adheres to conventional standards for style.

Integrity: This consultation was completed on a computer system managed by NMFS in accordance with relevant information technology security policies and standards set out in Appendix III, 'Security of Automated Information Resources,' Office of Management and Budget Circular A-130; the Computer Security Act; and the Government Information Security Reform Act.

Objectivity:

Information Product Category: Natural Resource Plan.

Standards: This consultation and supporting documents are clear, concise, complete, and unbiased; and were developed using commonly accepted scientific research methods. They adhere to published standards including the NMFS ESA Consultation Handbook, ESA Regulations, 50 CFR 402.01, et seq., and the MSA implementing regulations regarding EFH, 50 CFR 600.920(j).

Best Available Information: This consultation and supporting documents use the best available information, as referenced in the Literature Cited section. The analyses in this Opinion/EFH consultation contain more background on information sources and quality.

Referencing: All supporting materials, information, data and analyses are properly referenced, consistent with standard scientific referencing style.

Review Process: This consultation was drafted by NMFS staff with training in ESA and MSA implementation, and reviewed in accordance with Northwest Region ESA quality control and assurance processes.

LITERATURE CITED

Adams, P.B., C.B. Grimes, J.E. Hightower, S.T. Lindley, and M.L. Moser. 2002. Status Review for North American Green Sturgeon, *Acipenser medirostris*. NOAA.

Adams, P.B, C.B. Grimes, J.E. Hightower, S.T. Lindley, and M.L. Moser. 2005. Status Review for North American Green Sturgeon, *Acipenser medirostris.* National Marine Fisheries Service, Portland, Oregon.

Adams, P.B., Grimes ,C., Hightower, J.E., Lindley, S.T., Moser, M.L., Parsley, M.J. 2007. Population status of North American green sturgeon, *Acipenser medirostris*. Environ Biol Fish, doi: 10.1007/s10641-006-9062-z

APHETI (Association for Protection of Hammersley, Elt and TottenInlets). 2006. Photos taken November 3, 2006 under mussel rafts in Gallagher Cove during dive commissioned by APHETI, a citizen group. Available: http://www.protectourshoreline.com/articles/APHETI_Totten_Dead_Zone.pdf, accessed 2007.09.19.

Beamesderfer, R.C. and M.A.H. Webb. 2002. Green Sturgeon Status Review Information. Sacramento: State Water Contractors.

Beamesderfer, R.C., M.L. Simpson, and G.J. Kopp. 2007. Use of life history information in a population model for Sacramento green sturgeon. Environmental Biology of Fishes 79:315-337.

Beamis, W.E. and B. Kynard. 1997. Sturgeon rivers: An introduction to acipensiform biogeography and life history. Environmental Biology of Fishes 48:167-183.

Bishop, S. And A. Morgan, editors. 1996. Critical Habitat Issues by Basin for Natural Chinook Salmon Stocks in the Coastal and Puget Sound Areas of Washington State. Northwest Indian Fisheries Commission, Olympia.

Blackmon, D., Wyllie-Echeverria, T., and Shafer, D. 2006. The role of seagrasses and kelps in marine fish support. WRAP Technical Notes Collection, U. S. Army Engineer Research and Development Center, Vicksburg, MS. ERDC TN-WRAP-06-1. http://el.erdc.usace.army.mil/wrap

Cabaco, S., A. Alexandre, and R. Santos. 2005. Population-level effects of clam harvesting on the seagrass, *Zostera noltii*.

Casillas, E. 2008. Personal communication. Phone conversation with Laura Hamilton, NMFS. November 14, 2008.

Creekman, L.L., and E.F. Hurlburt. 1987. Control of burrowing shrimp on oyster beds in Willapa Bay and Grays Harbor 1985. Wash. Dep. Fish. Spec. Shellfish Rep. No. 3. 27 p.

CRMC (Coastal Resources Management Council, Rhode Island). 2008. CRMC Working Group on Aquaculture Regulations, Subcommittee on Biology. Report on Biological Impacts of Aquaculture. January 2008.

DeAlteris, J.T., B.D. Kilpatrick, and R.B. Rehault. 2004. A comparative evaluation of the habitat value of shellfish aquaculture gear, submerged aquatic vegetation and a nonvegetated seabed. Journal of Shellfish Research. (23:3) 867-874.

Dernie, K.M., M.J. Kaiser, and R.M. Warkwick. 2003. Recovery rates of benthic communities following physical disturbance. *Journal of Animal Ecology* 2003:72.

Doty, D.C., D.A. Armstrong, and B.R. Dumbauld. 1990. Comparison of Carbaryl pesticide impacts on Dungeness crab (Cancer magister) versus benefits of improved refuge habitat derived from oyster culture in Willapa Bay, Washington. University of Washington, School of Fisheries Report No. FRI-UW-9020. Seattle, Washington.

Dumbauld, B. R. 1997. A review of studies on the impact of oyster aquaculture to west coast benthic ivertebrate communities. Journal of Shellfish Research.

Dumbauld, B., J. Ruesnik, H. Macrellis, F. Oyaarzum, and S. Hacker. 2003. Interactions between oyster aquaculture and seagrass (*Zostera marina*) in estuaries along the coast of North Amnerica.

Dumbauld, B.R., K.M. Brooks and M.H. Posey. 2001. Response of an estuarine benthic community to application of the pesticide carbaryl and cultivation of Pacific oysters (*Crassostrea gigas*) in Willapa Bay, Washington, *Marine Pollution Bulletin* **42** (2001), pp. 826–844.

Dumbauld, B.R., D.A. Armstrong, and T.L. McDonald. 1993. Use of oyster shell to enhance intertidal habitat and mitigate loss of Dungeness crab (Cancer magister) caused by dredging. Canadian Journal of Fisheries and Aquatic Sciences 50(2):381-390.

Dumbauld, B.R., S. Wyllie-Echeverria. 2003. The Influence of Burrowing Thalassinid Shrimps on the Distribution of Intertidal Seagrasses in Willapa Bay, Washington, USA. Aquatic Botany 77:27-42

Dumbauld, B.R., D.L. Holden and O.P. Langness. 2008. Do sturgeon limit burrowing shrimp populations in Pacific Northwest Estuaries? *In* Environ Biol Fish.

Entrix, Inc. 2004. Draft Programmatic Biological Evaluation of Potential Impacts of Intertidal Geoduck Ciulture Facilities to Endangered Species and Essential Fish Habitat: Taylor Shellfish, Seattle Shellfish, and Chelsea Farms Culture Facilities. Prepared for Taylor Shellfish, Seattle shellfish and Chelsea Farms.

Environ. 2008a. Technical Memorandum: An Analysis of the Environmental Concerns Associated with Intertidal Geoduck Clam Culture. April 14, 2008.

Environ. 2008b. NWP 48 Biological Assessment Addendum: Screening Level Risk Assessment to Threatened and Endangered Species from the Use of Carbaryl to Control Burrowing Shrimp in Washington State Shellfish Aquaculture. Prepared for: U.S. Army Corps of Engineers, Portland, Oregon. 2008. Project or Version Number: 0320390A.

Everett, R., G. Ruiz, and J. Carlton. 1995. Effect of oyster mariculture on submerged aquatic vegetation: an experimental test in a Pacific Northwest estuary. Marine Progress Series.

Feldman, K.L., Armstrong, D.A., Dumbauld, B.R., DeWitt, T.H. and Doty, D.C. 2000. Oysters, crabs, and burrowing shrimp: an environmental conflict over aquatic resources and pesticide use in Washington state's (USA) coastal estuaries. *Estuaries* **23**, 141–176

Fleece, C., D. Waller, J. Fisher, J. Vanderpham, and G. Reub. 2004. Programmatic biological evaluation of potential impacts of intertidal geoduck culture facilities to endangered species and essential fish habitat. Draft biological evaluation prepared on October 27, 2004 by Entrix, Inc. for Taylor Shellfish, Seattle Shellfish, and Chelsea Farms, Olympia, Washington.

Good, T.P., R.S. Waples, and P. Adams (editors). 2005. Updated status of federally listed ESUs of West Coast salmon and steelhead. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-66, 598 p.

Grant, J., C. Bacher. 2001. A numerical model of flow modification induced by suspended aquaculture in a Chinese bay. CANADIAN JOURNAL OF FISHERIES AND AQUATIC SCIENCES, 2001

Grant, J., Hatcher, A., Scott, D.B., Pocklington, P., Schafer, C.T., and Winters, G.V. 1995. A multidisciplinary approach to evaluating impacts of shellfish aquaculture on benthic communities. Estuaries. 18(1A): 124-144.

Gregory, R.S. and C.D. Levings. 1998. Turbidity reduces predation on migrating juvenile Pacific salmon. Trans Amer Fish Soc 127: 275-285.

Griffin K. 1997. Commercial oyster cultivation and eelgrass ecology in Tillamook Bay, Oregon: a literature review and synthesis. Garibaldi (OR): Tillamook Bay National Estuary Project. 36 p.

Grimaldo, L., and S. Zeug. 2001. The IEP Resident Fish Project Work Team hosts meeting on green sturgeon. IEP Newsletter 14(4): 19-32.

Haertel, L., Charles Osterberg. 1997. Ecology of Zooplankton, Benthos and fishes in the Columbia River Estuary. Ecology: Vol. 48, No. 3 pp. 459-472

Herker, W.H., and B.D. Rogers. 1993. Maintenance of the Estuarine Environment. Pp 263-283 in C. Kohler and W. Hubert, editors. Inland Fisheries Management in North America. American Fisheries Society. Bethesda, Maryland.

Hogarth, W.T. 2005. Memorandum from William T. Hogarth to Regional Administrators, Office of Protected Resources, NMFS (Application of the "Destruction or Adverse Modification" Standard Under Section 7(a)(2) of the Endangered Species Act) (November 7, 2005).

Hoss, D.E., G.W. Thayer. The Importance of Habitat to the Early Life History of Estuarine Dependant Fishes. American Fisheries Society Symposium. 14 (1993), pp. 147-158

Hunter, M.A. 1992. Hydropower flow fluctuations and salmonids: a review of the biological effects, mechanical causes, and options for mitigation. Washington Department of Fisheries Technical Report #119. Washington Department of Fisheries, Olympia, Washington.

Hurlburt, E. 1986. Control of Burrowing Shrimp on Oyster Beds in Willapa Bay and Grays Harbor 1984. Washington Department Fisheries Special Shellfish Report No. 2, Olympia, WA

IARC (International Agency for Research on Cancer). 1976. The IARC Monogr. Eval. Carcinog. Risk Chem. Hum., 12: 43.

Israel, J.A. and B. May. 2007. Mixed stock analysis of green sturgeon from Washington State coastal aggregations. Final report. Genomic Variation Laboratory Department of Animal Science, University of California, Davis.

Jamieson, G, R. O'Boyle, J. Arbour, D. Cobb, S. Courtenay, R. Gregory, C. Levings, J. Munro, I. Perry, and H. Vandermeulen. 2001. Proceedings of the National Workshop on Objectives and Indicators For Ecosystem-based Management. Sidney, British Columbia, 27 February – 2 March 2001. CSAS Proc. Ser. 2001/09: 140 pp.

Johnson, K.A.. 2002. A Review of National and International Literature on the Effects of fishing on Benthic Habitats. NOAA Technical memorandum NMFS-F/SPO-57. August 2002.

Jones and Stokes. 2007. Corps of Engineers Biological Assessment; Issuance of NWP 48, Existing Commercial Shellfish Aquaculture Activities (72 Federal Register [FR] 11092.

Kuttel, M., Jr. 2003. Salmonid Habitat Limiting Factors Water Resource Inventory Areas 15 West (Kitsap Basin) and 14 North (Kennedy-Goldsborough Basin). Washington Conservation Commission. Olympia, Washington. 312 pages.

Lloyd, D.S., J.P. Koenings, and J.D. LaPerriere. 1987. Effects of turbidity in fresh waters of Alaska. North American Journal of Fisheries Management: 18-33.

Major, III, W., C Grue, J. Cabarrus, J. Grassley, N. Overman, B. Dumbauld. 2005. Exposure of salmonids to carbaryl following applications to control burrowing shrimp. Abstract of Presentation at 25th Annual Meeting in North America of the Society of Environmental Toxicology and Chemistry.

Mayer, F.L. Jr., and Ellersieck, M.R. 1986. Manual of Acute Toxicity: Interpretation oand Data Base for 410 Chemicals and 66 Species of Freshwater Animals. Resiyrce Oybkucatuib 160. US Fish and Wildlife Service, Department of the Interior, Washington D.C. 579 pp.

McElhany, P., M. Ruckleshaus, M.J. Ford, T. Wainwright, and E. Bjorkstedt. 2000. Viable Salmon Populations and the Recovery of Evolutionarily Significant Units. U.S. Department of Commerce, National Marine Fisheries Service, Northwest Fisheries Science Center, NOAA Technical Memorandum NMFS-NWFSC-42. 156 p. http://www.nwfsc.noaa.gov/publications/techmemos/tm42/tm42.pdf

McLain, J. 2006. The likely distribution of the southern distinct population segment of North American green sturgeon in SWR Waters. Memorandum to the Southern Distinct Population Segment of North American green sturgeon consultation guidance from J. McLain, National Marine Fisheries Service, Sacramento, California.

Moser, M. and S. Lindley. 2007. Use of Washington estuaries by subadult and adult green sturgeon. Environmental Biology of Fishes 79:243-253.

Myers, J.M., R.J. Kope, G.J. Bryant, D. Teel, L.J. Lierheimer, T.C. Wainwright, W.S. Grant, 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 Technical Memorandum NMFS-NWFSC-35, U.S. Department of Commerce, Seattle, Washington.

Mumford. T.F. 2007. Kelp and Eelgrass in Puget Sound. Technical Report 2007-05. Prepared in support of the Puget Sound Nearshore Partnership.

NMFS (National Marine Fisheries Service). 1998. Factors Contributing to the Decline of Chinook Salmon: An Addendum to the 1996 West Coast Steelhead Factors For Decline Report.

NMFS. 1999. Status review update for chum salmon from Hood Canal summer-run and Columbia River ESUs. February. Available at: http://www.nwr.noaa.gov/Publications/Biological-Status-Reviews/upload/SR1999-chum.pdf.

NMFS. 2004. Artificial propagation evaluation workshop report. NOAA Fisheries, Northwest Region, Protected Resources Division. April 21-23, 2004. Available at: http://www.nwr.noaa.gov/1srd/Prop_Determins/

NMFS. 2004a. Salmonid Hatchery Inventory and Effects Evaluation Report. NOAA Fisheries Northwest Region Salmon Recovery Division. May 18, 2004. Available on the internet at: www.nwr.noaa.gov/1srd/Prop_Determins/.

NMFS. 2005a. Updates to the May 18, 2004, Salmonid Hatchery Inventory and Effects Evaluation report. Salmon Recovery Division. Portland, OR.

NMFS. 2005b. 2005 Report to Congress Pacific Coastal Salmon Recovery Fund 2000-2004. NMFS, Northwest Region, Seattle, Washington. 51 p.

NMFS. 2006. Endangered and threatened wildlife and plants: threatened status for Southern distinct population segment of North American Green Sturgeon. Federal Register 71:67(7 April 2006):17757-17766.

NMFS (National Marine Fisheries Service). 2008a. Endangered Species Act - Section 7 Consultation Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation on the re-issuance of regional general permit 3, authorizing 23 maintenance activities in Suisun Marsh, Solano County, California. NMFS, Southwest Region, Long Beach, California.

NMFS. 2008b. Proposed Designation of Critical Habitat for the Southern Distinct Population Segment of North American Green Sturgeon, Draft Biological Report. NMFS Southwest Region, Long Beach, California.

NMFS-TRT 2001. (National Marine Fisheries Service - Puget Sound Technical Recovery Team). Planning ranges and preliminary guidelines for the delisting and recovery of the Puget Sound Chinook salmon evolutionary significant unit. http://www.nwfsc.noaa.gov/trt/trt_puget.htm.

Nearshore Habitat Program. 2001. The Washington State ShoreZone Inventory. CD-ROM. Olympia, WA: DNR Nearshore Habitat Program. Download Data on ShoreZone Inventory from the Aquatics Data Table.

Newcombe, C.P. and J.O.T. Jensen. 1996. Channel Suspended Sediment and Fisheries: A Synthesis for Quantitative Assessment of Risk and Impact. *In* North American Journal of Fisheries Management 16:693-727. 1996

Newell, R.I.E., J.E. Cornwell, and M.S. Owens. 2002. Influence of simulated bivalve biodeposition and microphytopbenthos on sediment nitrogen dynamics: A laboratory study. Limnol. Oceanogr. 47(5) 1367-1379.

Newell, R.I.E. 2004. Ecosystem influences of natural and cultivated populations of suspension-feeding bivalve molluscs: A review. Journal of Shellfish Research. 23(1):51-61.

Newell, Roger. 2006. Oyster reef restoration and oyster aquaculture. Pages 53 – 60 in Best Management Practices for Sediment Control and water Clarity Enhancement. Report CBP/TRS-282-06, Chesapeake Bay Program.

Newell, Carter. 2007. Understanding shellfish aquaculture environments in North America and Europe by combining field measurements with computational fluid dynamics and bioenergetic models. Presentations at the Northwest Workshop on Bivalve Aquaculture and the Environment, Seattle, September, 2007.

Nugues, M.M., M.J. Kaiser, B.E. Spencer and D.B. Edwards, Benthic community changes associated with intertidal oyster cultivation, /Aquaculture Research/ *27* (1996), pp. 913–924.

Pearce, C. M., Y. X. An, J. M. Blackburn, L. J. Keddy, D. L. Paltzat, and S. W. Williams. 2007. Geoduck aquaculture: an examination of predator protection methodology and potential environmental impacts. PowerPoint presentation at the October 19 meeting of the B. C. Shellfish Growers Association.

PFMC (Pacific Fishery Management Council). 1998. The Coastal Pelagic Species Fishery 206 Management Plan: Amendment 8. Pacific Fishery Management Council, Portland, Oregon (December 1998). http://www.pcouncil.org/cps/cpsfmp.html

PFMC. 1999. Amendment 14 to the Pacific Coast Salmon Plan. Appendix A: Description and Identification of Essential Fish Habitat, Adverse Impacts and Recommended Conservation Measures for Salmon. Pacific Fishery Management Council, Portland, Oregon. March 1999. http://www.pcouncil.org/salmon/salfmp/a14.html

PFMC (Pacific Fishery Management Council). 2005. Amendment 19 to the Pacific coast groundfish fishery management plan. Appendix B: Pacific Coast Groundfish Essential Fish Habitat. Pacific Fishery Management Council, Portland, Oregon. http://www.pcouncil.org/groundfish/gffmp/gfa19.html.

PFMC. 2006. Amendment 19 (essential fish habitat) to the Pacific Coast groundfish fishery management plan for the California, Oregon, and Washington groundfish fishery. November 2005. 97 pages + appendices. http://www.pcouncil.org/groundfish/gffmp/gfa19/A18-19Final.pdf.

Pentilla, D. 2007. Marine Forage Fishes in Puget Sound. Puget Sound Nearshore Partnership Report No. 2007-03. Published by Seattle District, U.S. Army Corps of Engineers, Seattle, Washington.

Phinney, L.A., and P. Bucknell. 1975. A catalog of Washington streams and salmon utilization, volume 2, coastal region. Washington Department of Fisheries, Olympia, Washington

PSP (Puget Sound Partnership). 2007. Puget Sound Update. Available at http://www.psparchives.com/puget_sound/update.htm

Redding J.M., Schreck C.B., and Everest F.H. 1987. Physiological effects on coho salmon and steelhead of exposure to suspended solids. Trans Am Fish Soc 116: 737-744.

Rice, M. 2007. Shellfish Restoration and Aquaculture Projects As A Means To Mitigate Coastal Nutrient Pollution. Talk Presented at the Northwest Workshop on Bivalve Aquaculture and the Environment. Seattle, WA 13-14 September 2007

Robbins C. W., C. E. Brockway. 1978. Irrigation water salt on sediment removal by ponds. Soil Scientist Society of America Journal

Ruckelshaus, M.H., K.P. Currens, W.H. Graeber, R.R. Fuerstenberg, K. Rawson, N.J. Sands, and J.B. Scott. 2006. Independent populations of Chinook salmon in Puget Sound. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-78, 125 p.

Ruesink, J. and S. Hacker. 2005. Annual Progress Report: Scale-dependent and indirect effects of filter feeders on eelgrass: Understanding complex ecological interactions to improve environmental impacts of aquaculture.

Rumrill, S.S., and V.K. Poulton. 2003. Ecological impacts of commercial oyster long-line culture in Humboldt Bay, CA.

Saxby., S.A. 2002. A Review of Food Availability, Sea Water Characteristics and Bivalve Growth Performance at Coastal SA Saxby, Fisheries Research Division, W Australia … - 2002 - fish.wa.gov.au

Scholz NL, N.K. Truelove, J.S. Laabenia, D.H. Baldwin, T.K. Collier. 2006. Dose-additive inhibition of chinook salmon acetylcholinesterase activity by mixtures of organophosphate and carbamate insecticides. *In* Environmental Toxicology and Chemistry. Volume: 25 Issue: 5 MAY 2006.

Schroder, S., and K. Fresh. 1992. Results of the Grays Harbor coho survival investigation 1987-1990. Wash. State Dep. Fish. Tech. Rep. No. 118, 414 p.

Servizi, J.A. and D.W. Martens. 1991. Effect of Temperature, Season, and Fish Size on Acute Lethality of Suspended Sediments to Coho Salmon (*Oncorhynchus kisutch*). Canadian Journal of Fisheries and Aquatic Sciences, Vol. 48, No. 3, p 493-497, March 1991.

Shared Strategy Development Committee. 2007. Puget Sound Salmon Recovery Plan. Adopted by the National Marine Fisheries Service January 19, 2007.

Simenstad, C. A., B. S. Miller, C. F. Nyblade, K. Thornburgh, and L. J. Bledsoe. 1979. Food web relationships of northern Puget Sound and the Strait of Juan de Fuca: A synthesis of the available knowledge. EPA DOC Research Report EPA-600/7-79-259 (Also Fish. Res. Inst., Univ. Wash., Seattle, WA. FRI-UW-7914). 335 pp.

Simenstad, C.A., J.R. Cordell, and L.A. Weitkamp. 1991. Effects of Substrate Modifications on Littoral Flat Meiofauna: Assemblage Structure Changes Associated With Structure Adding Gravel. Technical Report to Washington Department of Fisheries Point Whitney Shellfish Laboratory. Brinnon Washington.

Smith and Wenger. 2001. Chehalis Basin and Nearby Drainages, Water Resource Inventory Areas 22 and 23. Washington State Conservation Commission Final Report, May 2001.

Snover, A.K., P. W. Mote, L. Whitely Binder, A.F. Hamlet, and N.J. Mantua. 2005. Uncertain Future: Climate Change and its Effects on Puget Sound. A report for the Puget Sound Action Team by the Climate Impacts Group (Center for Science in the Earth System, Joint Institute for the Study of the Atmosphere and Oceans, University of Washington, Seattle). (http://www.psat.wa.gov/climatechange).

Stonick, C. 1999. Screening Survey of Carbaryl (SevinTM) and 1-naphthol Concentrations in Willapa Bay Sediments. Prepared for the Washington State Department of Ecology. Publication No. 99-323.

Straus, K.M., L.M. Crosson, and B. Vadopalas. 2008. Effects of Geoduck Aquaculture on the Environment: A Synthesis of Current Knowledge, Prepared for Washington Sea Grant. January 25, 2008.

Takesue, R.K., B.J. Rosenbauer, and E.E. Grossman. 2005. Sedimentation and contaminant loading: effects on eelgrass (*Zostera marina*) bed health in northern Puget Sound: Proceedings of the 2005 Puget Sound Georgia Basin Research Conference.

Thom, R.M., T.L. Parkwell, D.K. Niyogi and D.K. Shreffler. 1994. Effects of graveling on the primary productivity, respiration, and nutrient flux of two estuarine tidal flats. Marine Biology 118:329-341

Tufts, D. F. (ed.). 1989. The use of the insecticide SEVIN to control burrowing shrimp in Willapa Bay and Grays Harbor in 1986. Special Shellfish Report No. 4, Washington Department of Fisheries, Olympia, Washington.

Tufts, D. F. (ed.). 1990. Control of burrowing shrimp in Willapa Bay and Grays Harbor in 1987. Special Shellfish Report No. 5, Washington Department of Fisheries, Olympia, Washington.

USFWS (U.S. Fish and Wildlife Service). 2008. Information Sheet: Summary of Kootenai River White Sturgeon Studies. Upper Columbia Fish and Wildlife Office, Spokane, Washington, 2007/2008.

USGS (U.S. Geological Survey). 2004. Website: http://soundwaves.usgs.gov/2004/09/, accessed 12/11/2008.

Waples, R.S. 1991. Definition of 'Species' Under the Endangered Species Act: Application to Pacific Salmon. U.S. Department of Commerce, National Marine Fisheries Service, Northwest Fisheries Science Center, NOAA Technical Memorandum NMFS- F/NWC-194. http://www.nwfsc.noaa.gov/publications/techmemos/tm194/waples.htm

WBFEG (Willapa Bay Fisheries Enhancement Group). WRIA 24 Watershed Characteristics, http://www.wbfeg.com/wria.htm. Website accessed on January 4, 2009.

WDOE (Washington State Department of Ecology). 2001. Carbaryl Concentrations in Willapa Bay and Recommendations for Water Quality Guidelines, WDOE. March 2001, Publication No. 01-03-005, pg iv.

WDOE. 2007. see env baseline (see geoduck HCP BO) or FEMA BO

WDOE. 2008. http://www.ecy.wa.gov/programs/sea/pugetsound/species/eelgrass.html, accessed 12/11/2008

WDFW (Washington Department of Fish and Wildlife) and ODFW (Oregon Department of Fish and Wildlife). 2002. Status report Columbia River fish runs and fisheries, 1938- 2000. Joint Columbia River Management Staff, Clackamas, Oregon/Vancouver, Washington.

WDNR (Washington Dept. of Natural Resources) and Weyerhaeuser Co. 1993. Tolt River watershed analysis.

WDNR. 1997a. Lake Whatcom watershed analysis. Washington Department of Natural Resources, Forest Practices Division. Olympia, WA.

WDNR, Ed. 1997b. Lake Whatcom watershed analysis.

WDNR. 2006. Totten Inlet Mussel Rafts, December 11, 2006 report by Ken Dean. Signed report not addressed.

WDNR.. 2009. Fact Sheet: "Why Eelgrass and Eelgrass Monitoring are Important." http://www.dnr.wa.gov/Publications/aqr_nrsh_eelgrass_monitor.pdf. Website accessed on January 8, 2009.

Weisskopf, C.P. and Felsot, A.S. 1998. Carbaryl and Imidacloprid Concentrations in Willapa Bay Water and Sediment Following Application for Control of Burrowing Shrimp. A final report to the Washington State Commission on Pesticide Regulation and the Willapa-Grays Harbor Oyster Growers Association.

WSCC (Washington State Conservation Commission) and King County Department of Natural Resources. 2000. Habitat limiting Factors and Reconnaissance Report, Green/Duwamish and Central Puget Sound Watersheds, Water Resource Inventory area 9 and Vashon Island. Olympia and Seattle, Washington (Kerwin and Nelson 2000).

WSCC. 2001. Salmon and Steelhead Habitat Limiting Factors Report for the Cedar-Sammamish Basin, Water Resource Inventory Area 8. Olympia, Washington. (Kerwin 2001).

WSCC (Washington State Conservation Commission). 2003. Salmon and Steelhead Limiting Factors Analysis in Water Resource Inventory Areas 3 and 4, the Skagit and Samish Basins. (Smith 2003a).

WSCC (Washington State Conservation Commission). 2003a. Salmon and Steelhead Limiting Factors Analysis in Water Resource Inventory Area 16, Dosewallips-Skokomish Basin (Correa 2003).

Willner, Georgina B. 2006. The Potential Impacts of the Commercial Geoduck (*Panope generosa*) Hydraulic Harvest Method on Organisms in the Sediment and at the Water-Sediment Interface in Puget Sound. MES Thesis, The Evergreen State College. June 2006.

APPENDIX A. MARINE MAMMAL DETERMINATIONS

Marine Mammals (Steller sea lions, humpback whales, Southern Resident killer whales):

The above ESA listed marine mammal species may occur in the proposed action area. There are no Steller sea lion rookeries in Washington State, and Steller sea lion haul out locations in Washington State are not proximate to areas with ongoing shellfish aquaculture in the proposed action area. In the event marine mammals are present during aquaculture activities, vessel operations associated with the proposed action may cause temporary disturbance. The proposed action may indirectly affect prey availability of marine mammals (i.e., salmon prey of Southern Resident killer whales and Steller sea lions) by changes to habitat and water quality, discussed in detail above for salmon.

A very low level of vessel operations will be associated with the aquaculture activities (small and larger work boats and barges). Vessels would remain relatively immobile until work is complete, with minimal sound and insignificant potential for disturbance. Any encounters with ESA listed whales are expected to be sporadic and transitory and vessel strikes are extremely unlikely and therefore discountable. Steller sea lions potentially swimming in the vicinity of aquaculture activities may temporarily avoid project activity, also with insignificant potential for disturbance.

The proposed activities are likely to result in some adverse effect to salmon, as a result of increased water turbidity, shading and benthic disturbance. Additional adverse effects and take of salmon are likely to result from application of the insecticide carbaryl on tide flats in Willapa Bay and Grays Harbor. The consequences of these adverse effects are described in the salmon analysis.

As described in the salmon conclusions, the salmon ESUs addressed in this consultation are distributed widely enough and are presently at high enough abundance levels that any short-term adverse effects resulting from existing commercial shellfish aquaculture activities will not have an observable effect on the spatial structure, productivity, abundance and diversity of Puget Sound Chinook salmon, Hood Canal summer-run chum salmon, Columbia River chum salmon or LCR Chinook salmon. Anticipated localized adverse effects to salmon would result in an insignificant effect to adult equivalent prey resources for marine mammals that may intercept the affected stocks within their range (i.e., Southern Resident killer whales or Steller sea lions).

The application of carbaryl in Willapa Bay and Grays Harbor may also have short-term effects on salmon quality. Because carbaryl is quickly metabolized, however (IARC 1976), it is unlikely that carbaryl ingested in these areas by juvenile Chinook salmon would still be present when the Chinook are consumed by Southern Resident killer whales years later. For adult Chinook, it is unlikely that any entering Willapa Bay and Grays Harbor and ingesting carbaryl would be consumed by killer whales because the adult salmon would be moving toward natal rivers to spawn and the exposure would likely occur during the summer period when killer whales are not in the area. In addition, it is likely that very few adult Chinook salmon are exposed, as described in the salmon analysis.

The NMFS finds that all potential adverse effects to ESA listed marine mammals are discountable or insignificant and concurs with your determination of "may affect, not likely to adversely affect" for Steller sea lions, humpback whales, and Southern Resident killer.

Critical Habitat, Southern Resident killer whales:

Critical habitat for Southern Resident killer whales occurs in the proposed action area. The proposed action may affect PCEs of the whales' critical habitat, including passage, and quantity and quality of prey. Vessels associated with the proposed action would remain relatively immobile until work is complete, with minimal sound and insignificant potential to affect passage. Any encounters with ESA listed whales are expected to be sporadic and transitory and effects on passage are extremely unlikely and therefore discountable. Additionally, anticipated localized impacts to salmon, identified in the Opinion, would result in an insignificant effect to adult equivalent prey resources and insignificant effect on prey quantity available in the Southern Residents' critical habitat. Regarding prey quality, as described above, any carbaryl ingested by juvenile Chinook in Willapa Bay and Grays Harbor would be metabolized before the Chinook salmon were consumed by killer whales, and any adult salmon ingesting carbaryl are unlikely to be eaten by killer whales.

The NMFS finds that potential effects on critical habitat of Southern Resident killer whales are discountable or insignificant and concurs with your determination of "may affect, not likely to adversely affect" for Southern Resident killer whale critical habitat.

APPENDIX B: IMPACTS OF CARBARYL ON SOUTHERN DPS GREEN STURGEON

The following describes the approach and assumptions used to assess the effects of carbaryl on preys species and Southern DPS green sturgeon abundance (subadult/adult only). A worse-case scenario approach was taken for both assessments. Information was predominantly from Feldman et al. (2000), Beamesderfer and Webb (2002), and Adams et al. (2007). Assumptions and information common to both assessments were:

1. Size of Willapa Bay is 78,999 acres at Mean High Water.
   Size of Grays Harbor is 54,702 acres at Mean Higher High Water.

2. Acreage sprayed with carbaryl in Willapa Bay is 600 acres.
   Acreage sprayed with carbaryl in Grays Harbor is 200 acres.

3. Acreage affected (area sprayed plus drift) by carbaryl in Willapa Bay is 848 acres.
   Acreage affected (area sprayed plus drift) by carbaryl in Grays Harbor is 448 acres.

   Although distance is dependent upon tidal direction, water velocity, turbulence and site-specific characteristics, Doty et al. (1990, in Feldman et al. 2000) reported carbaryl detection up to 800 meters from the application site. Assuming detection outside of the application area occurs in a down-drift radius of 800 meters from the application site, an additional 248 acres will be affected.

Assessment of effect on prey abundance

To assess the effect of carbaryl on prey abundance, it was necessary to determine the biomass of prey available. While no information was found regarding the biomass of non-target species such as benthic invertebrates, information to estimate the biomass of shrimp (carbaryl's target species) in Willapa Bay and Grays Harbor was available. Feldman et al. (2000) reported the biomass of shrimp in Willapa Bay may approach 7-10 tons per hectare, and that carbaryl removes an estimated 476 tons of shrimp (66 million) per year (Dumbauld 1994 in Feldman et al. 2000). No information was provided for Grays Harbor, so the same numbers for biomass and removal of shrimp as Willapa Bay were used for Grays Harbor. Dumbauld et al. (2006) reported an 84-96 percent removal efficiency, and the BA (ENVIRON 2008) reported a 90-95 percent removal efficiency on target species. A range of 84-96 percent removal was assumed. It was assumed that shrimp are distributed equally throughout Willapa Bay and throughout Grays Harbor.

Applying these assumptions, the percent loss from the use of carbaryl on shrimp biomass within the affected acreages was then determined:

1. Estimated biomass of shrimp was back-calculating using the 84-96 percent efficiency and the removal rate of 476 tons per hectare per year from 324 hectares. From this a removal rate per hectare was calculated at 84 percent efficiency and 96 percent efficiency.

2. Using the above removal rates, the loss of biomass from within the affected acreage was calculated as a percent of the total estimated to be available.

A worse-case estimate of shrimp biomass loss due to carbaryl use in Willapa Bay is less than 1 percent of the total shrimp biomass available within Willapa Bay. A worse-case estimate of shrimp biomass loss due to carbaryl use in Grays Harbor is less than one percent of the total shrimp biomass available within Grays Harbor.

Calculations above were only for shrimp. Feldman et al. (2000) reported short-term acute toxicity to small marine fish and infaunal and epibenthic invertebrates, and Doty et al. (1990 in Feldman et al. 2000) indicated 100 percent crab mortality in affected areas. Consequently, 100 percent mortality of non-target prey species within affected acreage was assumed, but not quantified.

Assessment of effect on Southern DPS green sturgeon abundance

To assess the effect of carbaryl on green sturgeon abundance, it was first necessary to determine abundance estimates for Southern DPS green sturgeon. No spawning in Willapa Bay or Grays Harbor tributaries is known to occur, and juveniles rear in natal streams. Consequently, only subadults and adults could be exposed to the effects of carbaryl in Willapa Bay and Grays Harbor. Based on combined Northern and Southern DPS green sturgeon abundance estimates in Beamesderfer and Webb (2002), an estimated abundance for the subadult/adult portion of the Southern DPS was derived. Assumptions and methodology used to parse out a subadult/adult abundance estimate for Southern DPS green sturgeon were:

1. The Klamath River, Rogue River, and British Columbia Waters area estimates were assumed to be all Northern DPS, and San Pablo Bay to be all Southern DPS. The resulting ratio of Northern DPS to Southern DPS of 85.5 percent to 14.5 percent was applied to the mixed stock areas of Oregon and Washington Oceans.

2. The Washington Bays and Estuaries area was assumed to be Willapa Bay and Grays Harbor. Historical green sturgeon harvest (Adams et al. 2007) of 52 percent Willapa Bay and 48 percent Grays Harbor was applied to the Washington Bays and Estuaries area abundance estimate. This yielded mixed DPS estimates for Willapa Bay ranging from 2,477 to 12,386, and estimates of 2,287 to 12,386 for Grays Harbor. A study by Israel and May (2006 in NMFS 2008a) identified 75 percent of the sturgeon sampled from Willapa Bay and 51 percent of those sampled from Grays Harbor as Southern DPS. These percentages were applied then applied to mixed Willapa Bay and Grays Harbor abundance estimates resulting in 1,858 to 9,290 Southern DPS subadults/adults in Willapa Bay, and 1,166 to 6,317 in Grays Harbor. Combining those numbers resulted in the estimated abundance of Southern DPS subadults/adults for the Washington Bays and Estuaries area.

3. Israel and May (2007) reported 1995 sampling results from the Columbia River indicated 83.3 percent were Southern DPS. This value was applied to the mixed stock area of Columbia River Estuary.

4. Combined sampling results from the Israel and May study in Willapa Bay and Grays Harbor produced a ratio of 63.5 Southern DPS to 36.5 percent Northern DPS. Assuming more Northern DPS would be present in the Oregon Bays and Estuaries area, a ratio of 36.5 Southern DPS to 63.5 Northern DPS was applied.

The table below summarizes the calculations made to determine the subadult/adult abundance estimates. The portion estimated to be Southern DPS ranges from 13,900 to 70,400.

Area	Mixed Population		Southern DPS		Northern DPS	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Oregon Ocean	9,850	39,400	1,428	5,713	8,422	33,687
Washington Ocean	2,700	10,800	392	1,566	2,309	9,234
Oregon Bays & Estuaries	2,000	20,000	730	7,300	1,270	12,700
Washington Bays & Estuaries	4,764	23,820	3,024	15,121	1,740	8,699
Columbia River Estuary	9,084	45,320	7,567	37,752	1,969	7,568
Mixed Stock Total	**28,398**	**139,340**	**13,141**	**67,451**	**15,709**	**71,889**
Klamath River					2,810	5,620
Rogue River					400	4,000
British Columbia waters					2,000	8,000
San Pablo Bay			750	3,000		
TOTAL			**13,891**	**70,451**	**20,919**	**89,509**

Limited tagging using acoustic and PIT (Passive Integrated Transponder) tags has occurred since 2002. Approximately 350 green sturgeon from Oregon (Rouge River, Klamath River), California (Sacramento River, San Pablo Bay), and Washington (Columbia River, Willapa Bay, Grays Harbor) were tagged between 2002 and 2005 (Olaf Langness, WDFW personal communication; David Woodbury, NMFS personal communication). As results are limited and preliminary, this data was not used to determine abundance estimates.

Finally, the number of subadults/adults affected by carbaryl was estimated:

1. An equal distribution of sturgeon across Willapa Bay and across Grays Harbor was assumed. Use of 2006 tag detection information indicated that 40 percent of the 35 tagged fish detected were detected at multiple receiver locations throughout the bay (Mary Moser, NMFS personal communication). This indicates that green sturgeon exhibit a high level of movement within the estuary. However, while sturgeon movement is acknowledged, for purposes of this analysis an equal distribution of sturgeon across Willapa Bay and across Grays Harbor was assumed.

2. The density of subadult/adult Southern DPS green sturgeon (number per acre) was calculated by dividing the number of sturgeon (see second assumption for estimating abundance above) by the number of acres in Willapa Bay and Grays Harbor, respectively.

3. Applying sturgeon density to the acreage affected carbaryl, the number of sturgeon affected ranges from 20 to 100 in Willapa Bay and 10 to 48 in Grays Harbor.

4. It was assumed that green sturgeon do not avoid carbaryl. Coastal cutthroat trout do not avoid carbaryl (Labenia et al. 2007), and as NMFS could identify no studies regarding sturgeon avoidance, sturgeon were assumed to behave in a similar manner as coastal cutthroat trout when exposed to carbaryl.

A worse-case scenario of 100 percent mortality, lowest DPS subadult/adult abundance (13,900), and largest number of sturgeon affected (148 combined) was assumed. Consequently, a loss of 1.06 percent of the subadult/adult Southern DPS green sturgeon could occur annually from the combined application of carbaryl at all sites in Willapa Bay and Grays Harbor.