United States Department of the Interior

FISH AND WILDLIFE SERVICE

Washington Fish and Wildlife Office
510 Desmond Dr. SE, Suite 102
Lacey, Washington 98503

MAR 24 2009

In Reply Refer To:
13410-F-2008-0461

Lawrence C. Evans, Chief Regulatory Branch
Portland District, Corps of Engineers
P.O. Box 2946
Portland, Oregon 97208-2946

Dear Mr. Evans:

Subject: Biological Opinion of the Nationwide Permit 48

This letter transmits the Biological Opinion (Opinion) of the U.S. Fish and Wildlife Service based on our review of the proposed Nationwide Permit 48 for the State of Washington. A detailed description of the Proposed Action and its potential effects to listed species is provided in the enclosed Biological Opinion. The U.S. Army Corps of Engineers (Corps) determined that activities permitted under the Nationwide Permit 48 "may affect, but are not likely to adversely affect" marbled murrelet (*Brachyramphus marmoratus*), California brown pelican (*Pelecanus occidentalis*), western snowy plover (*Charadrius alexandrinus nivosus*) and critical habitat, the Columbia River Interim Recovery Unit of the bull trout (*Salvelinus confluentus*), and critical habitat of the Coastal-Puget Sound Interim Recover Unit of bull trout. The Corps determined that carbaryl application in Grays Harbor would adversely affect the Coastal-Puget Sound Interim Recovery Unit of bull trout.

This Opinion will address and evaluate effects to bull trout within the Coastal-Puget Sound Interim Recovery Unit (Puget Sound IRU) as well as to designated critical habitat for the bull trout [50 FR 56212 (October 26, 2005)]. We also address adverse effects to marbled murrelets.

Your request for formal and informal consultation, dated June 30, 2008, was received July 3, 2008. This consultation is in accordance with section 7(a)(2) of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*).The enclosed Opinion is based on information provided in the Biological Assessment for the Nationwide Permit 48. A complete decisional record of this consultation is on file at the U.S. Fish and Wildlife Service's Washington Fish and Wildlife Office in Lacey, Washington.

If you have any questions about the enclosed Biological Opinion, or your responsibilities under the Endangered Species Act, please contact Andrea LaTier (360) 753-9593 or John Grettenberger (360) 753-6044, of my staff.

Sincerely,

Ken S. Berg, Manager
Washington Fish and Wildlife Office

Enclosure:
Nationwide Permit 48 Biological Opinion

cc:
Corps, Seattle, WA (M. Walker)
Corps, Vancouver, WA (B. Abadie)

Endangered Species Act - Section 7 Consultation

BIOLOGICAL OPINION

U.S. Fish and Wildlife Service Reference: 13410-2008-F-0461

Nationwide Permit #48 for Shellfish Aquaculture

State of Washington

Agency:

U.S. Army Corps of Engineers
Portland Operating Division
Portland, Oregon

Consultation Conducted By:

U.S. Fish and Wildlife Service
Washington Fish and Wildlife Office
Lacey, Washington

March 2009

_______________ for
Ken S. Berg, Manager
Washington Fish and Wildlife Office

3/24/2009
Date

United States Department of the Interior

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Corps, Seattle, WA (M. Walker)
Corps, Vancouver, WA (B. Abadie)
Corps, Headquarters, (J. Moyer)

Endangered Species Act - Section 7 Consultation

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Washington Fish and Wildlife Office
Lacey, Washington

March 2009

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Ken S. Berg, Manager Washington Fish and Wildlife Office	Date

TABLE OF CONTENTS

LIST OF TABLES and FIGURES

1.0 INTRODUCTION

This document transmits the U.S. Fish and Wildlife Service's (Service) Biological Opinion (Opinion) based on our review of the U.S. Corps of Engineers (Corps) proposal to implement the Nationwide Permit 48 for Shellfish Aquaculture (NWP 48) in Washington State for a 5-year period. The NWP 48 will be implemented under the authority of Section 404(e) of the Clean Water Act (33 U.S.C. 1344) and Section 10 of the Rivers and Harbors Act of 1899 (33 CFR 322.3(a)). This Biological Opinion addresses effects to listed resources under the Service's jurisdiction, in accordance with section 7 of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 et seq.).

This Opinion is based on information provided in the Corps' Biological Assessment (BA) received on July 3, 2008, telephone conversations, meetings, field investigations, and other sources of information. A complete record of this consultation is on file at the Western Washington Fish and Wildlife Office in Lacey, Washington.

The section 7 implementing regulations at 50 CFR 402 establish that a Federal agency must request formal consultation with the Service if it determines that its action "may affect" any listed species or designated critical habitat, unless the Service concurs with a determination by the Federal agency that the proposed action "is not likely to adversely affect" listed species or critical habitat. The preamble to the regulations defines "not likely to adversely affect" as "…beneficial, discountable, or insignificant effects upon listed species or their critical habitats…" The following excerpt from the preamble to the regulations further explains (emphasis added) the rationale for the "may affect" threshold for formal consultation:

> "The threshold for formal consultation must be set sufficiently low to allow Federal agencies to satisfy their duty to "insure" *(no jeopardy)* under section 7(a)(2). Therefore the burden is on the Federal agency to show the absence of likely, adverse effects to listed species…in order to be excepted from the formal consultation obligation."

If the Service cannot agree that there is an "absence of likely, adverse effects" to listed species or critical habitat, we cannot conclude consultation with a concurrence letter or adequately defend any challenge to a decision that a concurrence determination was warranted under those circumstances.

In the case of the proposed action evaluated in this Biological Opinion, the Service has determined that the best scientific and commercial information available is currently insufficient to "show the absence of likely, adverse effects" to the bull trout and the marbled murrelet from all proposed activities. On that basis, a "may affect" determination, and subsequent formal consultation, is warranted.

Please note that under formal consultation, the Service must meet a different standard in evaluating the likelihood of "incidental take" of listed animal species as the result of a Federal agency action. Absent sufficient evidence that the proposed Federal action is likely to have biological effects to a listed animal species that conform to the regulatory definition of take, the

Service cannot make a determination that incidental take is anticipated. In the case of this proposed action, the "Effects of the Action" and the "Incidental Take Statement" sections below reflect application of that standard.

2.0 CONSULTATION HISTORY

The Corps issued its final notice on the reauthorization of existing Nationwide Permits, including the NWP 48, on March 12, 2007. The permits took effect on March 19, 2007. The NWP 48 is valid for five years following completion of this section 7 consultation. The NWP 48 authorizes the installation of buoys, floats, racks, trays, nets, lines, tubes, containers, and other structures necessary for the continued operation of existing commercial aquaculture activity. This NWP also authorizes discharges of dredged or fill material necessary for shellfish seeding, rearing, cultivating, transplanting, and harvesting activities. Rafts and other floating structures must be securely anchored and clearly marked.

This NWP does not authorize new operations or the expansion of the project area for an existing commercial shellfish aquaculture activity. This NWP does not authorize the cultivation of new species (i.e., species not previously cultivated in the waterbody). The NWP does not authorize attendant features such as docks, piers, boat ramps, stockpiles, staging areas, or the deposition of shell material back into waters of the United States as waste.

The notable events related to this consultation are summarized below:

November 21, 2007: The Service sent comments to the Corps on the Nationwide 48 Draft BA. Comments focused on 1) the inadequacy of the analysis as it related to additive or cumulative effects of the entire action, 2) inadequate description of the scope of the action, and 3) a definition of terms and concepts.

February 14, 2008: The responses were subsequently discussed at a meeting at the Western Washington Fish and Wildlife Office. The meeting was attended by individuals from the Corps, the Service, National Oceanic and Atmospheric Administration (NOAA), and Jones and Stokes.

May 8, 2008: The Service received the Draft NWP 48 BA Addendum: Screening Level Risk Assessment to Threatened and Endangered Species from the use of carbaryl to Control Burrowing Shrimp in Washington State.

May 28, 2008: The Service submitted comments on the BA Addendum. Prior to the submittal these were discussed at a meeting on May 15, 2008, attended by representatives from the Corps, NOAA, the Service, and ENVIRON.

May 29, 2008: The Service received a revised draft BA from the Corps.

June 6, 2008: The Service submitted comments on the revised draft BA. Our comments centered on the fact that the BA was still incomplete with regard to an analysis of additive effects from all shellfish farms on listed species and critical habitat. The BA also did not contain the spatial information (maps and database information) necessary to characterize the scope of the action.

July 3, 2008: The final BA was submitted to the Service on requesting initiation of formal consultation.

July 18, 2008: The Service requested additional information in the form of Geographic Information System (GIS) point and polygon shape files of the Washington shellfish culture areas and an electronic version of the shellfish growing areas database.

August 14, 2008: The Service sent an e-mail to the Corps indicating that it had received the electronic versions of the Washington shellfish culture area maps and database from ENVIRON on August 4, 2008 and that formal consultation had been initiated.

September 26, 2008: The Service sent an email to the Corps outlining the timeline for initiation and expected completion dates for the NWP 48 formal consultation.

The Corps determined that activities permitted under the NWP 48 **"**may affect, but are not likely to adversely affect**"** marbled murrelet (murrelet), California brown pelican (pelican) and the western snowy plover (Table 2.1). These species are present in Willapa Bay and Grays Harbor where intensive shellfish aquaculture, in addition to carbaryl application, takes place. We concur with effect determinations for western snowy plover and pelican. We agree that the Columbia River Interim Recovery Unit of the bull trout will not be affected by the proposed action, as it is outside of the action area. This Opinion will address and evaluate effects to bull trout within the Coastal-Puget Sound Interim Recovery Unit (Puget Sound IRU) as well as to designated critical habitat for the bull trout [50 FR 56212 (October 26, 2005)]. We also address adverse effects to murrelets, due to indirect effects from aquaculture activities.

Table 2.1. The Corps' effect determinations for federally-listed resources in Washington State that are under the jurisdiction of the Service.

Common Name	Scientific Name	Status	Corps Effect Determinations	
Birds			**Species**	**Critical Habitat**
Marbled murrelet (species and critical habitat)	*Brachyramphus marmoratus*	T	NLAA	NE
Western snowy plover (coastal populations and critical habitat)	*Charadrius alexandrinus nivosus*	T	NLAA	NLAA
California Brown pelican	*Pelecanus occidentalis*	E	NLAA	NA
Fish				
Bull trout (species and critical habitat)	*Salvelinus confluentus*	T	LAA	NLAA

NA: Not applicable
NLAA: Not likely to adversely affect
LAA: Likely to adversely affect
NE: No effect

3.0 CONCURRENCE

3.1 Western Snowy Plover

Western Snowy plovers (*Charadrius alexandrinus nivosus*) (snowy plover) are year-round residents and nest along coastal beaches from Copalis Spit to, and including, the Long Beach Peninsula. Annual surveys of the Washington coastal beaches have been conducted since the mid 1970's. The snowy plover was listed by the Washington State Department of Fish and Wildlife as a State endangered species in 1981, and was listed as threatened under the Federal Endangered Species Act in 1993. Survey efforts intensified after the listing and currently include multiple visits a week to occupied beaches during the nesting season as well as winter surveys. Survey information documents that nesting snowy plovers occur in the vicinity of Willapa Bay on beaches fronting the Pacific Ocean from Grayland to the middle of the Long Beach Peninsula. With the exception of Graveyard Spit, which is located at the mouth of Willapa Bay, there are no records of snowy plovers foraging or nesting in the bay or along the eastern shore of the Long Beach Peninsula. Although there are a few isolated reports of snowy plovers foraging or sheltering from winter storms on the northern tip of Leadbetter Point, use of the area along the eastern tip of the peninsula is very limited. Snowy plovers also nest and forage along Damon Point, located at the mouth of Grays Harbor. Although there are historic records of snowy plovers using the coastal beaches at Westport (south side of Grays Harbor), the area is no longer occupied.

Spraying for ghost shrimp is conducted once a year during the lowest tides between July and August. Based on over 20 years of survey information, it is extremely unlikely that snowy plovers will be directly exposed to carbaryl, or that they will be indirectly affected by the loss of prey resources (aquatic invertebrates) because the spray operations are conducted in areas that snowy plovers do not use and/or during the time of year (nesting season) when snowy plover activity is restricted to the outer beaches. We therefore concur with your effect determination of "may affect, not likely to adversely affect" for the snowy plover.

3.1.1 Snowy Plover Critical Habitat

Snowy plover critical habitat has been designated at Willapa Bay and Grays Harbor. Primary constituent elements are as follows:

(1) Sparsely vegetated areas above daily high tides (e.g., sandy beaches, dune systems immediately inland of an active beach face, salt flats, seasonally exposed gravel bars, dredge spoil sites, artificial salt ponds and adjoining levees) that are relatively undisturbed by the presence of humans, pets, vehicles or human-attracted predators;

(2) Sparsely vegetated sandy beach, mud flats, gravel bars or artificial salt ponds subject to daily tidal inundation but not currently under water, that support small invertebrates such as crabs, worms, flies, beetles, sand hoppers, clams, and ostracods; and,

(3) Surf or tide-cast organic debris such as seaweed or driftwood located on open substrates such as those mentioned above (essential to support small invertebrates for food, and to provide shelter from predators and weather for reproduction).

The proposed action will not be altering Primary Constituent Elements (PCEs) 1 or 3. As previously described in the effects to snowy plovers section, it is expected that any effects to invertebrates (PCE 2) are likely to be insignificant. We therefore concur with your effect determination of "may affect, not likely to adversely affect" for snowy plover critical habitat.

3.2 California Brown Pelican

Pelicans occur in Willapa Bay and Grays Harbor primarily during the summer months, with peak abundance typically occurring in August (Jaques and O'Casey 2006) after pelicans have left their breeding grounds. Pelicans are known to use night and diurnal roost sites and forage in Willapa Bay and Grays Harbor. In these waterbodies, pelicans use sandbars and sand islands as roost sites, as well as anthropogenic features such as breakwaters. However, these sand islands are often ephemeral. Surveys by Jaques and Casey (2006) have documented changes in sand bar configurations and loss and gain of sand bars in these areas.

3.2.1 Aquaculture Activities

Pelicans primarily forage by plunge diving after sighting prey from the air, but they will also take fish while floating if large schools of fish are present (Murphy 1936; Haverschmidt 1949; Dinsmore 1974 all as cited in Shields 2002). Water depth in the intertidal areas where aquaculture occurs is expected to generally preclude plunge diving by Pelicans. Although pelicans forage in shallower areas by feeding from the surface (Jaques and O'Casey 2006), it is unlikely that these project areas provide suitable habitat for large schools of fish that would attract pelicans. Therefore, effects to pelicans from actions within the aquaculture beds that may affect foraging are likely to be insignificant.

Factors that affect the ability of pelicans to find individual roost sites includes waves, bald eagle presence, human disturbance, and location of foraging activities (Jaques and O'Casey 2006). Low-flying aircraft are now considered to be a primary source of disturbance to roosting birds (Seattle Audubon Society 2005 – 2008). However, Jaques and O'Casey (2006) observed during their study that bald eagles were the most frequent source of disturbance to roosting pelicans.

The proposed action will result in the use of helicopters and boats that may be in proximity to pelican night and diurnal roost sites. Increased activity levels from support boats, planting, and harvesting activities are also likely. However, Willapa Bay and Grays Harbor experience significant boat traffic due to pleasure, fishing and commercial boating activities. Pelicans did not flush from boats that approached as close as 30 meters of a breakwater used for roosting (Jaques and O'Casey 2006). We do not anticipate that boat and other anthropogenic activities associated with planting and harvesting will measurably affect roosting and foraging pelicans. These activities are likely to be less than the normal boat and human activity levels that occur in these two waterbodies. It is reasonable to assume that pelicans using these areas are accustomed to these disturbance levels. Therefore, effects to pelicans due to support boats, planting, and harvesting activities are likely to be insignificant.

Helicopter use would be limited to July and August for up to seven days, and no more than two hours per day. These months also correspond to the periods of higher pelican abundance. Disturbance of pelicans due to helicopters may affect the use of diurnal and night roost sites, as well as foraging. However, we anticipate that the disturbance will be temporary, due to the limited number of days and hours of potential disturbance associated with helicopter flights. Although pelicans may flush if a helicopter approaches, we anticipate that this would not result in a measurable effect to there ability to forage or find cover during this time period. Therefore, we concur with your "not likely to adversely affect" determination for pelicans.

3.2.2 Carbaryl Application

Pelicans are known to use Willapa Bay and Grays Harbor during the time when carbaryl is applied to mudflats to control ghost shrimp. Pelicans will consume crustaceans (Shields 2002), and so we assumed that they would be attracted by helicopters and would feed on dead and dying ghost shrimp during the first incoming tide following each application. Carbaryl is applied to mudflats for approximately one week on an annual basis.

In order to predict whether pelicans will experience adverse effects from consumption of contaminated prey, we calculated the predicted dose a pelican would receive on a daily basis assuming a one-week exposure period. No information was available to suggest that birds are adversely affected on an acute (short-term) exposure basis from the use of carbaryl to control burrowing shrimp (EPA 2003). To our knowledge, there have never been any reports of pelican mortality after carbaryl spraying. It is more likely that pelicans will experience acute (short term) exposure that would result in sublethal effects.

We were unable to conduct a similar analysis for 1-naphthol, the primary breakdown product of carbaryl. This degradate is not measured in fish tissue nor are there toxicity data available for birds. Therefore, we are unable to conclude whether 1-naphthol would be toxic to pelicans.

We were, however, able to evaluate carbaryl, which is present is greater amounts. Table 3.1 presents the exposure assumptions we used to calculate the daily dose to pelicans. We assumed the maximum exposure for those parameters for which data were available. This was done in an effort to be conservative in our predictions. We used the maximum carbaryl concentrations detected in sediment and shrimp tissue. We assumed that pelicans fed exclusively on ghost shrimp for the entire week. Pelicans consume marine water through the removal of salt through specialized gland, although no data upon which to calculate carbaryl consumption through drinking water. We do not expect that this will significantly influence the amount of carbaryl ingested. In general, when calculating food web exposure, water ingestion has little impact on the overall predicted dose.

Table 3.1 Exposure Parameters for California Bown Pelicans

Parameter	Values	Unit	Comment
Body weight (BW)	5	kg	Maximum
Food ingestion Rate (IR)	0.6	kg/day	Adult
Water ingestion Rate		ml/day	No data
Sediment ingestion Rate	0.003	kg/day	Assumed to be similar to probing shorebird
Sediment concentration	3.4	mg/kg	Max. carbaryl concentration
Prey concentration	15	mg/kg	Max. carbaryl concentration in burrowing shrimp
Site use factor (SUF)	100	%	In treated area at all times
Assimilation efficiency (AE)	1	unitless	Assume shrimp assimilate into their tissues all carbaryl they consume

We assumed that pelicans would feed on immobilized fishes and dying ghost shrimp following carbaryl treatment in Willapa Bay and Grays Harbor. Therefore, we assumed the following to predict exposure and calculate effects:

- Pelicans become habituated to the helicopters and learn to follow them to feed on compromised prey
- Pelicans feed exclusively on compromised prey for an entire week (7 days)
- Pelicans assimilate all the carbaryl ingested
- Amount of sediment ingested is similar to a probing shorebird

We used the following equation to calculate the daily dose of carbaryl ingested by pelicans feeding exclusively on burrowing shrimp in Willapa Bay and Grays Harbor following carbaryl application:

[1] Dose (mg/kg BW day) = (SUF (IR[food]*C[food]) + (IR[water]*C[water]) + IR[sed]*C[sed]*AE))/BW

Using the equation above the predicted daily dose is 1.8 mg/kg BW per day on a wet weight basis. We then used the following equation to calculate the expected risk quotient (RQ):

$$[2]\ RQ = \frac{\text{Daily dose}}{\text{TRV}}$$

Response - The data for effects to birds are sparse. The Environmental Protection Agency (EPA) considers carbaryl slightly to practically nontoxic to birds on an acute exposure basis. This toxicity classification is based on a mallard LD_{50} greater than 2,000 mg/kg for technical grade carbaryl. Passerines appear to be more sensitive than most birds to carbaryl, as LD_{50} values for granular carbaryl have been reported to be as low as 16.2 mg/kg and 56.2 mg/kg for the European starling (*Sturnus vulgaris*) and the red-winged blackbird (*Agelaius phoeniceus)*, respectively (Schafer et al. 1983 as cited in EPA 2003, p. 150). EPA considered these data unreliable for the use in risk assessment as they are based on simple screening tests. The data do suggest that passerine birds may be significantly more sensitive to carbaryl exposure than non-passerine birds, but more data are required to confirm.

In avian reproduction studies, using the mallard duck (*Anas platyrhynchos*), carbaryl exposure resulted in reduced number of eggs produced and increased number of eggs cracked. These chronic toxicity measurement endpoints are considered germane to chemical that acts on endocrine-mediated pathways. When considered along with open literature, there is uncertainty with the endocrine disrupting potential of carbaryl and its 1-naphthol degradate (EPA 2003, p. 49).

To evaluate a range of potential effects to pelicans we calculated risk quotients for the range of toxicity reference values (TRVs) available. We focused our risk conclusion on sublethal effects, mainly the reproductive effects in mallards, and the behavioral effects in 2-week-old chickens. Although passerines are likely more sensitive to carbaryl than either chickens or ducks, we have no reason to believe that pelicans are as sensitive as passerines. There have never been any reports of mortality in pelicans during carbaryl application and we suspect that less overt effects such as acetylcholinesterase inhibition are more likely. The results of the risk calculations are presented in Table. 3.2.

Table 3.2 Toxicity Reference Values Developed for Avian Species Fed a Diet Dosed with Carbaryl

Species	Dose (mg/kg BW day)	Endpoint	Risk Quotient
Chicken (2 wks old)[1]	100	Behavioral effect LOAEL	0.018
Chicken (Adults)	100	NOAEL Esterase Inhibition	0.018
Mallard[2]	300	NOAEL Reproductive	0.006
Pigeon[3]	3,000	LC_{50} NOAEL	0.0006
Quail[3]	2,300	LC_{50} NOAEL	0.0007
Mallard[3]	2,000	LC_{50}NOAEL	0.0009

[1] (Farage-Elawar et al. 1988)
[2] (EPA 2003)
[3] Kidd and James 1991(as cited in Extension Toxicology Network 1996)
NOAEL: No observed adverse effect level
LOAEL: Lowest observed adverse effect level

In the risk assessment paradigm under the Comprehensive Environmental Response, Compensation, and Liability Act a risk quotient greater that 1.0 indicates potential for risk. This is also consistent with the EPA approach to evaluating endangered species under the Federal Insecticide, Fungicide and Rodenticide Act, where the "Potential for chronic risk may warrant regulatory action, endangered species may potentially be affected through chronic exposure (chronic RQ > 1 for all animals)."

None of the hazard quotients listed in Table 3.2 are approaching 1.0. The greatest RQ is 0.018 for the most sensitive endpoints (behavioral effect and esterase inhibition). This is two orders of magnitude below the 1.0 level of concern. This is because the daily dose for pelicans is substantially lower than the daily dose fed to the test species.

These RQ's must be considered in context with the highly conservative exposure parameters we used. It is unlikely that pelicans will spend the entire week consuming only shrimp that have the highest carbaryl tissue concentrations measured to date. Therefore, we have likely over predicted exposure (which is what we intended with this screening level approach) and consequently effects. Therefore, based on the low magnitude of the RQ's, we conclude that effects to pelicans are insignificant.

4.0 BIOLOGICAL OPINION

4.1 Overview of the NWP 48

The NWP 48 authorizes the ongoing activities associated with operation of shellfish aquaculture farms and facilities for up to 5 years. It authorizes the installation of buoys, floats, racks, trays, nets, lines, tubes, containers, and other structures necessary for the continued operation of existing commercial shellfish aquaculture activity. To prepare beds for setting seed the NWP 48 also authorizes discharges of dredged or fill material necessary for shellfish seeding, rearing, cultivating, transplanting, and harvesting activities.

The NWP 48 only covers existing operations; it does not authorize new operations or the expansion of the project area[1] for an existing shellfish aquaculture activity. The NWP 48 does not authorize the cultivation of new species (i.e., species not previously cultivated in the water body). The NWP 48 does not authorize attendant features such as docks, piers, boat ramps, stockpiles, staging areas, or the deposition of shell material back into waters of the United States as waste.

Different levels of reporting are required under the NWP 48 depending on whether permittees propose to engage in certain activities requiring a pre-construction notification (PCN). For activities that do not require a PCN, the permittee must submit a report to the district engineer that includes:

- The size of the project area for the commercial shellfish aquaculture activity (in acres).
- The location of the activity.
- A brief description of the culture method and harvesting method(s).
- The name(s) of the cultivated species.
- Whether canopy predator nets are being used.

A PCN is required if:

- The project area is greater than 100 acres.
- 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.
- There is a change in species being cultivated.
- There is a change in culture methods (e.g., from bottom culture to off-bottom culture).

[1] Project area: The area of waters of the United States occupied by the existing operation. In most cases, the project area will consist of the area covered by the state or local aquaculture permit, license or lease. The project area may consist of several sites that are not contiguous. The project area may include areas in which there has been no previous aquaculture activity and/or areas that periodically lie fallow as part of normal operations.

- Dredge harvesting, tilling, or harrowing is conducted in areas inhabited by submerged aquatic vegetation (See general condition 27 - Sections 10 and 404).
- For work that would impact aquatic resources requiring special protection or designated critical resource waters.
- If any listed species or designated critical habitat or essential fish habitat might be affected or is in the vicinity of the project.
- If there will be effects to any historic properties.

Because a substantial number of aquaculture facilities are located within designated critical habitat, it is likely that most will require a PCN. However, not all PCN's will be forwarded to the Service for review and comment. Only those that trigger the activities listed in the first five of the eight bullets outlined above will trigger a review by the Service (Bill D. Abadie, US Army Corps of Engineers, *in litt.* 2009) . For those NWP 48 activities requiring a PCN, the district engineer will immediately provide a copy of the PCN to the Service. The Service will then have 10 calendar days *from the date the material is transmitted* to telephone or fax the district engineer that we intend to provide substantive, site-specific comments. If so contacted by the Service, the district engineer will wait an additional 15 calendar days before making a decision on the PCN. The district engineer will fully consider agency comments received within the specified timeframe, but will provide no response to the Service. The Corps will 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 Corps does not respond within 45 days, the default result is verification that NWP 48 applies.

The general conditions that have a clear and immediate relevance to NWP 48 include the following:

- No activity may cause more than a minimal adverse effect on navigation.
- No activity may substantially disrupt the necessary life cycle movements of those species of aquatic life indigenous to the water body, including those species that normally migrate through the area.
- Activities in spawning areas during spawning seasons must be avoided to the maximum extent practicable.
- No activity or its operation may impair reserved tribal rights, including, but not limited to, reserved water rights and treaty fishing and hunting rights.
- General condition 28 requires that "for NWP 48 activities that require reporting, the district engineer will provide a copy of each report within 10 calendar days of receipt to the appropriate regional office of the NMFS".

The Final Rule for the Nationwide Permits was published on March 12, 2007 (Federal Register Vol., 72, No. 47 11092 - 11198). However, the Corps did not consult with the Service under section 7 of the Act on a National level for these nationwide permits. Therefore, although the Corps has issued the Final Rule, the Corps has not completed section 7 consultation with the

Service, which is required prior to issuing individual permits to shellfish growers under the NWP 48. The section 7 consultation is being conducted on a state by state basis in the Pacific Northwest Region, which consists of Alaska, Washington, Oregon and California. This Biological Opinion covers implementation of the NWP 48 in the State of Washington.

4.2 Descritpion of the Proposed Action

The NWP 48 authorizes continuance of existing shellfish operations, subject to certain limitations identified in NWP 48. The potential effects of the proposed action on listed species and bull trout critical habitat are assessed in this Opinion by evaluating the Environmental effects of shellfish aquaculture in Washington, and determining how these impacts affect listed species and critical habitat. NWP 48 authorizes continuance of shellfish aquaculture, which has been performed in some areas (parts of Willapa Bay) since the 19th Century. The following project description was taken from the Final Biological Assessment (USACE 2008) received in our office on July 3, 2007.

4.2.1 Hatchery and Nursery Operations

All shellfish culture species (oysters, clams and mussels) are grown from seed that is caught as wild spat onto cultch (mother shell) placed in the water 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 oyster culture in Willapa Bay and in Dabob Bay in Hood Canal. Most oyster beds are established naturally from spawning of the oysters cultured in these waterbodies. In Willapa Bay, the spawning occurs in early to mid-July, with spat settling out 2-3 weeks later. In Dabob Bay, spawning typically occurs 2-3 weeks after Willapa Bay.

Hatchery and nursery operations are separated into distinct activities: 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 is conducted 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 chlorination. 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, but small enough so two or more cannot. Once they have been set this way, the size of single seed is commonly boosted by using a secondary nursery system such as a Floating Upwelling System (FLUPSY) (Figure 4.1).

Figure 4.1 A FLUPSY (Fisher Island Oysters 2007 as cited in USACE 2008)

The FLUPSY, an integral part of many companies' seed production systems, is a highly efficient method for growing seed out to a larger size. Juvenile clams and oysters, one to two millimeters in length, are transported to 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 at onshore facilities in “kiddie pools” (open plastic containers about 5 ft across and 1 ft deep) through which fresh seawater is circulated using a pump with a screened intake. Broodstock maintenance consists of the care and feeding of adult bivalves used for propagating future generations of various shellfish species.

4.2.2 Oyster Cultch Preparation and Setting

Many farmers raising ground or longline cultured oysters, or focused on shellstock production for shucking houses, prepare or purchase oyster cultch for remote setting. Oyster cultch is generally prepared by bundling washed and aged Pacific oyster shells (“mother shells”) in large plastic mesh bags. Hundreds to thousands of cultch bags are required to sustain farm inventories. Natural seed is collected on bags of cultch, stakes, or other substrate, and placed in the intertidal zone prior to spawning season. Once the oysters have set on the substrate, they are kept until a suitable size for planting. Alternatively, remote setting may occur in an upland location. In this case cultch bags, usually stacked on pallets, are placed in large tanks containing well-mixed controlled temperature seawater. Ready-to-set larvae are added to the seawater, sometimes with a small quantity of algal “paste.” The larvae then rapidly set onto the mother shell and metamorphose into tiny juvenile oysters or “spat.” The set cultch bags are then placed on the beach, either loose or on pallets, until the seed is large enough or “hard” enough (firmly cemented onto the mother shell and able to resist predation and desiccation) to withstand being moved onto the culture beds.

4.2.3 Mussel Raft and Longline Culture

Two species of mussels are farmed on the U.S. 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.

4.2.3.1 Raft Placement

Mussels are grown suspended from rafts or surface longlines anchored in subtidal waters (Figure 4.2). Raft platforms are constructed of lumber, aluminum, galvanized steel, and plywood. Flotation is made from reclaimed polyurethane food-grade barrels, or coated 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.

Figure 4.2 Commercial mussel raft culture in south Puget Sound (NOAA 2001 as cited in USACE 2008).

Seeding

Naturally spawned mussel seed is set on lines or metal screen frames in net cages. These structures 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 6 to 12 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. The seed is 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.

4.2.3.2 Grow-out and Harvesting

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.

When the mussels reach market size, socks or lines of mussels are removed 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.

4.2.4 Oyster Culture: General Considerations

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*). Different approaches can be taken to oyster grow-out, depending upon target market, beach characteristics, and environmental conditions. The types of approaches include bag, rack and bag, suspended culture methods and growing in clusters. 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 and 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 3 to 6 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.

4.2.5 Oyster Long-line Culture

4.2.5.1 Bed Preparation

In some areas, silt may build up because 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.

4.2.5.2 Seeding

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.

4.2.5.3 Grow-out

The oysters grow in clusters supported by the longlines, which keep them from sinking into soft substrate and protect them from predators (Figure 4.3). Oysters are allowed to grow out over 2 to 3 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.

Figure 4.3 Oyster longlines at 2.5-foot spacing, in Humboldt Bay, California (USACE 2008).

4.2.5.4 Harvesting

Oysters on longlines 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, barged to shore and transported to processing plants or market.

4.2.6 Oyster Rack-and-Bag Culture

4.2.6.1 Bed Preparation

Beds are prepared during low tides by removing debris, such as driftwood, and undesirable organisms, such as oyster drills. In some cases, the substrate is enhanced with crushed oyster shells and/or gravel to harden the ground. The ground may be marked with stakes for working purposes. During low tides, some operations install longlines 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.

4.2.6.2 Seeding

Seeding is performed as described above under "oyster cultch preparation and setting." Single-set seed is placed in reusable plastic net bags closed with plastic ties or galvanized metal rings.

4.2.6.3 Grow-out

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.

4.2.6.4 Harvesting

Bags are released from any supports, loaded into a boat or (during low tides) a wheelbarrow for transport to shore, and then transported to processing plants or market.

4.2.7 Oyster Stake Culture

4.2.7.1 Bed Preparation

Beds are prepared during low tides in the intertidal zone by removing debris such as driftwood, and organisms considered by the growers as pests (drills and sea stars). In some areas, the substrate may occasionally be enhanced with crushed oyster shells to harden the ground, 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 2 ft apart to allow good water circulation and easy access at harvest. Stakes are typically limited to 2 ft in height to minimize hazards to boaters.

4.2.7.2 Seeding

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 one to several pieces of seeded cultch to each stake.

4.2.7.3 Grow-out

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. 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 above the mud.

4.2.7.4 Harvesting

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 re-attach 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.

4.2.8 Oyster Bottom Culture

4.2.8.1 Bed Preparation

Prior to planting a new crop of oysters, oyster beds may be cleaned of debris, such as driftwood, and unwanted organisms, 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 and mud build-up. If the substrate is too soft or muddy and not naturally suitable for planting oysters, it may be enhanced, 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.

4.2.8.2 Seeding

Seed is produced as described above under “oyster cultch preparation and setting.” 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. 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.

4.2.8.3 Grow-out

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. When this happens, the oysters must be harrowed periodically to pull them up out of the mud. The harrow is a skidder with many tines, towed along the substrate by a boat. The harrow penetrates the substrate by a few inches and moves the oysters back to the surface.

4.2.8.4 Harvesting

During hand harvest, workers hand-pick oysters at low tide and place them into bushel-sized containers. These are emptied into large (15-20 bushels) 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. This type of harvest apparatus is arranged to provide for adjustment so that minimal negative impact occurs on sensitive bottom substrate layers as tidal levels change. 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 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.

4.2.9. Oyster Suspended Culture

4.2.9.1 Seeding

Seeding is performed as described above under "oyster cultch preparation and setting." Single set oyster seed is placed on the trays or in the bags and suspended in the water. Seed set on cultch is attached to the vertical ropes or wires.

4.2.9.2 Grow-out

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.

4.2.9.3 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. It conditions them to close their shells tightly when out of the water, which retains body fluids. Abrasion on the beach substrate literally hardens the oyster 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.

4.2.10 Littleneck, Manila, and Butter Clam Ground Culture

4.2.10.1 Bed Preparation

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. 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.

4.2.10.2 Seeding

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 in some areas natural sets of clams occur. 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 4 inches deep; hand-spreading seed on an outgoing tide when the water is approximately 2 to 3 ft deep; or spreading seed at high tide from a boat.

4.2.10.3 Bed Maintenance

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.

4.2.10.4 Harvesting

Before harvesting 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. Each digger is responsible for going back and smoothing over the beach upon completion of the dig. Market-size 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 marine waters or in upland tanks filled with seawater, to purge sand for at least 24 hours.

Technology has been developed to harvest clams mechanically, although only one or two growers use it. 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.

4.2.11 Littleneck, Manila, and Butter Clam Bag Culture

4.2.11.1 Bed Preparation

Prior to setting bags on the tidelands, debris is removed from the area to be planted and shallow (typically 2 to 4 inches) trenches may be dug during low tide with rakes or hoes to provide a more secure foundation for setting down the clam bags.

4.2.11.2 Seeding

Clam seed (typically 5-8 millimeters) is placed in reusable plastic net bags closed with plastic ties or galvanized metal rings. Substrate, consisting of pea 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. Bags are monitored during low tides throughout the grow-out cycle to make sure they are properly secured, and turned occasionally to optimize growth.

4.2.11.3 Harvesting

When the clams reach market size, the bags are removed from the growing area. Harvesting occurs when there is 1 to 2 ft 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.

4.2.12 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.

4.2.12.1 Bed Preparation

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.

4.2.12.2 Tube Placement and Seeding

The most common method of culture currently in use consists of placing 10-to 12- inch-long sections of 4 to 6 inch diameter PVC pipe by hand into the substrate during low tide, usually leaving 2 to 3 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 on beaches with heavy wind and wave action to prevent the tubes from becoming dislodged in storms. Some growers do not use the individual nets on tubes, and instead use nets that cover the whole field of tubes.

4.2.12.3 Grow-out

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.

4.2.12.4 Harvesting

When geoducks reach market size, approximately 2 pounds in 4 to 7 years, the crop is harvested, either at low tide or, if at high tide, by divers. The geoduck, which have burrowed as far as 3 ft into the sand, are extracted by loosening the sand around each clam using approximately 20 gallons per minute of seawater delivered at approximately 40 pounds per square inch pressure via a hose and nozzle. 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 brought to shore by boat on a flood tide and then transported to processing facilities.

4.2.13 Support Activities

4.2.13.1 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. The principal vessels are small open craft powered by 2-stroke or 4-stroke outboard motors. These are used to ferry crews and material to and from the culture beds and rafts. Larger vessels 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. Vessels serving shellfish beds are normally grounded on mudflats or vacant culture beds to load and offload personnel and equipment. These activities are conducted to minimize the size of the impacted area, avoid damage to shellfish beds and minimize excessive turbidity, which is harmful to shellfish beds. Vessels are not grounded in areas of eelgrass, and vessel operations avoid eelgrass areas as much as possible. Operations are normally conducted at elevations below those used for forage fish spawning. 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.

4.2.13.2 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 traverse 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.

4.2.13.3 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 saltwater used may be artificial (made from potable water with salts added), or pumped from an adjacent water body. The water is typically filtered and disinfected using ultraviolet 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 recirculating 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 Corps has used oyster shell as substrate in restoration projects, and growers often use old oyster shell to improve beach substrate for shellfish beds.

4.2.14 Conservation Measures

The following conservation measures were proposed in the Biological Assessment:

- No activity may substantially disrupt the necessary life cycle movements of those species of aquatic life indigenous to the water body, including those species that normally migrate through the area.

- Activities in spawning areas (e.g., forage fish spawning areas) during spawning seasons must be avoided to the maximum extent practicable. Activities that result in the physical destruction (e.g., through excavation, fill, or downstream smothering by substantial turbidity) of an important spawning area are not authorized.
- Material used for construction or discharged must be free from toxic pollutants in toxic amounts.
- If any listed species or designated critical habitat might be affected or is in the vicinity of the project, or if the project is located in designated critical habitat, for non-Federal applicants the PCN must include the name(s) of those endangered or threatened species that might be affected by the proposed work or utilize the designated critical habitat that may be affected by the proposed work.
- All gravel or crushed rock applied to shellfish beds should be washed prior to use. Washing should occur at an upland location and the wash water not discharged to surface waters unless treated in accordance with applicable regulations for point discharges. The purpose of this conservation measure is to minimize transient turbidity increases that have sometimes been observed during graveling operations.

4.2.15 Action Area

The action area is defined as all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR § 402.02). In delineating the action area, we evaluated the farthest reaching physical, chemical, and biotic effects of the action on the environment.

This consultation is unique in that it covers shellfish aquaculture farms, which are comprised of thousands of parcels (Figures 4.4 and 4.5). The farms may be privately owned, or leased from another private individual or the Washington Department of Natural Resources. Because opportunities for shellfish aquaculture are dictated by water quality, substrate type and urban development, farms tend to be concentrated in specific areas. This results in a discontinuous distribution of shellfish aquaculture. Therefore, the action area for this consultation consists of six discrete, smaller action areas. These include Willapa Bay, Grays Harbor, South Puget Sound, North Puget Sound, Hood Canal, and Samish Bay. Within each of these action areas, the area evaluated for direct and indirect effects is based on the potential stressors and includes 1) the uplands and beaches where materials are stored and the farming activities are staged, 2) the in-water area farmed, 3) the spatial extent of sediment transport, and 4) the habitat affected by changes in hydrodynamics and sediment transport. The action area also includes those upland and aquatic areas affected by the helicopters that are used as part of the proposed action to apply carbaryl within Willapa Bay and Grays Harbor. The action area is delineated by the spatial extent of the stressors generated by the project activities.

The Federal action in this consultation is the issuance of a permit allowing the continued shellfish production on these farms. In most cases the effects of the action are limited to the footprint of the farm and an area down current that may experience elevated turbidity or sediment impacts. The majority of stressors are confined to the immediate farm with activities that generate sediment resulting in stressors encountered farther afield. Table 4.1 presents the density of shellfish aquaculture in each action area.

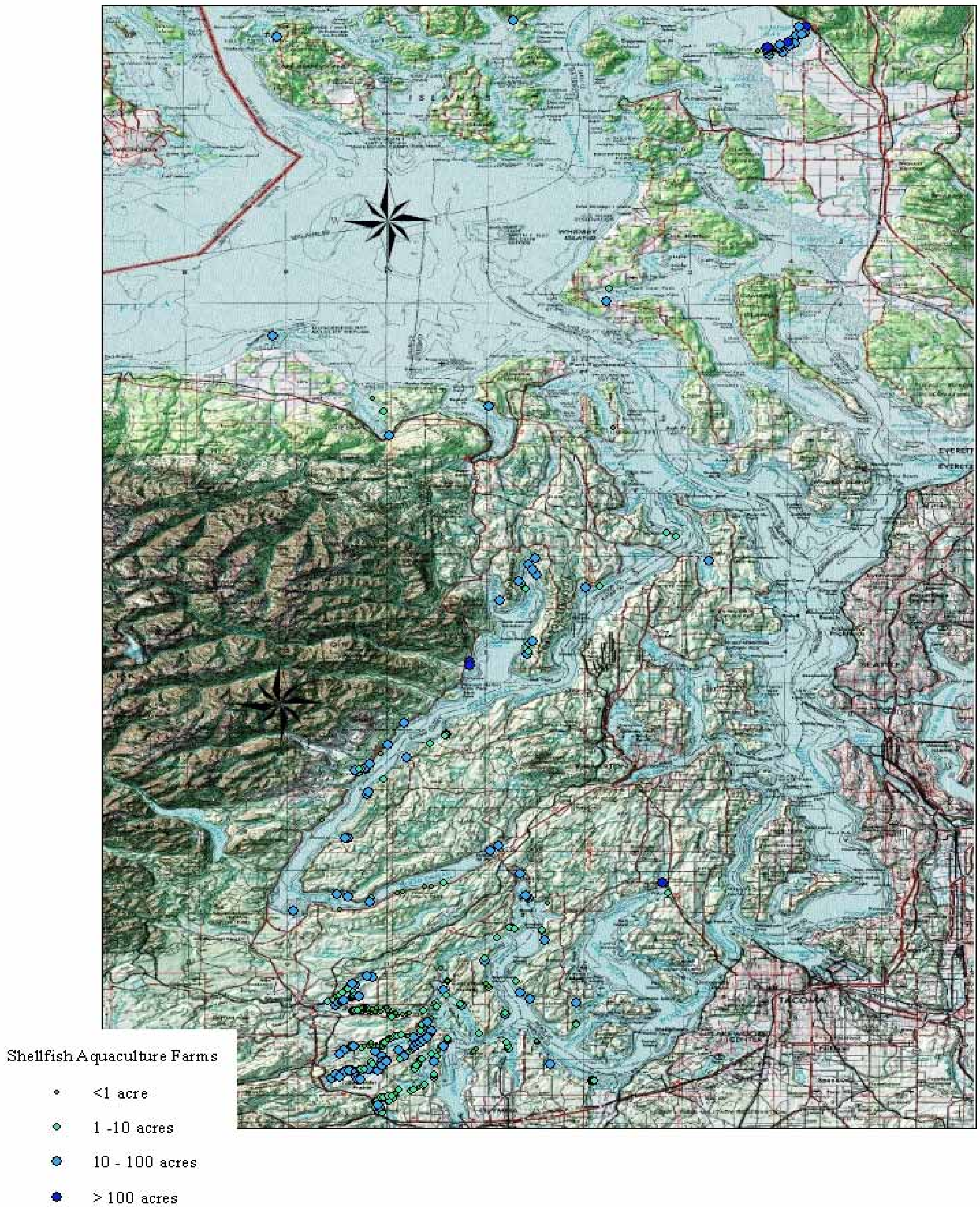

Figure 4.4 Shellfish Aquaculture Farms in the Northern and Greater Puget Sound Region

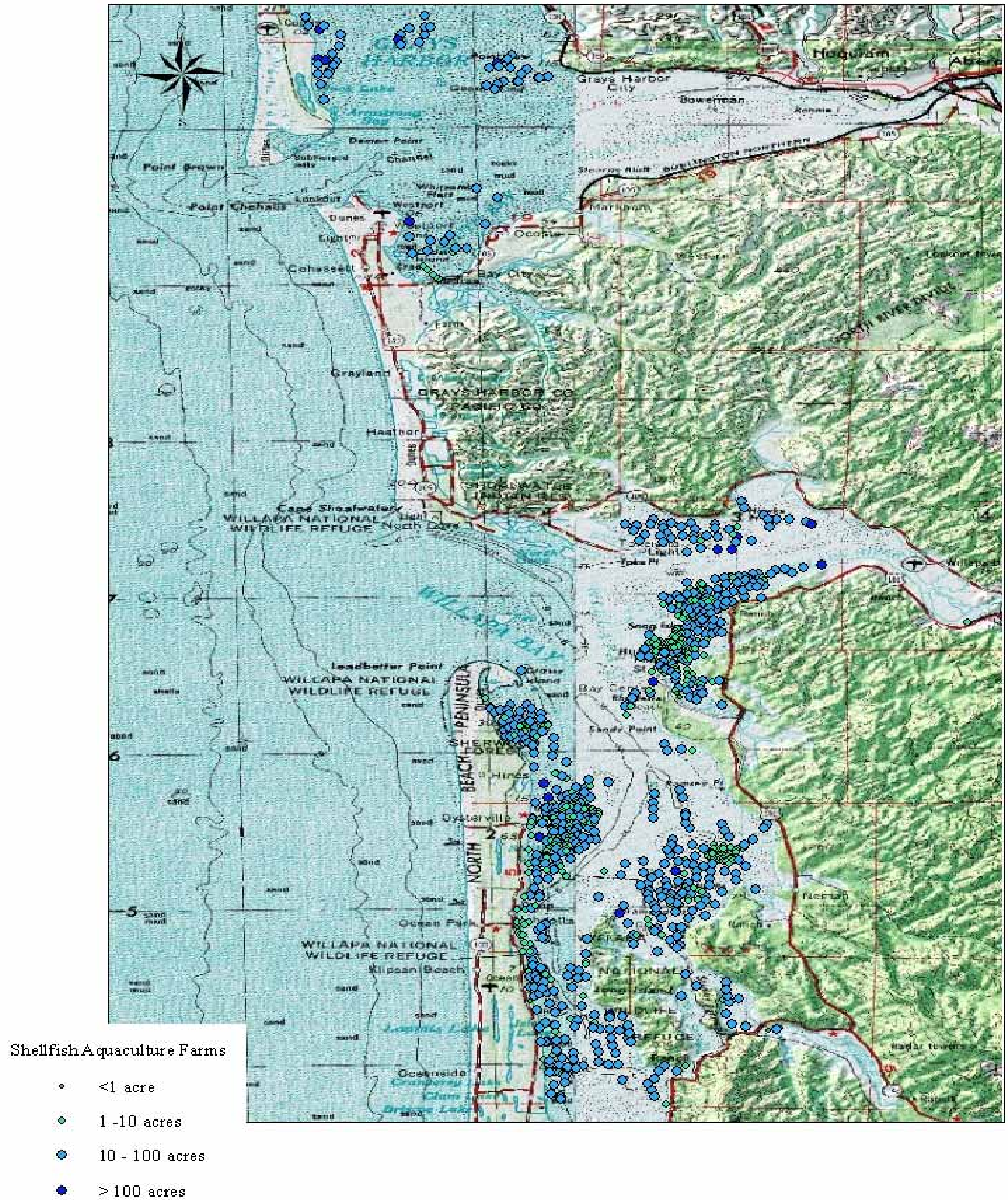

Figure 4.5 Shellfish Aquaculture Farms in Grays Harbor and Willapa Bay

Table 4.1 Approximate Density of Shellfish Farms and Total Acreage in the Action Areas.

Action Area	Total Parcels	Total Acreage
Willapa Bay	923	25,562
Grays Harbor	68	3,995
South Puget Sound	398	4,748
Hood Canal	78	1,677
North Puget Sound	28	554
Samish Bay	28	1,106
Grand Total	1,523	37,632

These numbers are approximate, as the reports submitted to the Corps did not always have a parcel number or accurate parcel size.
Where parcel size was submitted as a range (e.g., 10 -100) we used the highest values (e.g., 100).
Location data were not provided with all parcels; therefore, not all parcels could be mapped.
Location data provided were not always precise enough to map accurately. Therefore, some locations may be inaccurate.

4.2.15.1 Willapa Bay

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 in Smith 1999, p. 18). The major tributaries that support salmon include the South Fork Willapa River, Trap Creek, Mill Creek, Wilson Creek, Fork Creek, and Ellis Creek. The Willapa watershed supports fall Chinook (*Oncorhynchus tshawytscha*), coho (*O. kisutch*) and fall chum (*O. keta*) salmon and winter steelhead trout. There are no Endangered Species Act listed salmon runs in the Willapa Watershed. The only documented observation of bull trout in this watershed was in the Willapa River.

Three main channels in Willapa Bay are 10 to 20 meters deep and are surrounded by tide flats (Banas et al. 2004, p. 2,414). Approximately one-half of the estuary lies in the intertidal zone (Andrews 1965 as cited in Banas et al. 2004, p. 2,414). There are roughly 923 shellfish aquaculture parcels, totaling approximately 25,562 acres, according to data received from the Corps. The aquaculture species cultivated in Willapa Bay are primarily oysters and clams (Figure 4.6). Approximately two-thirds of the upland in the watershed is composed of commercial forestlands. Cranberry farms, consisting of 1,400 acres of bogs, comprise an additional seven percent.

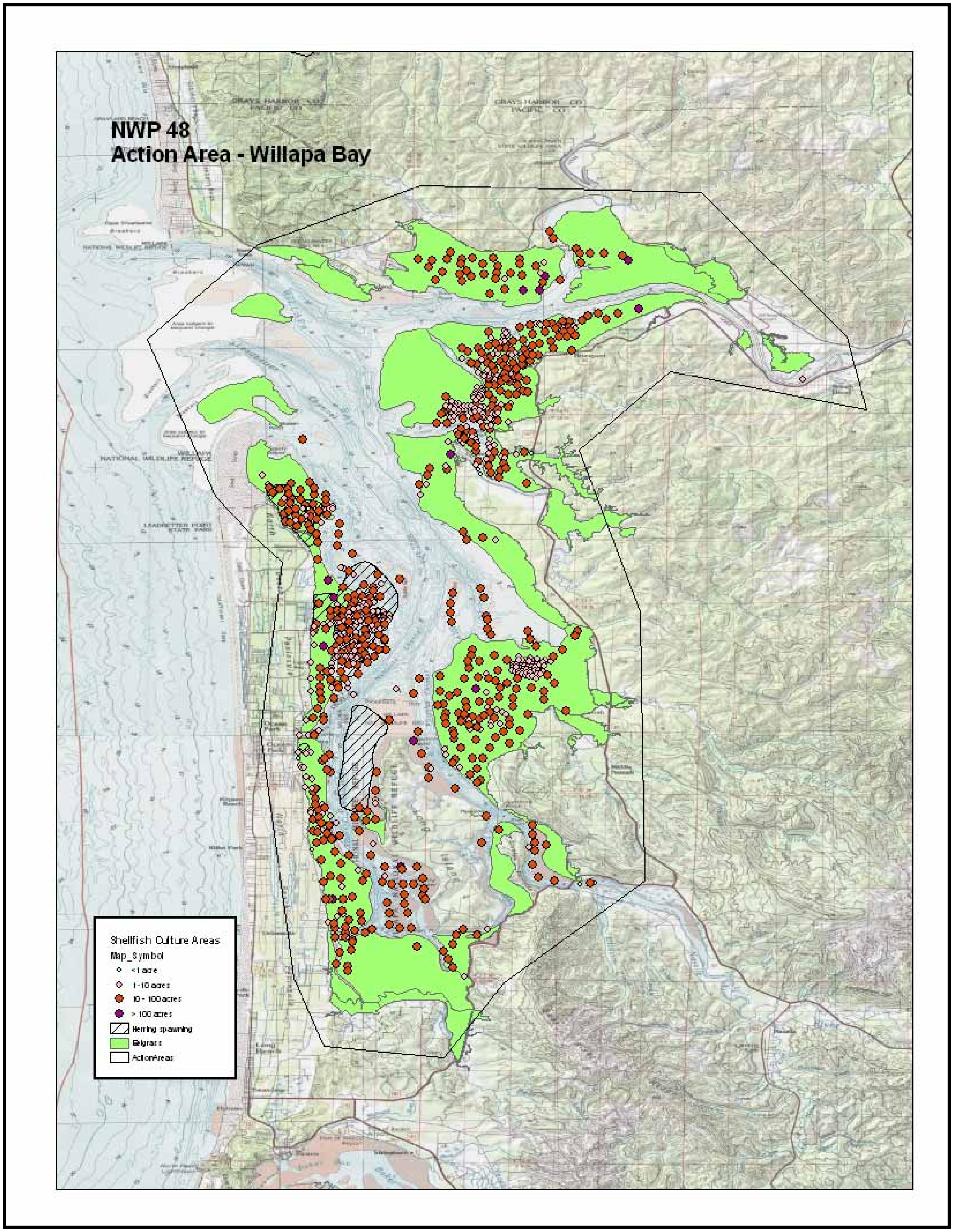

Figure 4.6 Willapa Bay Action Area.

4.2.15.2 Grays Harbor

Shellfish aquaculture farms are located in the Grays Harbor estuary (Table 4.2, Figure 4.7). The rivers and streams that feed into the Grays Harbor estuary influence the quality of the intertidal area. Grays Harbor is located in the lower Chehalis Watershed, which consists of Watershed Resource Inventory Areas (WRIAs) 22 and 23. The geographic range includes the entire Chehalis drainage and all tributaries to the Chehalis River. A number of independent watersheds also drain into Grays Harbor; these include the Humptulips River, the Hoquiam River, Johns River, Elk River, and a number of smaller streams. A total, of 1,391 streams comprising 3,353 linear stream miles occurs in these two WRIAs (Phinney and Bucknell 1975 in Smith and Wenger 2001, p. 27).

Table 4.2 Approximate Density of Shellfish Farms and Total 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 Corps did not always have an accurate parcel size. Where parcel size was submitted as a range (e.g., 10 -100) we used the highest values (e.g., 100).
Location data were not provided with all parcels; therefore not all parcels could be mapped.
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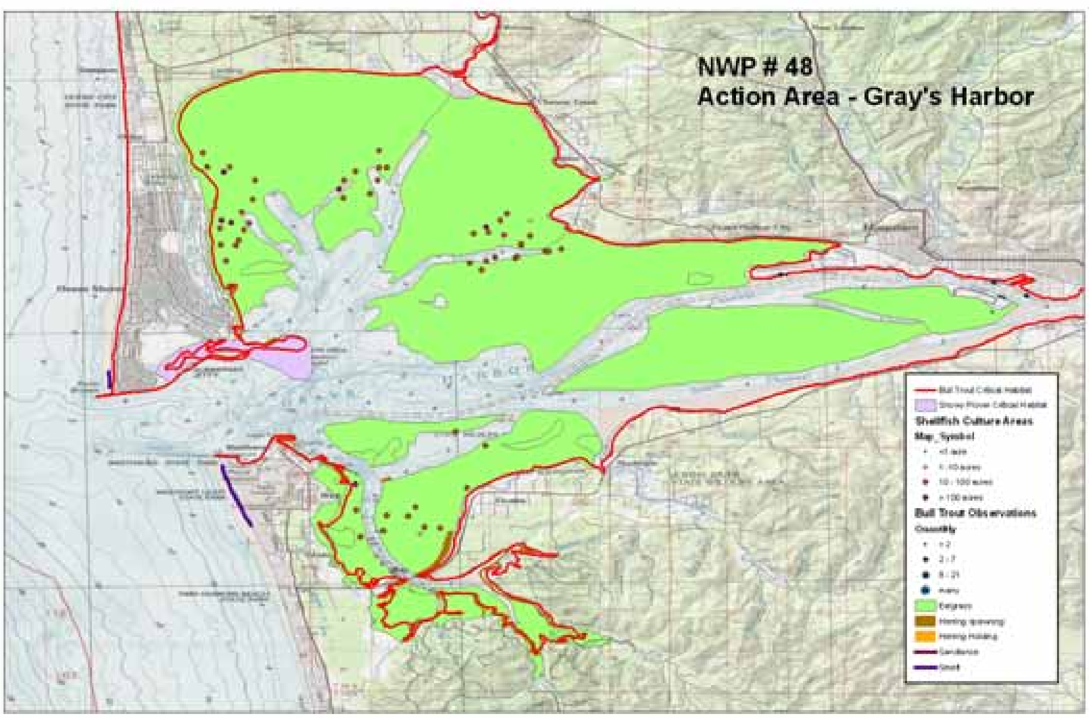

Figure 4.7 Grays Harbor Action Area.

4.2.15.3 South Puget Sound

The south Puget Sound action area consists of WRIA's 14 and 41 the Kennedy-Goldsborough and Deschutes, respectively. The basin is drained by many (139) small streams; 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 shoreline, residential development is generally found at the lower portions of streams near saltwater bays in this basin. The south Puget Sound action area has the greatest number of parcels (approximately 398) with an average parcel size of 12 acres (Table 4.3, Figure 4.8). This south Puget Sound action area appears to be the most active aquaculture area relative to the other action areas. In the south Puget Sound action area, Totten Inlet has the greatest number of active parcels, averaging approximately 18 acres/parcel.

Table 4.3 Approximate Density of Shellfish Farms and Total 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 Corps did not always have an accurate parcel size.
Where parcel size was submitted as a range (e.g., 10 -100) we used the highest values (e.g., 100).
Location data were not provided with all parcels; therefore not all parcels could be mapped.
Location data provided were not always precise enough to map accurately. Therefore some locations may be inaccurate.

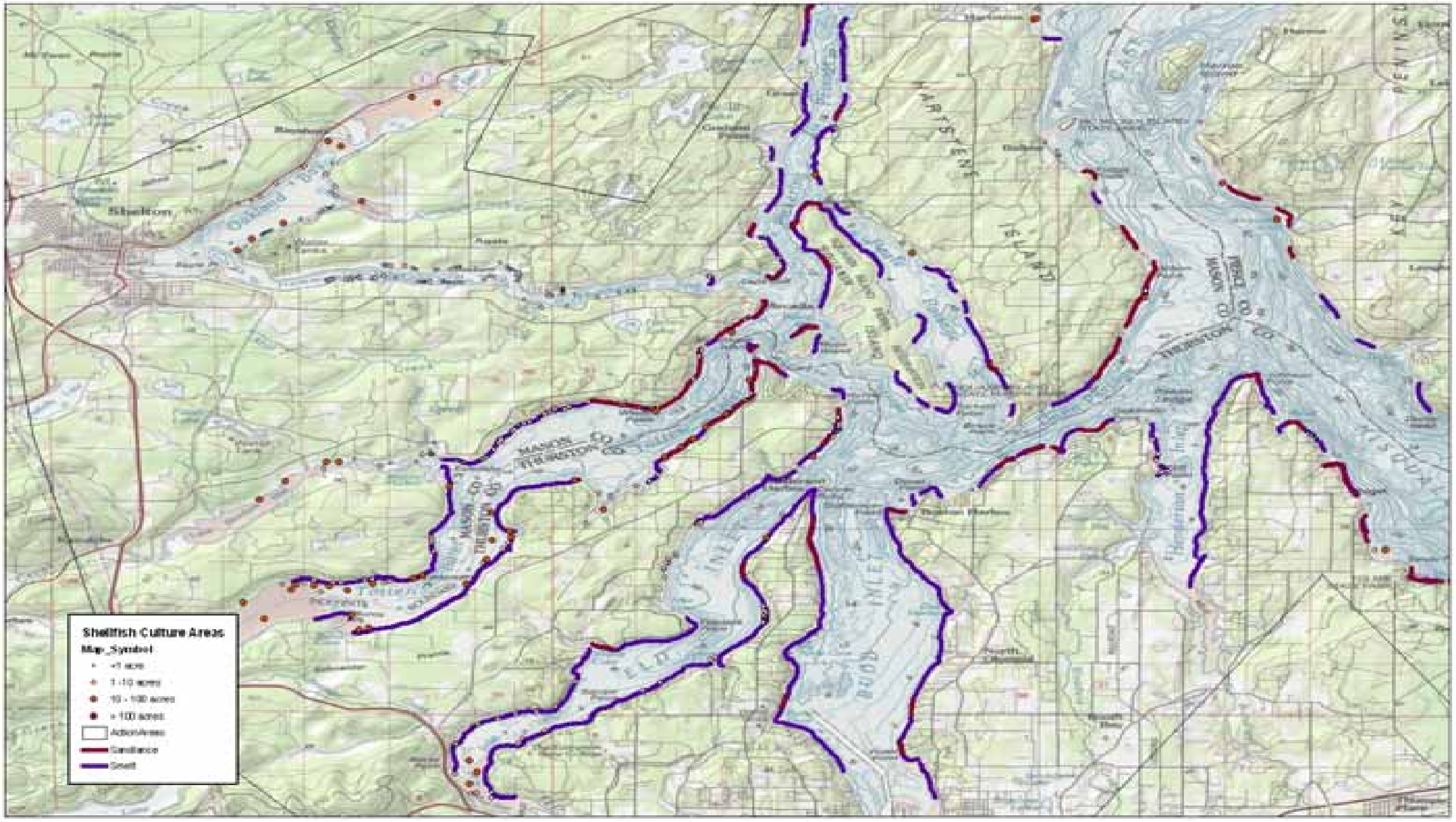

Figure 4.8 South Puget Sound Action Area.

4.2.15.4. Hood Canal

The Hood Canal action area consists of three WRIA's (14, 15 and 16). WRIAs 14 and 15 include the east shore of Hood Canal (west WRIA 15), and the south shore of Hood Canal (north WRIA 14). WRIA 14 and 15 extend from Foulweather Bluff in the north to the town of Union in the south. WRIA 16 is located on the eastern slope of the Olympic Mountains in Washington State. 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, p. 12).

Shellfish aquaculture in Hood Canal consists of approximately 78 parcels, comprising an estimated 1,677 acres (Table 4.4, Figure 4.9). The small coves and bays have minimum activity, although Port Gamble has a substantial farm growing geoduck and other clam species and oysters.

Table 4.4 Approximate Density of Shellfish Farms and Total 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 Corps did not always have an accurate parcel size.
Where parcel size was submitted as a range (e.g., 10 -100) we used the highest values (e.g., 100).
Location data were not provided with all parcels; therefore not all parcels could be mapped.
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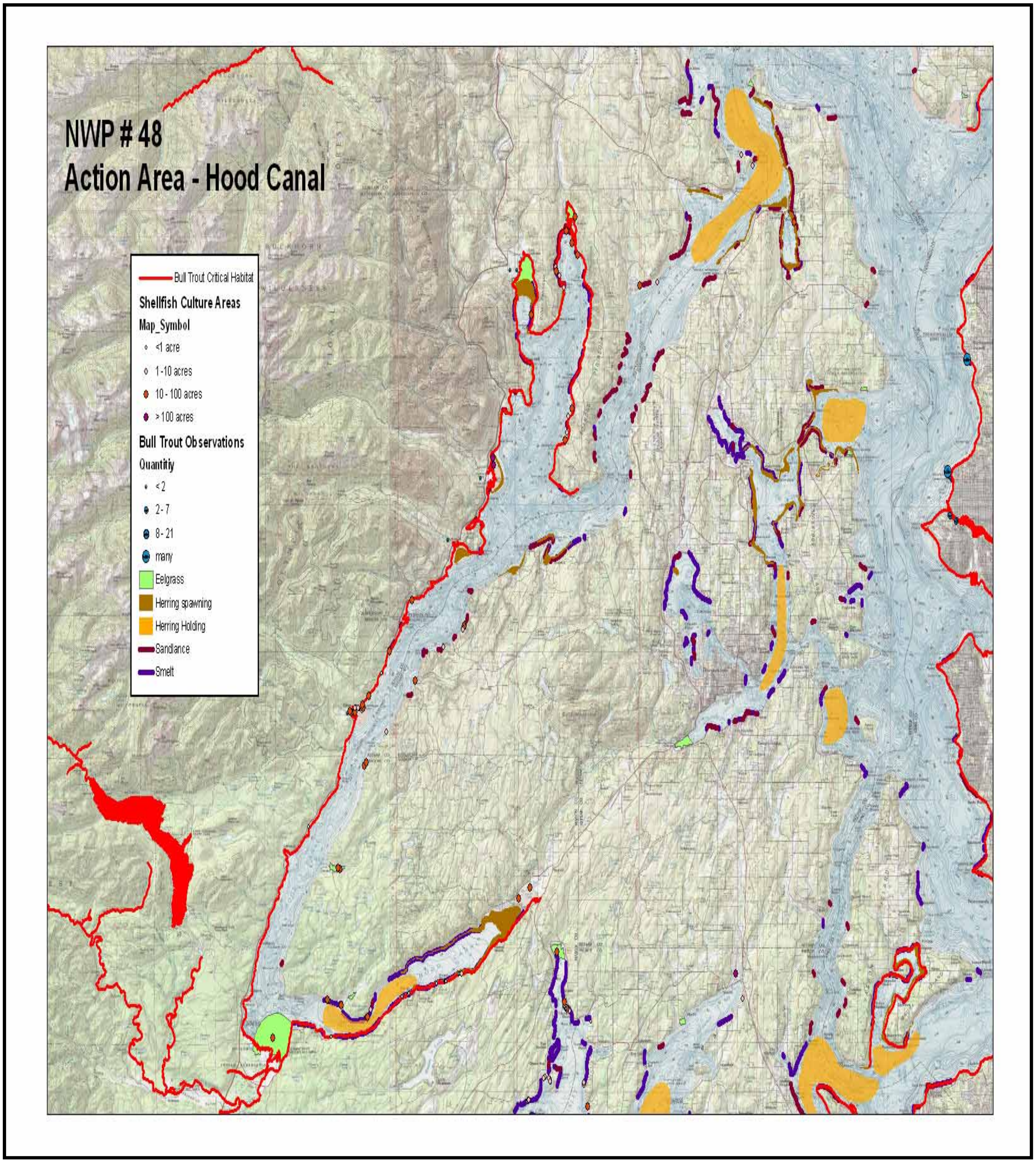

Figure 4.9 Hood Canal Action Area

4.2.15.5 North Puget Sound

The north Puget Sound action area consists of WRIAs 18- Elwha/Dungeness basins, 17 - Quilcene/Snow basins and 6 - Island County (Figure 4.10). WRIA 18 is located on the north Olympic Peninsula and its streams and rivers drain to the Strait of Juan de Fuca. WRIA 18 includes two large river systems the Dungeness and the Elwha Rivers); one medium sized river system (Morse Creek); and 14 smaller independent drainages to marine waters (Haring 1999, p. 17).

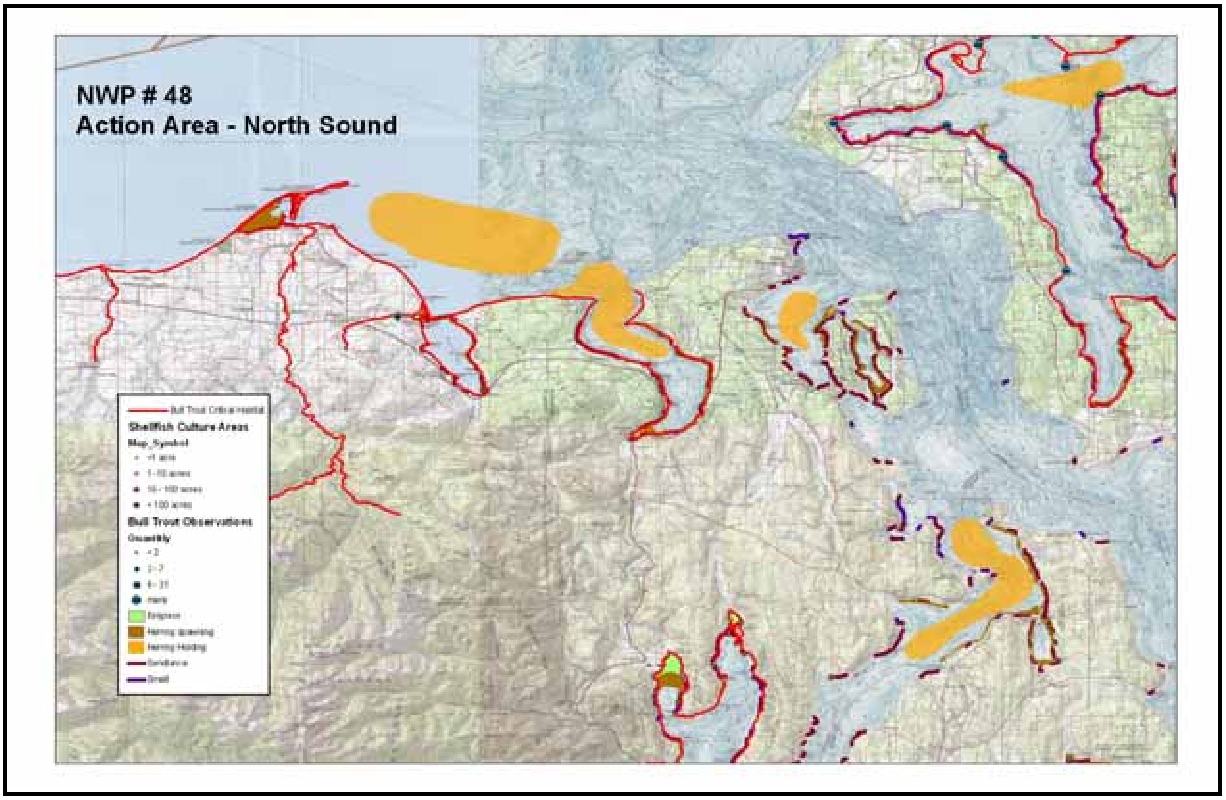

Figure 4.10 North Puget Sound Action Area.

WRIA 17 is located along the northeast corner of the Olympic Peninsula. It extends from the Marple/Jackson watershed in southeast Jefferson County northward and westward to, and including, the Johnson Creek watershed along the west side of Sequim Bay. It is bordered to the north by the Strait of Juan de Fuca, to the east by Admiralty Inlet, northern Puget Sound and Hood Canal, and to the south and west by the Olympic Mountains (Correa 2002, p. 14).

WRIA 6 overlaps Island County, including Whidbey, Camano, Ben Sur, Smith and Strawberry Islands. Whidbey and Camano, the two largest islands, together they cover about 538 km^2 and include 123 sub-basins (WSCC 2000b, p. 10).

Table 4.5 provides the approximate density of aquaculture farms and total acreage by waterway within this action area.

Table 4.5 Approximate Density of Shellfish Farms and Total Acreage in the Bays of the North Puget Sound Action Area.

Waterway	Total Parcels	Total Acreage
Buck Bay	1	22.8
Discovery Bay	7	156
Dungeness Bay	1	56
Killsut Harbor/Scow Bay	2	12.5
Penn Cove	2	60
Quilcene Bay	5	159
Sequim Bay	9	64
Westcott Bay	1	24
Grand Total	28	554

These numbers are approximate as the reports submitted to the Corps did not always have an accurate parcel size.
Where parcel size was submitted as a range (e.g., 10 -100) we used the highest values (e.g., 100).
Location data were not provided with all parcels; therefore not all parcels could be mapped.
Location data provided were not always precise enough to map accurately, therefore some locations may be inaccurate.

4.2.15.6. Samish Bay

The Samish Bay action area includes WRIA 6 (discussed above) and WRIA 3 - the Lower Skagit/Samish basins. Shellfish farming in Samish Bay occurs on approximately 28 parcels, comprising approximately 1,106 acres (Figure 4.11). Geoduck clams as well as other species of clams and oysters are grown in this bay, which measures approximately 7.5 km (5 miles) wide from north to south.

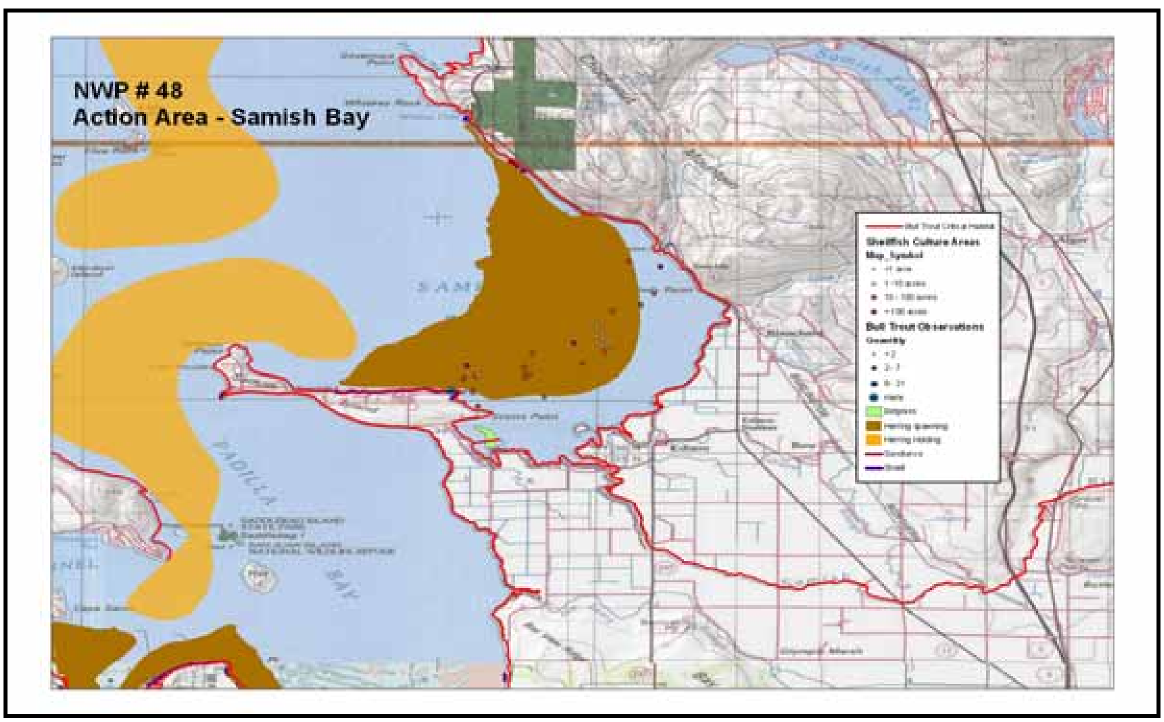

Figure 4.11 Samish Bay Action Area.

4.3 Status of the Species (Bull Trout)

Listing Status

The coterminous United States population of the bull trout (*Salvelinus confluentus*) was listed as threatened on November 1, 1999 (64 FR 58910). The threatened bull trout generally occurs in the Klamath River Basin of south-central Oregon; the Jarbidge River in Nevada; the Willamette River Basin in Oregon; Pacific Coast drainages of Washington, including Puget Sound; major rivers in Idaho, Oregon, Washington, and Montana, within the Columbia River Basin; and the St. Mary-Belly River, east of the Continental Divide in northwestern Montana (Bond 1992; Brewin and Brewin 1997a; Brewin and Brewin 1997b; WSCC 2000a).

Throughout its range, the bull trout are threatened by the combined effects of habitat degradation, fragmentation, and alterations associated with dewatering, road construction and maintenance, mining, grazing, the blockage of migratory corridors by dams or other diversion structures, poor water quality, entrainment (a process by which aquatic organisms are pulled through a diversion or other device) into diversion channels, and introduced non-native species (64 FR 58910). Although all salmonids are likely to be affected by climate change, bull trout are especially vulnerable given that spawning and rearing are constrained by their location in upper watersheds and the requirement for cold water temperatures (Battin et al. 2007a; Battin et al. 2007b). Poaching and incidental mortality of bull trout during other targeted fisheries are additional threats.

The bull trout was initially listed as three separate Distinct Population Segments (DPSs) (63 FR 31647; 64 FR 17110). The preamble to the final listing rule for the United States coterminous population of the bull trout discusses the consolidation of these DPSs with the Columbia and Klamath population segments into one listed taxon and the application of the jeopardy standard under section 7 of the Act relative to this species (64 FR 58910):

> Although this rule consolidates the five bull trout DPSs into one listed taxon, based on conformance with the DPS policy for purposes of consultation under section 7 of the Act, we intend to retain recognition of each DPS in light of available scientific information relating to their uniqueness and significance. Under this approach, these DPSs will be treated as interim recovery units with respect to application of the jeopardy standard until an approved recovery plan is developed. Formal establishment of bull trout recovery units will occur during the recovery planning process.

Current Status and Conservation Needs

In recognition of available scientific information relating to their uniqueness and significance, five segments of the coterminous United States population of the bull trout are considered essential to the survival and recovery of this species and are identified as interim recovery units: 1) Jarbidge River, 2) Klamath River, 3) Columbia River, 4) Coastal-Puget Sound, and 5) St. Mary-Belly River (USFWS 2004g; 2004i; Rieman et al. 2007). Each of these interim recovery units is necessary to maintain the bull trout's distribution, as well as its genetic and phenotypic diversity, all of which are important to ensure the species' resilience to changing environmental conditions.

A summary of the current status and conservation needs of the bull trout within these interim recovery units is provided below and a comprehensive discussion is found in the Service's draft recovery plans for the bull trout (USFWS 2004f; 2004g; 2004i).

The conservation needs of bull trout are often generally expressed as the four "Cs": cold, clean, complex, and connected habitat. Cold stream temperatures, clean water quality that is relatively free of sediment and contaminants, complex channel characteristics (including abundant large wood and undercut banks), and large patches of such habitat that are well connected by unobstructed migratory pathways are all needed to promote conservation of bull trout at multiple scales ranging from the coterminous to local populations (a local population is a group of bull trout that spawn within a particular stream or portion of a stream system). The recovery planning process for bull trout (USFWS 2004d; 2004g; 2004i) has also identified the following conservation needs: 1) maintenance and restoration of multiple, interconnected populations in diverse habitats across the range of each interim recovery unit, 2) preservation of the diversity of life-history strategies, 3) maintenance of genetic and phenotypic diversity across the range of each interim recovery unit, and 4) establishment of a positive population trend. Recently, it has also been recognized that bull trout populations need to be protected from catastrophic fires across the range of each interim recovery unit (Rieman et al. 2003a).

Central to the survival and recovery of bull trout is the maintenance of viable core areas (Rieman et al. 2003b; 2004g; 2004i). A core area is defined as a geographic area occupied by one or more local bull trout populations that overlap in their use of rearing, foraging, migratory, and overwintering habitat. Each of the interim recovery units listed above consists of one or more core areas. There are 121 core areas recognized across the coterminous range of the bull trout (USFWS 2004c; 2004g; 2004i).

Jarbidge River Interim Recovery Unit

This interim recovery unit currently contains a single core area with six local populations. Less than 500 resident and migratory adult bull trout, representing about 50 to 125 spawning adults, are estimated to occur in the core area. The current condition of the bull trout in this interim recovery unit is attributed to the effects of livestock grazing, roads, incidental mortalities of released bull trout from recreational angling, historic angler harvest, timber harvest, and the introduction of non-native fishes (USFWS 2004i). The draft bull trout recovery plan (USFWS 2004i) identifies the following conservation needs for this interim recovery unit: 1) maintain the current distribution of the bull trout within the core area, 2) maintain stable or increasing trends in abundance of both resident and migratory bull trout in the core area, 3) restore and maintain suitable habitat conditions for all life history stages and forms, and 4) conserve genetic diversity and increase natural opportunities for genetic exchange between resident and migratory forms of the bull trout. An estimated 270 to 1,000 spawning bull trout per year are needed to provide for the persistence and viability of the core area and to support both resident and migratory adult bull trout (USFWS 2004i).

Klamath River Interim Recovery Unit

This interim recovery unit currently contains three core areas and seven local populations. The current abundance, distribution, and range of the bull trout in the Klamath River Basin are greatly reduced from historical levels due to habitat loss and degradation caused by reduced water quality, timber harvest, livestock grazing, water diversions, roads, and the introduction of non-native fishes (USFWS 2004h). Bull trout populations in this interim recovery unit face a high risk of extirpation (USFWS 2002e). The draft Klamath River bull trout recovery plan (USFWS 2002h) identifies the following conservation needs for this interim recovery unit: 1) maintain the current distribution of bull trout and restore distribution in previously occupied areas, 2) maintain stable or increasing trends in bull trout abundance, 3) restore and maintain suitable habitat conditions for all life history stages and strategies, 4) conserve genetic diversity and provide the opportunity for genetic exchange among appropriate core area populations. Eight to 15 new local populations and an increase in population size from about 2,400 adults currently to 8,250 adults are needed to provide for the persistence and viability of the three core areas (USFWS 2002f).

Columbia River Interim Recovery Unit

The Columbia River interim recovery unit includes bull trout residing in portions of Oregon, Washington, Idaho, and Montana. Bull trout are estimated to have occupied about 60 percent of the Columbia River Basin, and presently occur in 45 percent of the estimated historical range (USFWS 2002g). This interim recovery unit currently contains 97 core areas and 527 local populations. About 65 percent of these core areas and local populations occur in central Idaho and northwestern Montana. The Columbia River interim recovery unit has declined in overall range and numbers of fish (63 FR 31647). Although some strongholds still exist with migratory fish present, bull trout generally occur as isolated local populations in headwater lakes or tributaries where the migratory life history form has been lost. Though still widespread, there have been numerous local extirpations reported throughout the Columbia River basin. In Idaho, for example, bull trout have been extirpated from 119 reaches in 28 streams (Idaho Department of Fish and Game *in litt.* 1995a). The draft Columbia River bull trout recovery plan (Idaho Department of Fish and Game *in litt.* 1995b) identifies the following conservation needs for this interim recovery unit: 1) maintain or expand the current distribution of the bull trout within core areas, 2) maintain stable or increasing trends in bull trout abundance, 3) restore and maintain suitable habitat conditions for all bull trout life history stages and strategies, and 4) conserve genetic diversity and provide opportunities for genetic exchange.

This interim recovery unit currently contains 97 core areas and 527 local populations. About 65 percent of these core areas and local populations occur in Idaho and northwestern Montana. The condition of the bull trout within these core areas varies from poor to good. All core areas have been subject to the combined effects of habitat degradation and fragmentation caused by the following activities: dewatering; road construction and maintenance; mining; grazing; the blockage of migratory corridors by dams or other diversion structures; poor water quality; incidental angler harvest; entrainment into diversion channels; and introduced non-native species. The Service completed a core area conservation assessment for the 5-year status review and determined that, of the 97 core areas in this interim recovery unit, 38 are at high risk of extirpation, 35 are at risk, 20 are at potential risk, 2 are at low risk, and 2 are at unknown risk (USFWS 2002b).

Coastal-Puget Sound Interim Recovery Unit

Bull trout in the Coastal-Puget Sound interim recovery unit exhibit anadromous, adfluvial, fluvial, and resident life history patterns. The anadromous life history form is unique to this interim recovery unit. This interim recovery unit currently contains 14 core areas and 67 local populations (USFWS 2004g). Bull trout are distributed throughout most of the large rivers and associated tributary systems within this interim recovery unit. Bull trout continue to be present in nearly all major watersheds where they likely occurred historically, although local extirpations have occurred throughout this interim recovery unit. Many remaining populations are isolated or fragmented and abundance has declined, especially in the southeastern portion of the interim recovery unit. The current condition of the bull trout in this interim recovery unit is attributed to the adverse effects of dams, forest management practices (e.g., timber harvest and associated road building activities), agricultural practices (e.g., diking, water control structures, draining of wetlands, channelization, and the removal of riparian vegetation), livestock grazing, roads, mining, urbanization, poaching, incidental mortality from other targeted fisheries, and the introduction of non-native species. The draft Coastal-Puget Sound bull trout recovery plan (USFWS 2004g) identifies the following conservation needs for this interim recovery unit: 1) maintain or expand the current distribution of bull trout within existing core areas, 2) increase bull trout abundance to about 16,500 adults across all core areas, and 3) maintain or increase connectivity between local populations within each core area.

St. Mary-Belly River Interim Recovery Unit

This interim recovery unit currently contains six core areas and nine local populations (USFWS 2004e). Currently, bull trout are widely distributed in the St. Mary-Belly River drainage and occur in nearly all of the waters that it inhabited historically. Bull trout are found only in a 1.2-mile reach of the North Fork Belly River within the United States. Redd count surveys of the North Fork Belly River documented an increase from 27 redds in 1995 to 119 redds in 1999. This increase was attributed primarily to protection from angler harvest (USFWS 2002c). The current condition of the bull trout in this interim recovery unit is primarily attributed to the effects of dams, water diversions, roads, mining, and the introduction of non-native fishes (USFWS 2002a). The draft St. Mary-Belly bull trout recovery plan (USFWS 2002d) identifies the following conservation needs for this interim recovery unit: 1) maintain the current distribution of the bull trout and restore distribution in previously occupied areas, 2) maintain stable or increasing trends in bull trout abundance, 3) restore and maintain suitable habitat conditions for all life history stages and forms, 4) conserve genetic diversity and provide the opportunity for genetic exchange, and 5) establish good working relations with Canadian interests because local bull trout populations in this interim recovery unit are comprised mostly of migratory fish, whose habitat is mostly in Canada.

Life History

Bull trout exhibit both resident and migratory life history strategies. Both resident and migratory forms may be found together, and either form may produce offspring exhibiting either resident or migratory behavior (Rieman and McIntyre 1993c). Resident bull trout complete their entire life cycle in the tributary (or nearby) streams in which they spawn and rear. The resident form tends to be smaller than the migratory form at maturity and also produces fewer eggs (Fraley and Shepard 1989; Goetz 1989b). Migratory bull trout spawn in tributary streams where juvenile fish rear 1 to 4 years before migrating to either a lake (adfluvial form), river (fluvial form) (Fraley and Shepard 1989; Goetz 1989b), or saltwater (anadromous form) to rear as subadults and to live as adults (Goetz 1989a; McPhail and Baxter 1996; WDFW et al. 1997). Bull trout normally reach sexual maturity in 4 to 7 years and may live longer than 12 years. They are iteroparous (they spawn more than once in a lifetime). Repeat- and alternate-year spawning has been reported, although repeat-spawning frequency and post-spawning mortality are not well documented (Leathe and Graham 1982; Fraley and Shepard 1989; Pratt 1992; Rieman and McIntyre 1996).

The iteroparous reproductive strategy of bull trout has important repercussions for the management of this species. Bull trout require passage both upstream and downstream, not only for repeat spawning but also for foraging. Most fish ladders, however, were designed specifically for anadromous semelparous salmonids (fishes that spawn once and then die, and require only one-way passage upstream). Therefore, even dams or other barriers with fish passage facilities may be a factor in isolating bull trout populations if they do not provide a downstream passage route. Additionally, in some core areas, bull trout that migrate to marine waters must pass both upstream and downstream through areas with net fisheries at river mouths. This can increase the likelihood of mortality to bull trout during these spawning and foraging migrations.

Growth varies depending upon life-history strategy. Resident adults range from 6 to 12 inches total length, and migratory adults commonly reach 24 inches or more (Pratt 1985; Goetz 1989b). The largest verified bull trout is a 32-pound specimen caught in Lake Pend Oreille, Idaho, in 1949 (Simpson and Wallace 1982).

Habitat Characteristics

Bull trout have more specific habitat requirements than most other salmonids (Rieman and McIntyre 1993c). Habitat components that influence bull trout distribution and abundance include water temperature, cover, channel form and stability, valley form, spawning and rearing substrate, and migratory corridors (Fraley and Shepard 1989; Hoelscher and Bjornn 1989; Goetz 1989b; Sedell and Everest 1991; Howell and Buchanan 1992; Pratt 1992; Rieman and McIntyre 1993c; 1995; Rich, Jr. 1996; Watson and Hillman 1997). Watson and Hillman (1997) concluded that watersheds must have specific physical characteristics to provide the habitat requirements necessary for bull trout to successfully spawn and rear and that these specific characteristics are not necessarily present throughout these watersheds. Because bull trout exhibit a patchy distribution, even in pristine habitats (Rieman and McIntyre 1993c), bull trout should not be expected to simultaneously occupy all available habitats (Rieman et al. 1997b).

Migratory corridors link seasonal habitats for all bull trout life histories. The ability to migrate is important to the persistence of bull trout (Rieman and McIntyre 1993c; Mike Gilpin *in litt.* 1997; Rieman et al. 1997b). Migrations facilitate gene flow among local populations when individuals from different local populations interbreed or stray to non-natal streams. Local populations that are extirpated by catastrophic events may also become reestablished by bull trout migrants. However, it is important to note that the genetic structuring of bull trout indicates there is limited gene flow among bull trout populations, which may encourage local adaptation within individual populations, and that reestablishment of extirpated populations may take a long time (Rieman and McIntyre 1993c; Rieman et al. 1997a). Migration also allows bull trout to access more abundant or larger prey, which facilitates growth and reproduction. Additional benefits of migration and its relationship to foraging are discussed below under "Diet."

Cold water temperatures play an important role in determining bull trout habitat quality, as these fish are primarily found in colder streams (below 15 °C or 59 °F), and spawning habitats are generally characterized by temperatures that drop below 9 °C (48 °F) in the fall (Fraley and Shepard 1989; Pratt 1992; Rieman and McIntyre 1993c).

Thermal requirements for bull trout appear to differ at different life stages. Spawning areas are often associated with cold-water springs, groundwater infiltration, and the coldest streams in a given watershed (Pratt 1992; Rieman and McIntyre 1993c; Baxter et al. 1997; Rieman et al. 1997b). Optimum incubation temperatures for bull trout eggs range from 2 °C to 6 °C (35 °F to 39 °F) whereas optimum water temperatures for rearing range from about 6 °C to 10 °C (46 °F to 50 °F) (McPhail and Murray 1979; Goetz 1989b; Buchanan and Gregory 1997). In Granite Creek, Idaho, Bonneau and Scarnecchia (1996) observed that juvenile bull trout selected the coldest water available in a plunge pool, 8 °C to 9 °C (46 °F to 48 °F), within a temperature gradient of 8 °C to 15 °C (4 °F to 60 °F). In a landscape study relating bull trout distribution to maximum water temperatures, (Dunham et al. 2003) found that the probability of juvenile bull trout occurrence does not become high (i.e., greater than 0.75) until maximum temperatures decline to 11 °C to 12 °C (52 °F to 54 °F).

Although bull trout are found primarily in cold streams, occasionally these fish are found in larger, warmer river systems throughout the Columbia River basin (Fraley and Shepard 1989; Rieman and McIntyre 1993c; 1995; Buchanan and Gregory 1997; Rieman et al. 1997b). Availability and proximity of cold water patches and food productivity can influence bull trout ability to survive in warmer rivers (Myrick et al. 2002). For example, in a study in the Little Lost River of Idaho where bull trout were found at temperatures ranging from 8 °C to 20 °C (46 °F to 68 °F), most sites that had high densities of bull trout were in areas where primary productivity in streams had increased following a fire (Bart L. Gamett, pers. comm. June 20, 2002).

All life history stages of bull trout are associated with complex forms of cover, including large woody debris, undercut banks, boulders, and pools (Fraley and Shepard 1989; Hoelscher and Bjornn 1989; Goetz 1989b; Sedell and Everest 1991; Pratt 1992; Thomas 1992; Rich, Jr. 1996; Sexauer and James 1997; Watson and Hillman 1997). Maintaining bull trout habitat requires stability of stream channels and maintenance of natural flow patterns (Rieman and McIntyre 1993c). Juvenile and adult bull trout frequently inhabit side channels, stream margins, and pools with suitable cover (Sexauer and James 1997). These areas are sensitive to activities that directly or indirectly affect stream channel stability and alter natural flow patterns. For example, altered stream flow in the fall may disrupt bull trout during the spawning period, and channel instability may decrease survival of eggs and young juveniles in the gravel from winter through spring (Fraley and Shepard 1989; Pratt 1992; Pratt and Huston 1993). Pratt (1992) indicated that increases in fine sediment reduce egg survival and emergence.

Bull trout typically spawn from August through November during periods of increasing flows and decreasing water temperatures. Preferred spawning habitat consists of low-gradient stream reaches with loose, clean gravel (Fraley and Shepard 1989). Redds are often constructed in stream reaches fed by springs or near other sources of cold groundwater (Goetz 1989b; Pratt 1992; Rieman and McIntyre 1996). Depending on water temperature, incubation is normally 100 to 145 days (Pratt 1992). After hatching, fry remain in the substrate, and time from egg deposition to emergence may surpass 200 days. Fry normally emerge from early April through May, depending on water temperatures and increasing stream flows (Pratt 1992; Ratliff and Howell 1992b).

Early life stages of fish, specifically the developing embryo, require the highest inter-gravel dissolved oxygen (IGDO) levels, and are the most sensitive life stage to reduced oxygen levels. The oxygen demand of embryos depends on temperature and on stage of development, with the greatest IGDO required just prior to hatching.

A literature review conducted by the Washington Department of Ecology (Ratliff and Howell 1992a) indicates that adverse effects of lower oxygen concentrations on embryo survival are magnified as temperatures increase above optimal (for incubation). In a laboratory study conducted in Canada, researchers found that low oxygen levels retarded embryonic development in bull trout (Giles and Van der Zweep 1996 cited in WDOE 2002). Normal oxygen levels seen in rivers used by bull trout during spawning ranged from 8 to 12 mg/L (in the gravel), with corresponding instream levels of 10 to 11.5 mg/L (Stewart et al. 2007). In addition, IGDO concentrations, water velocities in the water column, and especially the intergravel flow rate, are interrelated variables that affect the survival of incubating embryos (ODEQ (Oregon Department of Environmental Quality) 1995). Due to a long incubation period of 220+ days, bull trout are particularly sensitive to adequate IGDO levels. An IGDO level below 8 mg/L is likely to result in mortality of eggs, embryos, and fry.

Migratory forms of bull trout may develop when habitat conditions allow movement between spawning and rearing streams and larger rivers, lakes or nearshore marine habitat where foraging opportunities may be enhanced (Frissell 1993; Goetz et al. 2004; Brenkman and Corbett 2005). For example, multiple life history forms (e.g., resident and fluvial) and multiple migration patterns have been noted in the Grande Ronde River (Baxter 2002). Parts of this river system have retained habitat conditions that allow free movement between spawning and rearing areas and the mainstem Snake River. Such multiple life history strategies help to maintain the stability and persistence of bull trout populations to environmental changes. Benefits to migratory bull trout include greater growth in the more productive waters of larger streams, lakes, and marine waters; greater fecundity resulting in increased reproductive potential; and dispersing the population across space and time so that spawning streams may be recolonized should local populations suffer a catastrophic loss (Rieman and McIntyre 1993c; MBTSG 1998; Frissell 1999). In the absence of the migratory bull trout life form, isolated populations cannot be replenished when disturbances make local habitats temporarily unsuitable. Therefore, the range of the species is diminished, and the potential for a greater reproductive contribution from larger size fish with higher fecundity is lost (Rieman and McIntyre 1993c).

Diet

Bull trout are opportunistic feeders, with food habits primarily a function of size and life-history strategy. A single optimal foraging strategy is not necessarily a consistent feature in the life of a fish, because this strategy can change as the fish progresses from one life stage to another (i.e., juvenile to subadult). Fish growth depends on the quantity and quality of food that is eaten (Gerking 1994), and as fish grow, their foraging strategy changes as their food changes, in quantity, size, or other characteristics. Resident and juvenile migratory bull trout prey on terrestrial and aquatic insects, macrozooplankton, and small fish (Boag 1987; Goetz 1989b; Donald and Alger 1993). Subadult and adult migratory bull trout feed on various fish species (Leathe and Graham 1982; Fraley and Shepard 1989; Donald and Alger 1993; Brown 1994). Bull trout of all sizes other than fry have been found to eat fish half their length (Beauchamp and VanTassell 2001). In nearshore marine areas of western Washington, bull trout feed on Pacific herring (*Clupea pallasi*) (herring), Pacific sand lance (*Ammodytes hexapterus*), and surf smelt (*Hypomesus pretiosus*) (WDFW et al. 1997; Goetz et al. 2004).

Bull trout migration and life history strategies are closely related to their feeding and foraging strategies. Migration allows bull trout to access optimal foraging areas and exploit a wider variety of prey resources. Optimal foraging theory can be used to describe strategies fish use to choose between alternative sources of food by weighing the benefits and costs of capturing one source of food over another. For example, prey often occur in concentrated patches of abundance ("patch model;" (Gerking 1994)). As the predator feeds in one patch, the prey population is reduced, and it becomes more profitable for the predator to seek a new patch rather than continue feeding on the original one. This can be explained in terms of balancing energy acquired versus energy expended. For example, in the Skagit River system, anadromous bull trout make migrations as long as 121 miles between marine foraging areas in Puget Sound and headwater spawning grounds, foraging on salmon eggs and juvenile salmon along their migration route (WDFW et al. 1997). Anadromous bull trout also use marine waters as migration corridors to reach seasonal habitats in non-natal watersheds to forage and possibly overwinter (Goetz et al. 2004; Brenkman and Corbett 2005).

<u>Changes in Status of the Coastal-Puget Sound Interim Recovery Unit</u>

Although the status of bull trout in Coastal-Puget Sound interim recovery unit has been improved by certain actions, it continues to be degraded by other actions, and it is likely that the overall status of the bull trout in this population segment has not improved since its listing on November 1, 1999. Improvement has occurred largely through changes in fishing regulations and habitat-restoration projects. Fishing regulations enacted in 1994 either eliminated harvest of bull trout or restricted the amount of harvest allowed, and this likely has had a positive influence on the abundance of bull trout. Improvement in habitat has occurred following restoration projects intended to benefit either bull trout or salmon, although monitoring the effectiveness of these projects seldom occurs. On the other hand, the status of this population segment has been adversely affected by a number of Federal and non-Federal actions, some of which were addressed under section 7 of the Act. Most of these actions degraded the environmental baseline; all of those addressed through formal consultation under section 7 of the Act permitted the incidental take of bull trout.

Section 10(a)(1)(B) permits have been issued for Habitat Conservation Plans (HCP) completed in the Coastal-Puget Sound population segment. These include: 1) the City of Seattle's Cedar River Watershed HCP, 2) Simpson Timber HCP, 3) Tacoma Public Utilities Green River HCP, 4) Plum Creek Cascades HCP, 5) Washington State Department of Natural Resources HCP, 6) West Fork Timber HCP (Nisqually River), and 7) Forest Practices HCP. These HCPs provide landscape-scale conservation for fish, including bull trout. Many of the covered activities associated with these HCPs will contribute to conserving bull trout over the long-term; however, some covered activities will result in short-term degradation of the baseline. All HCPs permit the incidental take of bull trout.

<u>Changes in Status of the Columbia River Interim Recovery Unit</u>

The overall status of the Columbia River interim recovery unit has not changed appreciably since its listing on June 10, 1998. Populations of bull trout and their habitat in this area have been affected by a number of actions addressed under section 7 of the Act. Most of these actions resulted in degradation of the environmental baseline of bull trout habitat, and all permitted or analyzed the potential for incidental take of bull trout. The Plum Creek Cascades HCP, Plum Creek Native Fish HCP, and Forest Practices HCP addressed portions of the Columbia River population segment of bull trout.

<u>Changes in Status of the Klamath River Interim Recovery Unit</u>

Improvements in the Threemile, Sun, and Long Creek local populations have occurred through efforts to remove or reduce competition and hybridization with non-native salmonids, changes in fishing regulations, and habitat-restoration projects. Population status in the remaining local populations (Boulder-Dixon, Deming, Brownsworth, and Leonard Creeks) remains relatively unchanged. Grazing within bull trout watersheds throughout the recovery unit has been curtailed. Efforts at removal of non-native species of salmonids appear to have stabilized the Threemile and positively influenced the Sun Creek local populations. The results of similar efforts in Long Creek are inconclusive. Mark and recapture studies of bull trout in Long Creek indicate a larger migratory component than previously expected.

Although the status of specific local populations has been slightly improved by recovery actions, the overall status of Klamath River bull trout continues to be depressed. Factors considered threats to bull trout in the Klamath Basin at the time of listing – habitat loss and degradation caused by reduced water quality, past and present land use management practices, water diversions, roads, and non-native fishes – continue to be threats today.

Changes in Status of the Saint Mary-Belly River Interim Recovery Unit

The overall status of bull trout in the Saint Mary-Belly River interim recovery unit has not changed appreciably since its listing on November 1, 1999. Extensive research efforts have been conducted since listing, to better quantify populations of bull trout and their movement patterns. Limited efforts in the way of active recovery actions have occurred. Habitat occurs mostly on Federal and Tribal lands (Glacier National Park and the Blackfeet Nation). Known problems due to instream flow depletion, entrainment, and fish passage barriers resulting from operations of the U.S. Bureau of Reclamation's Milk River Irrigation Project (which transfers Saint Mary-Belly River water to the Missouri River Basin) and similar projects downstream in Canada constitute the primary threats to bull trout and to date they have not been adequately addressed under section 7 of the Act. Plans to upgrade the aging irrigation delivery system are being pursued, which has potential to mitigate some of these concerns but also the potential to intensify dewatering. A major fire in August 2006 severely burned the forested habitat in Red Eagle and Divide Creeks, potentially affecting three of nine local populations and degrading the baseline.

Bull trout use of habitat with above optimal temperatures

Although currently there is little information on temperature requirements of subadult and adult bull trout, in general, adult fish are physiologically less tolerant of elevated temperatures than smaller fish of the same species (Myrick et al. 2002, p. 11). When water temperatures are above the optimal range, the following effects to bull trout may occur: 1) an increased rate of physiological damage, including sublethal impacts, 2) changes in the relative abundance of bull trout in relation to other salmonids, 3) reduction in overall abundance, 4) changes in the distribution of bull trout, and 5) behavioral adjustments (Saffel and Scarnecchia 1995, pp. 304, 314-315; Myrick et al. 2002, pp. 3-10).

As bull trout mature, they move to larger rivers, lakes, or marine waters in order to exploit the availability of larger or more abundant prey items. Although temperatures in these habitats may be elevated during periods of low flow or during the warmest months, these fish are able to exploit the spatial variation of temperatures within a stream and can behaviorally thermoregulate by periodically moving to more-suitable, cooler thermal environments.

Limited information is available that indicates under certain conditions bull trout will occupy waters with temperatures likely warmer than optimal for short periods of time. For example, mature adult anadromous char have been observed in Puget Sound tributaries when stream temperatures were 20 to 24 °C (C. Kraemer, WDFW, pers. comm, as cited in Brown 1994). Two separate studies have documented bull trout in waters warmer than is usually associated with their presence. In the Lostine River, Oregon, where archival temperature tags were attached to the fish, the maximum 7 day average daily maximum temperatures in waters occupied by the tagged fish were mostly 16 to 18 °C and potentially as high as 21 °C (P. Howell et al. *in litt.* 2008). In the Little Lost River, Idaho, the maximum temperature of sites where bull trout were present ranged from 8.1 to 20.0 °C (Gamett 2002, p. 27).

In the Puget Sound telemetry study by Goetz et al. (2004), bull trout tended to move out of marine waters when water temperatures increased above 16 to 17°C. In that same study, in 2002, all bull trout left the delta area by the time water temperatures exceed 18°C.

Foraging behavior

When not making cross channel migrations bull trout tend to use the shallow, near-shore waters. In one study the majority of fish occupied depths less than 4 m. (USGS *in litt.* 2008). Another study (Goetz et al. 2004) suggested bull trout densities were greatest at depths greater than 2.0 to 2.5 m. although the recorded depths may have been influenced by sampling techniques as fish were captured by seining and may have been disturbed from their normal position (USGS, *in litt.* 2008). Shallow water habitats not only provide bull trout with opportunities for foraging, but may preclude effective predation on bull trout by large predators such as seals.

Temperature can influence the abundance and well-being of fish by controlling their metabolic processes. Fish and other aquatic species have optimal metabolic ranges. Increasing stream temperatures result in changes in metabolism because higher temperatures require more energy to sustain increased rates and processes (Johnson and Jones 2000). At warmer temperatures bull trout consume more food; the increase in energy required for basic life processes can deplete the energy reserves of individual fish. Conversely, as food availability decreases, optimal temperature for bull trout decreases (lower temperatures require less energy to sustain metabolic rates and processes) (McMahon et al. 2001).

A number of studies suggest that bull trout are more active at twilight, dawn and dusk (Goetz et al. 2004). In a telemetry study in the Wenatchee River most bull trout were likely to be more active at night, although some adults did show activity during the day (Kelly Ringel and DeLaVergne 2008).

4.4 Status of the Species (Marbled Murrelet)

Legal Status

The murrelet was federally listed as a threatened species in Washington, Oregon, and northern California effective September 28, 1992 (57 FR 45328 [October 1, 1992]). The final rule designating critical habitat for the murrelet (61 FR 26256 [May 24, 1996]) became effective on June 24, 1996. The Service recently proposed a revision to the 1996 murrelet critical habitat designation (71 FR 44678 [July 31, 2008]). A final rule is expected in 2009. The species' decline has largely been caused by extensive removal of late-successional and old-growth coastal forests which serve as nesting habitat for murrelets. Additional listing factors included high nest-site predation rates and human-induced mortality in the marine environment from gillnets and oil spills.

The Service determined that the California, Oregon, and Washington distinct population segment of the murrelet does not meet the criteria set forth in the Service's 1996 Distinct Population Segment policy (61 FR 4722 [May 24, 1996]. However, the murrelet retains its listing and protected status as a threatened species under the Act until the original 1992 listing decision is revised through formal rule-making procedures, involving public notice and comment.

Critical habitat was designated for the murrelet to addresses the objective of stabilizing the population size. To fulfill that objective, the Marbled Murrelet Recovery Plan (USFWS 1997b) (Recovery Plan), focuses on protecting adequate nesting habitat by maintaining and protecting occupied habitat and minimizing the loss of unoccupied but suitable habitat (USFWS 1997b, p. 119). The Recovery Plan identified six Conservation Zones throughout the listed range of the species: Puget Sound (Conservation Zone 1), Western Washington Coast Range (Conservation Zone 2), Oregon Coast Range (Conservation Zone 3), Siskiyou Coast Range (Conservation Zone 4), Mendocino (Conservation Zone 5), and Santa Cruz Mountains (Conservation Zone 6).

As explained in the Endangered Species Consultation Handbook (USFWS 1997c) and clarified for recovery units through Memorandum (USFWS 2006b), jeopardy analyses must always consider the effect of proposed actions on the survival and recovery of the listed entity. In the case of the murrelet, the Service's jeopardy analysis will consider the effect of the action on the long-term viability of the murrelet in its listed range (Washington, Oregon, and northern California), beginning with an analysis of the action's effect on Conservation Zones 1 and 2 (described below).

Conservation Zone 1

Conservation Zone 1 includes all the waters of Puget Sound and most waters of the Strait of Juan de Fuca south of the U.S.-Canadian border and extends inland 50 mi from the Puget Sound, including the north Cascade Mountains and the northern and eastern sections of the Olympic Peninsula. Forest lands in the Puget Trough have been predominately replaced by urban development and the remaining suitable habitat in Zone 1 is typically a considerable distance from the marine environment, lending special importance to nesting habitat close to Puget Sound (USFWS 1997b).

Conservation Zone 2

Conservation Zone 2 includes waters within 1.2 mi of the Pacific Ocean shoreline south of the U.S.-Canadian border off Cape Flattery and extends inland to the midpoint of the Olympic Peninsula. In southwest Washington, the Zone extends inland 50 mi from the Pacific Ocean shoreline. Most of the forest lands in the northwestern portion of Zone 2 occur on public (State, county, city, and Federal) lands, while most forest lands in the southwestern portion are privately owned. Extensive timber harvest has occurred throughout Zone 2 in the last century, but the greatest loss of suitable nest habitat is concentrated in the southwest portion of Zone 2 (USFWS 1997b). Thus, murrelet conservation is largely dependent upon Federal lands in northern portion of Zone 2 and non-Federal lands in the southern portion.

Life History

Murrelets are long-lived seabirds that spend most of their life in the marine environment, but use old-growth forests for nesting. Detailed discussions of the biology and status of the murrelet are presented in the final rule listing the murrelet as threatened (57 FR 45328 [October 1, 1992]), the Recovery Plan, Ecology and Conservation of the Marbled Murrelet (Ralph et al. 1995a), the final rule designating murrelet critical habitat (61 FR 26256 [May 24, 1996]), and the Evaluation Report in the 5-Year Status Review of the Marbled Murrelet in Washington, Oregon, and California (McShane et al. 2004b).

Physical Description

The murrelet is taxonomically classified in the family Alcidae (alcids), a family of Pacific seabirds possessing the ability to dive using wing-propulsion. The plumage of this relatively small (9.5 in to 10 in) seabird is identical between males and females, but the plumage of adults changes during the winter and breeding periods providing some distinction between adults and juveniles. Breeding adults have light, mottled brown under-parts below sooty-brown upperparts contrasted with dark bars. Adults in winter plumage have white under-parts extending to below the nape and white scapulars with brown and grey mixed upperparts. The plumage of fledged young is similar to the adult winter plumage (USFWS 1997b).

Distribution

The range of the murrelet, defined by breeding and wintering areas, extends from the northern terminus of Bristol Bay, Alaska, to the southern terminus of Monterey Bay in central California. The listed portion of the species' range extends from the Canadian border south to central California. Murrelet abundance and distribution has been significantly reduced in portions of the listed range, and the species has been extirpated from some locations. The areas of greatest concern due to small numbers and fragmented distribution include portions of central California, northwestern Oregon, and southwestern Washington (USFWS 1997b).

Reproduction

Murrelet breeding is asynchronous and spread over a prolonged season. In Washington, the murrelet breeding season occurs between April 1 and September 15 (Figure 4.12). Egg laying and incubation occur from late April to early August and chick rearing occurs between late May and late August, with all chicks fledging by early September (Hamer et al. 2003).

Murrelets lay a single-egg clutch (Nelson 1997a), which may be replaced if egg failure occurs early (Hebert et al. 2003; McFarlane-Tranquilla et al. 2003). However, there is no evidence a second egg is laid after successfully fledging a first chick. Adults typically incubate for a 24-hour period, then exchange duties with their mate at dawn. Hatchlings appear to be brooded by an adult for one to two days and are then left alone at the nest for the remainder of the rearing period, except during feedings. Both parents feed the chick, which receives one to eight meals per day (Nelson 1997a). Most meals are delivered early in the morning while about a third of the food deliveries occur at dusk and intermittently throughout the day (Nelson and Hamer 1995b). Chicks fledge 27 to 40 days after hatching. The initial flight of a fledgling appears to occur at dusk and parental care is thought to cease after fledging (Nelson 1997a).

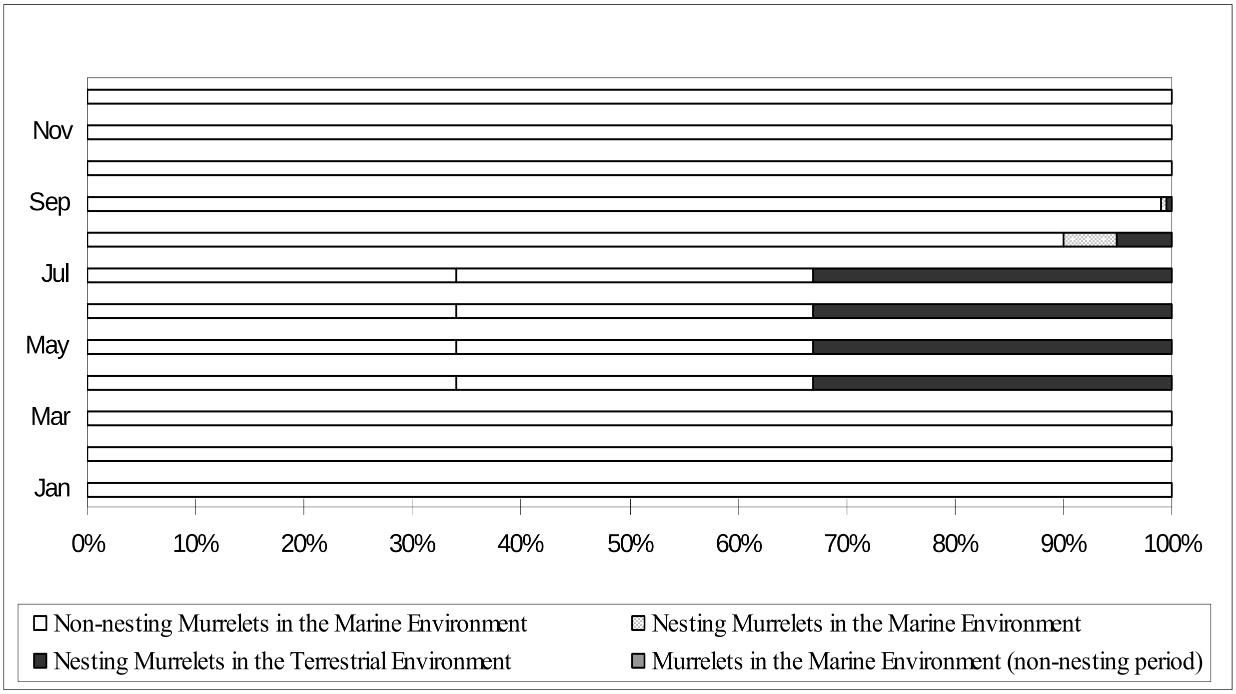

Figure 4.12 The seasonal changes in the relative proportion of breeding and non-breeding murrelets in the marine and terrestrial environments[2] within Washington State (Conservation Zones 1 and 2).

Vocalization

Murrelets are known to vocalize between 480 Hertz and 4.9 kilohertz and have at least 5 distinct call types (Nelson 1997b). Murrelets tend to be more vocal at sea compared to other alcids (Nelson 1997a). Individuals of a pair vocalize after surfacing apart from each other, after a disturbance, and during attempts to reunite after being separated (Strachan et al. 1995).

MURRELETS IN THE MARINE ENVIRONMENT

Murrelets are usually found within 5 miles (8 kilometers) from shore, and in water less than 60 meters deep (Ainley et al. 1995; Burger 1995; Strachan et al. 1995; Nelson 1997a; Day and Nigro 2000; Raphael et al. 2007). In general, birds occur closer to shore in exposed coastal areas and farther offshore in protected coastal areas (Nelson 1997a). Courtship, foraging, loafing, molting, and preening occur in marine waters. Beginning in early spring, courtship continues throughout summer with some observations even noted during the winter period (Speckman 1996; Nelson 1997a). Observations of courtship occurring in the winter suggest that pair bonds are maintained throughout the year (Speckman 1996; Nelson 1997a). Courtship involves bill posturing, swimming together, synchronous diving, vocalizations, and chasing in flights just

[2] Demographic estimates were derived from Peery et al. (2004) and nesting chronology was derived from Hamer and Nelson (1995) and Bradley et al. (2004) where April 1 is the beginning of the nesting season, September 15 is the end of the nesting season, and August 6 is the beginning of the late breeding season when an estimated 70 percent of the murrelet chicks have fledged.

above the surface of the water. Copulation occurs both inland (in the trees) and at sea (Nelson 1997a).

Loafing

When murrelets are not foraging or attending a nest, they loaf on the water, which includes resting, preening, and other activities during which they appear to drift with the current, or move without direction (Strachan et al. 1995). Strachan et al. (1995) noted that vocalizations occurred during loafing periods, especially during the mid-morning and late afternoon.

Molting

Murrelets go through two molts each year. The timing of molts varies temporally throughout their range and are likely influenced by prey availability, stress, and reproductive success (Nelson 1997a). Adult (after hatch-year) murrelets have two primary plumage types: alternate (breeding) plumage and basic (winter) plumage. The pre-alternate molt occurs from late February to mid-May. This is an incomplete molt during which the birds lose their body feathers but retain their ability to fly (Carter and Stein 1995; Nelson 1997a). A complete pre-basic molt occurs from mid-July through December (Carter and Stein 1995; Nelson 1997a). During the pre-basic molt, murrelets lose all flight feathers somewhat synchronously and are flightless for up to two months (Nelson 1997a). In Washington, there is some indication that the pre-basic molt occurs from mid-July through the end of August (Chris Thompson, pers. comm. 2003).

Flocking

Strachan et al. (1995) defines a flock as three or more birds in close proximity which maintain that formation when moving. Various observers throughout the range of the murrelet report flocks of highly variable sizes. In the southern portion of the murrelet's range (California, Oregon, and Washington), flocks rarely contain more than 10 birds. Larger flocks usually occur during the later part of the breeding season and may contain juvenile and subadult birds (Strachan et al. 1995).

Aggregations of foraging murrelets are probably related to concentrations of prey. In Washington, murrelets are not generally found in interspecific feeding flocks (Strachan et al. 1995). Strong et al. (in Strachan et al. 1995) observed that murrelets avoid large feeding flocks of other species and presumed that the small size of murrelets may make them vulnerable to kleptoparasitism or predation in mixed species flocks. Strachan et al. (1995) point out that if murrelets are foraging cooperatively, the confusion of a large flock of birds could reduce foraging efficiency.

Foraging Behavior

Murrelets are wing-propelled pursuit divers that forage both during the day and at night (Carter and Sealy 1986a; Carter and Sealy 1986b; Gaston and Jones 1998; Kuletz 2005b). Murrelets typically forage in pairs, but have been observed to forage alone or in groups of three or more (Carter and Sealy 1990b; Strachan et al. 1995; Speckman et al. 2003). Strachan et al. (1995)

believe pairing enhances foraging success through cooperative foraging techniques. For example, pairs consistently dive together during foraging and often synchronize their dives by swimming towards each other before diving (Carter and Sealy 1990b) and resurfacing together on most dives. Strachan et al. (1995) speculate pairs may keep in visual contact underwater. Paired foraging is common throughout the year, even during the incubation period, suggesting that breeding murrelets may temporarily pair up with other foraging individuals (non-mates) (Strachan et al. 1995; Speckman et al. 2003).

Murrelets can make substantial changes in foraging sites within the breeding season, but many birds routinely forage in the same general areas and at productive foraging sites, as evidenced by repeated use over a period of time throughout the breeding season (Carter and Sealy 1990b; Whitworth et al. 2000; Becker et al. 2001; Hull et al. 2001; Mason et al. 2002; Piatt et al. 2007). Murrelets are also known to forage in freshwater lakes (Nelson 1997a). Activity patterns and foraging locations are influenced by biological and physical processes that concentrate prey, such as weather, climate, time of day, season, light intensity, up-wellings, tidal rips, narrow passages between islands, shallow banks, and kelp (*Nereocystis* spp.) beds (Strong et al. 1995; Ainley et al. 1995; Burger 1995; Speckman 1996; Nelson 1997a).

Juveniles are generally found closer to shore than adults (Beissinger 1995) and forage without the assistance of adults (Strachan et al. 1995). Kuletz and Piatt (1999) found that in Alaska, juvenile murrelets congregated in kelp beds. Kelp beds are often with productive waters and may provide protection from avian predators (Kuletz and Piatt 1999). McAllister (in litt. in Strachan et al. 1995) found that juveniles were more common within 328 ft of shorelines, particularly, where bull kelp was present.

Murrelets usually feed in shallow, near-shore water less than 30m (98 ft) deep (Huff et al. 2006), but are thought to be able to dive up to depths of 47 m (157 ft) (Mathews and Burger 1998). Variation in depth and dive patterns may be related to the effort needed to capture prey. Thick-billed murres (*Uria lomvia*) and several penguin species exhibit bi-modal foraging behavior in that their dive depths mimic the depth of their prey, which undergo daily vertical migrations in the water column (Croll et al. 1992; Butler and Jones 1997). Jodice and Collopy's (1999) data suggest murrelets follow this same pattern as they forage for fish that occur throughout the water column but undergo daily vertical migrations (to shallower depths at night and back to deeper depths during the day). Murrelets observed foraging in deeper water likely do so when upwelling, tidal rips, and daily activity patterns concentrate the prey near the surface (Strachan et al. 1995).

The duration of dives appears to depend upon age (adults vs. juveniles), water depth, visibility, and depth and availability of prey. Murrelet dive duration ranges from 8 seconds to 115 seconds, although most dives last between 25 and 45 seconds (Thorensen 1989; Jodice and Collopy 1999; Watanuki and Burger 1999; Day and Nigro 2000).

Adults and subadults often move away from breeding areas prior to molting and must select areas with predictable prey resources during the flightless period (Carter and Stein 1995; Nelson 1997a). During the non-breeding season, murrelets disperse and can be found farther from shore (Strachan et al. 1995). Little is known about marine-habitat preference outside of the breeding season, but use during the early spring and fall is thought to be similar to that preferred during the breeding season (Nelson 1997a). During the winter there may be a general shift from exposed outer coasts into more protected waters (Nelson 1997a), for example many murrelets breeding on the exposed outer coast of Vancouver Island appear to congregate in the more sheltered waters within the Puget Sound and the Strait of Georgia in fall and winter (Burger 1995). However, in many areas, murrelets remain associated with the inland nesting habitat during the winter months (Carter and Erickson 1992) and throughout the listed range, murrelets do not appear to disperse long distances, indicating they are year-round residents (McShane et al. 2004b).

Prey Species

Throughout their range, murrelets are opportunistic feeders and utilize prey of diverse sizes and species. They feed primarily on fish and invertebrates in marine waters although they have also been detected on rivers and inland lakes (Carter and Sealy 1986a); 57 FR 45328 [October 1, 1992]). In general, small schooling fish and large pelagic crustaceans are the main prey items. Pacific sand lance, northern anchovy *(Engraulis mordax)*, immature Pacific herring, capelin *(Mallotus villosus)*, Pacific sardine (*Sardinops sagax*), juvenile rockfishes (*Sebastas* spp.) and surf smelt (Osmeridae) are the most common fish species taken. Squid (*Loligo* spp.), euphausiids, mysid shrimp, and large pelagic amphipods are the main invertebrate prey. Murrelets are able to shift their diet throughout the year and over years in response to prey availability (Becker et al. 2007). However, long-term adjustment to less energetically-rich prey resources (such as invertebrates) appears to be partly responsible for poor marbled murrelet reproduction in California (Becker and Beissinger 2006).

Breeding adults exercise more specific foraging strategies when feeding chicks, usually carrying a single, relatively large (relative to body size) energy-rich fish to their chicks (Burkett 1995; Nelson 1997a), primarily around dawn and dusk (Nelson 1997a; Kuletz 2005b). Freshwater prey appears to be important to some individuals during several weeks in summer and may facilitate more frequent chick feedings, especially for those that nest far inland (Kuletz 2005a). Becker et al. (2007) found murrelet reproductive success in California was strongly correlated with the abundance of mid-trophic level prey (e.g. sand lance, juvenile rockfish) during the breeding and postbreeding seasons. Prey types are not equal in the energy they provide; for example parents delivering fish other than age-1 herring may have to increase deliveries by to up 4.2 times to deliver the same energy value (Kuletz 2005b). Therefore, nesting murrelets that are returning to their nest at least once per day must balance the energetic costs of foraging trips with the benefits for themselves and their young. This may result in marbled murrelets preferring to forage in marine areas in close proximity to their nesting habitat. However, if adequate or appropriate foraging resources (i.e., "enough" prey, and/or prey with the optimum nutritional value for themselves or their young) are unavailable in close proximity to their nesting areas, murrelets may be forced to forage at greater distances or to abandon their nests (Huff et al. 2006, p. 20). As a result, the distribution and abundance of prey suitable for feeding chicks may greatly influence the overall foraging behavior and location(s) during the nesting season, may affect reproductive success (Becker et al. 2007), and may significantly affect the energy demand on adults by influencing both the foraging time and number of trips inland required to feed nestlings (Kuletz 2005b).

Predators

At-sea predators include bald eagles (*Haliaeetus leucocephalus*), peregrine falcons (*Falco peregrinus*), western gulls (*Larus occidentalis*), and northern fur seals (*Callorhinus ursinus*) (McShane et al. 2004b). California sea lions (*Zalophus californianus*), northern sea lions (*Eumetopias jubatus*), and large fish may occasionally prey on murrelets (McShane et al. 2004e).

Murrelets in the Terrestrial Environment

Murrelets are dependent upon old-growth forests, or forests with an older tree component, for nesting habitat (Hamer and Nelson 1995; Ralph et al. 1995a; McShane et al. 2004b). Sites occupied by murrelets tend to have a higher proportion of mature forest age-classes than do unoccupied sites (McShane et al. 2004f). Specifically, murrelets prefer high and broad platforms for landing and take-off, and surfaces which will support a nest cup (Hamer and Nelson 1995). The physical condition of a tree appears to be the important factor in determining the tree's suitability for nesting (Ralph et al. 1995a); therefore, presence of old-growth in an area does not assure the stand contains sufficient structures (i.e. platforms) for nesting. In Washington, murrelet nests have been found in conifers, specifically, western hemlock (*Tsuga heterophylla*), Sitka spruce (*Picea sitchensis*), Douglas-fir (*Pseudotsuga menziesii*), and western red cedar (*Thuja plicata*) (Hamer and Nelson 1995; Hamer and Meekins 1999). Nests have been found in trees as small as 2.6 ft in diameter at breast height on limbs at least 65 ft from the ground and 0.36 ft in diameter (Hamer and Meekins 1999).

Murrelet populations may be limited by the availability of suitable nesting habitat. Although no data are available, Ralph et al. (1995a) speculate the suitable nesting habitat presently available in Washington, Oregon, and California may be at or near carrying capacity based on: 1) at-sea concentrations of murrelets near suitable nesting habitat during the breeding season, 2) winter visitations to nesting sites, and 3) the limitation of nest sites available in areas with large amounts of habitat removal.

Murrelets have been observed visiting nesting habitat during non-breeding periods in Washington, Oregon, and California (Naslund 1993; Nelson 1997a) which may indicate adults are defending nesting sites and/or stands (Ralph et al. 1995a). Other studies provide further insight to the habitat associations of breeding murrelets, concluding that breeding murrelets displaced by the loss of nesting habitat do not pack in higher densities into remaining habitat (McShane et al. 2004b). Thus, murrelets may currently be occupying nesting habitat at or near carrying capacity in highly fragmented areas and/or in areas where a significant portion of the historic nesting habitat has been removed (Ralph et al. 1995a).

Unoccupied stands containing nesting structures are important to the population for displaced breeders or first-time breeding adults. Even if nesting habitat is at carrying capacity, there will be years when currently occupied stands become unoccupied as a result of temporary disappearance of inhabitants due to death or to irregular breeding (Ralph et al. 1995a). Therefore, unoccupied stands will not necessarily indicate that habitat is not limiting or that these stands are not murrelet habitat (Ralph et al. 1995a) and important to the species persistence.

Radar and audio-visual studies have shown murrelet habitat use is positively associated with the presence and abundance of mature and old-growth forests, large core areas of old-growth, low edge and fragmentation, proximity to the marine environment, total watershed area, and increasing forest age and height (McShane et al. 2004b). In California and southern Oregon, areas with abundant numbers of murrelets were farther from roads, occurred more often in parks protected from logging, and were less likely to occupy old-growth habitat if it was isolated (more than 3 miles or 5 km) from other nesting murrelets (Meyer et al. 2002). Meyer et al. (2002) also found at least a few years passed before birds abandoned fragmented forests.

Murrelets do not form dense colonies which is atypical of most seabirds. Limited evidence suggests they may form loose colonies or clusters of nests in some cases (Ralph et al. 1995a). The reliance of murrelets on cryptic coloration to avoid detection suggests they utilize a wide spacing of nests in order to prevent predators from forming a search image (Ralph et al. 1995a). However, active nests have been seen within 328 ft (100 m) of one another in the North Cascades in Washington and within 98 ft (30 m) in Oregon (Kim Nelson, Oregon State University, pers. comm. 2005). Estimates of murrelet nest densities vary depending upon the method of data collection. For example, nest densities estimated using radar range from 0.007 to 0.104 mean nests per acre (0.003 to 0.042 mean nests per ha), while nest densities estimated from tree climbing efforts range from 0.27 to 3.51 mean nests per acre (0.11 to 1.42 mean nests per ha) (Nelson 2005).

There is little data available regarding murrelet nest site fidelity because of the difficulty in locating nest sites and observing banded birds attending nests. However, murrelets have been detected in the same nesting stands for many years (at least 20 years in California and 15 years in Washington), suggesting murrelets have a high fidelity to nesting areas, most likely at the watershed scale (Nelson 1997a). Use of the same nest platform in successive years as well as multiple nests in the same tree have been documented, although it is not clear whether the repeated use involved the same birds (Nelson and Peck 1995; Divoky and Horton 1995; Nelson 1997a; Manley 2000; Hebert et al. 2003). The limited observed fidelity to the same nest depression in consecutive years appears to be lower than for other alcids, but this may be an adaptive behavior in response to high predation rates (Divoky and Horton 1995). Researchers have suggested fidelity to specific or adjacent nesting platforms may be more common in areas where predation is limited or the number of suitable nest sites are fewer because large, old-growth trees are rare (Nelson and Peck 1995; Singer et al. 1995; Manley 1999).

Ralph et al. (1995a) speculated that the fidelity to nest sites or stands by breeding murrelets may be influenced by the nesting success of previous rearing attempts. Although murrelet nesting behavior in response to failed nest attempts is unknown, nest failures could lead to prospecting for new nest sites or mates. Other alcids have shown an increased likelihood to relocate to a new nest in response to breeding failure (Divoky and Horton 1995). However, murrelets likely remain in the same watershed over time as long as stands are not significantly modified (Ralph et al. 1995a).

It is unknown whether juveniles disperse from natal breeding habitat (natal dispersal) or return to their natal breeding habitat after reaching breeding age (natal philopatry). Natal dispersal distance can be expected to be as high or higher than other alcids given 1) the reduced extent of the breeding range, 2) the overlap between the wintering and breeding areas, 3) the distance individuals are known to move from breeding areas in the winter, 4) adult attendance of nesting areas during the non-breeding season where, in theory, knowledge of suitable nesting habitat is passed onto prospecting non-breeders, and 5) the 3-year to 5-year duration required for the onset of breeding age allowing non-breeding murrelets to prospect nesting and forage habitat for several years prior to reaching breeding age (Divoky and Horton 1995). Conversely, Swartzman et al. (1997 in McShane et al. 2004b) suggested juvenile dispersal is likely to be low, as it is for other alcid species. Nevertheless, the presence of unoccupied suitable nesting habitat on the landscape may be important for first-time nesters if they disperse away from their natal breeding habitat.

Murrelets generally select nests within 37 mi (60 kilometers (km)) of marine waters (Miller and Ralph 1995). However, in Washington, occupied habitat has been documented 52 mi (84 km) from the coast and murrelets have been detected up to 70 mi (113 km) from the coast in the southern Cascade Mountains (Evans Mack et al. 2003).

When tending active nests during the breeding season (and much of the non-breeding season in southern parts of the range), breeding pairs forage within commuting distance of the nest site. Daily movements between nest sites and foraging areas for breeding murrelets averaged 10 mi in Prince William Sound, Alaska (McShane et al. 2004b), 24 mi in Desolation Sound, British Columbia, Canada (Hull et al. 2001), and 48 mi in southeast Alaska. In California, Hebert and Golightly (2003a) found the mean extent of north-south distance traveled by breeding adults to be about 46 mi.

Murrelet nests have been located at a variety of elevations from sea level to 5,020 ft (Hebert and Golightly 2003b). However, most nests have been found below 3,500 ft. In Conservation Zone 1, murrelets have exhibited "occupied" behaviors up to 4,400 ft elevation and have been detected in stands up to 4,900 ft in the north Cascade Mountains (Peter McBride, WDNR, *in litt.* 2005). On the Olympic Peninsula, survey efforts for nesting murrelets have encountered occupied stands up to 4,000 ft within Conservation Zone 1 and up to 3,500 ft within Conservation Zone 2. Surveys for murrelet nesting at higher elevations on the Olympic Peninsula have not been conducted. However, recent radio-telemetry work detected a murrelet nest at 3,600 ft elevation on the Olympic Peninsula in Conservation Zone 1 (Martin Raphael, USFWS, pers. comm. 2005).

Population Status in the Coterminous United States

Population Abundance

Research on murrelet populations in the early 1990s estimated murrelet abundance in Washington, Oregon, and California at 18,550 to 32,000 (Ralph et al. 1995a). However, consistent population survey protocols were not established for murrelets in the coterminous United States until the late 1990s following the development of the marine component of the environmental Monitoring (EM) Program for the NWFP (Bentivoglio et al. 2002). As a consequence, sampling procedures have differed and thus the survey data collected prior to the EM Program is unsuitable for estimating population trends for the murrelet (McShane et al. 2004b).

The development of the EM Program unified the various at-sea monitoring efforts within the 5 Conservation Zones encompassed by the NWFP. The highest total population estimate for this area (20,500 +/- 4,600 birds at the 95 percent confidence interval) was in 2004 and the lowest total population estimate (17,400 +/- 4,600 birds at the 95 percent confidence interval) was in 2007 (Gary Falxa, pers. comm. 2008). The most recent population estimate for Conservation Zone 6 is 400 (+/- 140 birds at the 95 percent confidence interval) (M. Z. Peery, Moss Landing Marine Lab, pers. comm. 2007).

Population Trend

Estimated population trends within each Conservation Zone or for the entire coterminous population are not yet available from the marine survey data. Trend information will eventually be provided through the analysis of marine survey data from the EM Program (Bentivoglio et al. 2002) and from survey data in Conservation Zone 6 once a sufficient number of survey years have been completed. Depending on the desired minimum power (80 or 95 percent), at least 8 to 10 years of successive surveys are required for an overall population estimate and thus detection of an annual decrease, while 7 to 16 years are required for Conservation Zones 1 and 2 (Huff et al. 2003).

In the interim, demographic modeling has aided attempts to analyze and predict population trends and extinction probabilities of murrelets. Incorporating important population parameters and species distribution data (Beissinger 1995; Beissinger and Nur 1997 in USFWS 1997b; Cam et al. 2003; McShane et al. 2004b), demographic models can provide useful insights into potential population responses from the exposure to environmental pressures and perturbations. However, weak assumptions or inaccurate estimates of population parameters such as survivorship rates, breeding success, and juvenile-to-adult ratios (juvenile ratios), can limit the use of models. Thus, a cautious approach is warranted when forecasting long-term population trends using demographic models.

Most of the published demographic models used to estimate murrelet population trends employ Leslie Matrix modeling (McShane et al. 2004b). Two other more complex, unpublished models (Akcakaya 1997 and Swartzman et al. 1997 in McShane et al. 2004b) evaluate the effect of nest habitat loss on murrelets in Conservation Zone 4 (McShane et al. 2004b). McShane et al. (2004b) developed a stochastic Leslie Matrix model (termed "Zone Model") to project population trends in each murrelet Conservation Zone. The Zone Model was developed to integrate available demographic information for a comparative depiction of current expectations of future population trends and probability of extinction in each Conservation Zone (McShane et al. 2004b). Table 4.6 lists rangewide murrelet demographic parameter values from four studies all using Leslie Matrix models.

Table 4.6 Rangewide murrelet demographic parameter values based on four studies all using Leslie Matrix models.

Demographic Parameter	**Beissinger 1995**	**Beissinger and Nur 1997**	**Beissinger and Peery *in litt.* 2003**	**McShane et al. 2004**
Juvenile Ratios	0.10367	0.124 or 0.131	0.089	0.02 - 0.09
Annual Fecundity	0.11848	0.124 or 0.131	0.06-0.12	(See nest success)
Nest Success			0.16-0.43	0.38 - 0.54
Maturation	3	3	3	2 - 5
Estimated Adult Survivorship	85 % – 90%	85 % – 88 %	82 % - 90 %	83 % – 92 %

Regardless of model preference, the overall results of modeling efforts are in agreement, indicating murrelet abundance is declining (McShane et al. 2004b, pp. 6-27). The rates of decline are highly sensitive to the assumed adult survival rate used for calculation (Steven R. Beissinger and M. Z. Peery *in litt.* 2003). The most recent modeling effort using the "Zone Model" (McShane et al. 2004b) suggests the murrelet zonal sub-populations are declining at a rate of 3.0 to 6.2 percent per year.

Estimates of breeding success are best determined from nest site data, but difficulties in finding nests has led to the use of other methods, such as juvenile ratios and radio-telemetry estimations, each of which have biases. The nest success data presented in Murrelet Table 4.6 under McShane et al. (2004b) was derived primarily from radio telemetry studies; however the nests sampled in these studies were not representative of large areas and specifically did not include Washington or Oregon. In general, telemetry estimates are preferred over juvenile ratios for estimating breeding success due to fewer biases (McShane et al. 2004b), but telemetry data are not currently available for Washington or Oregon. Therefore, it is reasonable to expect that juvenile ratios derived from at-sea survey efforts best represent murrelet reproductive success in Washington, Oregon, and California.

Beissinger and Peery (Beissinger and Peery, *in litt.* 2003) performed a comparative analysis using data from 24 bird species to predict the juvenile ratios for murrelets of 0.27 (confidence intervals ranged from 0.15 to 0.65). Demographic models suggest murrelet population stability requires a minimum of 0.18 to 0.28 chicks per pair per year (Beissinger and Nur 1997 in USFWS 1997b). The lower confidence intervals for both the predicted juvenile ratio (0.15) and the stable population juvenile ratio (0.18) are greater than the juvenile ratios observed for any of the Conservation Zones (0.02 to 0.09 chicks per pair) (Beissinger and Nur 1997 in USFWS 1997b; Beissinger and Peery, *in litt.* 2003). Therefore, the juvenile ratios observed in the Conservation Zones are lower than predicted and are too low to obtain a stable population in any Conservation Zone. This indicates murrelet populations are declining in all Conservation Zones and will continue to decline until reproductive success improves.

Demographic modeling, the observed juvenile ratios, and adult survivorship rates suggests that the number of murrelets in Washington, Oregon, and California are too low to sustain a murrelet population. The rate of decline for murrelets throughout the listed range is estimated to be between 2.0 to 15.8 percent (Beissinger and Nur 1997 in USFWS 1997b; McShane et al. 2004b).

Murrelets in Washington (Conservation Zones 1 and 2)

Population estimates

Historically, murrelets in Conservation Zones 1 and 2 were "common" (Rathbun 1915 and Miller et al. 1935 in USFWS 1997b), "abundant" (Edson 1908 and Rhoades 1893 in USFWS 1997b), or "numerous" (Miller et al. 1935 in McShane et al. 2004b). Conservation Zone 1, encompassing the Puget Sound in northwest Washington, contains one of the larger murrelet populations in the species' listed range, and supports an estimated 41 percent of the murrelets in the coterminous United States (Huff et al. 2003). The 2007 population estimate (with 95 percent confidence intervals) for Conservation Zone 1 is 7,000 (4,100 – 10,400) and Conservation Zone 2 is 2,500 (1,300 – 3,800) (Falxa, pers. comm. 2008). In Conservation Zone 2, a higher density of murrelets occurs in the northern portion of the Zone (Huff et al. 2003) where the majority of available nesting habitat occurs. In Conservation Zone 1, higher densities of murrelets occur in the Straits of Juan de Fuca, the San Juan Islands, and the Hood Canal (Huff et al. 2003), which are in proximity to nesting habitat on the Olympic Peninsula and the North Cascade Mountains.

Although population numbers in Conservation Zones 1 and 2 are likely declining, the precise rate of decline is unknown. The juvenile ratio derived from at-sea survey efforts in Conservation Zone 1 is 0.09. The juvenile ratios was not collected in Conservation Zone 2; however, the juvenile ratio for Conservation Zone 3 is 0.08. Therefore, it is reasonable to infer that the juvenile ratio for Conservation Zone 2 is likely between 0.08 and 0.09. These low juvenile ratios infer there is insufficient juvenile recruitment to sustain a murrelet population in Conservation Zones 1 and 2. Beissinger and Peery (Beissinger and Peery, *in litt.* 2003) estimated the rate of decline for Conservation Zone 1 to be between 2.0 to 12.6 percent and between 2.8 to 13.4 percent in Conservation Zone 3. It is likely that the rate of decline in Conservation Zone 2 is similar to that of Conservation Zones 1 and 3.

Juvenile ratios in Washington may be skewed by murrelets coming and going to British Columbia. At-sea surveys are timed to occur when the least number of murrelets from British Columbia are expected to be present. However, recent radio-telemetry information indicates 1) murrelets nesting in British Columbia forage in Washington waters during the breeding season (Bloxton and Raphael 2008) and could be counted during at-sea surveys; and 2) adult murrelets foraging in Washington during the early breeding season moved to British Columbia in mid-June and mid-July (Bloxton and Raphael 2008) and would not have been counted during the at-sea surveys. The movements of juvenile murrelets in Washington and southern British Columbia are unclear. Therefore, until further information is obtained regarding murrelet migration between British Columbia and Washington, we will continue to rely on the at-sea derived juvenile ratios to evaluate the population status in Conservation Zones 1 and 2.

Habitat Abundance

Estimates of the amount of available suitable nesting habitat vary as much as the methods used for estimating murrelet habitat. McShane et al. (2004b) estimates murrelet habitat in Washington State at 1,022,695 acres, representing approximately 48 percent of the estimated 2,223,048 acres remaining suitable habitat in the listed range. McShane et al. (2004b) caution about making direct comparisons between current and past estimates due to the evolving definition of suitable habitat and methods used to quantify habitat. As part of the ongoing pursuit to improve habitat estimates, information was collected and analyzed by the Service in 2005 resulting in an estimated 751,831 acres in Conservation Zone 1 and 585,821 acres in Conservation Zone 2 (Table 4.7).

Table 4.7 Estimated acres of suitable nesting habitat for the murrelet managed by the Federal and non-Federal land managers in Conservation Zones 1 and 2.

Conservation Zone	**Estimated acres of suitable murrelet habitat by land management category** *				
	Federal	State	Private*	Tribal	Total
Puget Sound (Zone 1)	650,937	98,036	2,338	520	751,831
Western Washington Coast Range (Zone 2)	485,574	82,349	9,184	8,714	585,821
Total	1,136,511	180,385	11,522	9,234	1,337,652

*Estimated acres of private land represents occupied habitat. Additional suitable nesting habitat considered unoccupied by nesting murrelets is not included in this estimate.

Estimated acreages of suitable habitat on Federal lands in Table 4.7 are based on modeling and aerial photo interpretation and likely overestimate the actual acres of suitable murrelet habitat because 1) most acreages are based on models predicting spotted owl nesting habitat which include forested lands that do not have structures suitable for murrelet nesting, and 2) neither modeling or aerial photo interpretation can distinguish microhabitat features, such as nesting platforms or the presence of moss, that are necessary for murrelet nesting. The amount of high quality murrelet nesting habitat available in Washington, defined by the Service as large, old, contiguously forested areas not subject to human influences (e.g., timber harvest or urbanization) is expected to be a small subset of the estimated acreages in Table 4.7. Murrelets nesting in high-quality nesting habitat are assumed to have a higher nesting success rate than murrelets nesting in fragmented habitat near humans.

Other Recent Assessments of Murrelet Habitat in Washington

Two recent assessments of murrelet potential nesting habitat were developed for monitoring the Northwest Forest Plan (McShane et al. 2004d). This study provides a provincial-scale analysis of murrelet habitat derived from vegetation base maps, and includes estimates of habitat on State and private lands in Washington for the period of 1994 to 1996. Using vegetation data derived from satellite imagery, Raphael et al. (2006) developed two different approaches to model habitat suitability. The first model, or the Expert Judgment Model, is based on the judgment of an expert panel that used existing forest structure classification criteria (e.g., percent conifer cover, canopy structure, quadratic mean diameter, forest patch size) to classify forests into four classes of habitat suitability, with Class 1 indicating the least suitable habitat and Class 4 indicating the most highly suitable habitat. Raphael et al. (2006) found that across the murrelet range, most habitat-capable land (52 percent) is classified as Class 1 (lowest suitability) habitat and 18 percent is classified as Class 4 (highest suitability) habitat. In Washington, they found that there were approximately 954,200 acres of Class 4 habitat in between 1994 and 1996 (Table

3). However, only 60 percent of known nest sites in their study area were located in Class 4 habitat.

The second habitat model developed by Raphael et al. (2006) used the Biomapper Ecological Niche-Factor Analysis model developed by Hirzel et al. (2002). The resulting murrelet habitat suitability maps are based on both the physical and vegetative attributes adjacent to known murrelet occupied polygons or nest locations for each Northwest Forest Plan province. The resulting raster maps are a grid of 269 ft^2-cells (25 m^2-cells) (0.15 acres per pixel). Each cell in the raster is assigned a value of 0 to 100. Values closer to 100 represent areas that match the murrelet nesting locations while values closer to 0 are likely unsuitable for nesting (Raphael et al. 2006). These maps do not provide absolute habitat estimates, but rather a range of habitat suitability values, which can be interpreted in various ways. Raphael et al. (2006) noted that the results from the Ecological Niche Factor Analysis (ENFA) are not easily compared to results from the Expert Judgment Model because it was not clear what threshold from the habitat suitability ranking to use. Raphael et al. (2006) elected to display habitat suitability scores greater than 60 (HS >60) as a "generous" portrayal of potential nesting habitat and a threshold greater than 80 (HS >80) as a more conservative estimate. In Washington, there were over 2.1 million acres of HS >60 habitat, but only 440,700 acres of HS >80 habitat (Table 4.8). It is important to note that HS >60 habitat map captures 82 percent of the occupied nests sites in Washington, whereas the HS >80 habitat map only captures 36 percent of the occupied nests in Washington.

Table 4.8 Comparison of different habitat modeling results for the Washington nearshore zone (0 to 40 mi inland or Northwest Forest Plan Murrelet Zone 1).

Murrelet Habitat Model	**Habitat Acres on Federal Reserves (LSRs, Natl.Parks)**	**Habitat Acres on Federal, Non-Reserves (USFS Matrix)**	**Total Habitat Acres on Federal Lands**	**Total Habitat Acres on Non-Federal Lands (City, State, Private, Tribal)**	**Total Habitat Acres - All Ownerships**	**Percent of Total Habitat Acres on Non-Federal Lands**	**Percent of Known Murrelet Nest Sites in Study Area Occurring in this Habitat Classification**
ENFA* HS >80	284,300	18,600	302,900	137,800	440,700	31%	36%
EJM* Class 4	659,200	40,700	699,900	254,300	954,200	11%	60%
EJM Class 3 and Class 4	770,600	54,700	825,300	535,200	1,360,500	16%	65%
ENFA HS >60	927,000	85,300	1,012,300	1,147,100	2,159,400	53%	82%

*ENFA = Ecological Niche Facto Analysis. EJM = Expert Judgment Model. Results were summarized directly from Tables 4 and 5 and Tables 9 and 10 in Raphael et al (2005). All habitat estimates represent 1994-1996 values.

Because the HS >60 model performed best for capturing known murrelet nest sites, Raphael et al. (2006) suggest that the ENFA HS >60 model yields a reasonable estimate of potential murrelet nesting habitat. However, we found that large areas in southwest Washington identified in the HS >60 model likely overestimates the actual suitable habitat in this landscape due to a known lack of old-forest in this landscape. Despite the uncertainties associated with interpreting the various map data developed by Raphael et al. (2006), it is apparent that there is a significant portion of suitable habitat acres located on non-Federal lands in Washington, suggesting that non-Federal lands may play a greater role in the conservation needs of the species than has previously been considered. Using the most conservative criteria developed by Raphael et al. (2006) the amount of high-quality murrelet nesting habitat on non-Federal lands in Washington varies from 11 percent to as high as 31 percent (Table 4.8).

Raphael et al. (2006) note that the spatial accuracy of the map data are limited and that the habitat maps are best used for provincial-scale analysis. Due to potential errors in vegetation mapping and other potential errors, these maps are not appropriate for fine-scale project mapping.

Conservation Zone 1

The majority of suitable murrelet habitat in Conservation Zone (Zone) 1 occurs in northwest Washington and is found on Forest Service and National Park Service lands, and to a lesser extent on State lands. The majority of the historic habitat along the eastern and southern shores of the Puget Sound has been replaced by urban development resulting in the remaining suitable habitat further inland from the marine Environment (USFWS 1997b).

Conservation Zone 2

Murrelet nesting habitat north of Gray's Harbor in Zone 2 occurs largely on State, Forest Service, National Park Service, and Tribal lands, and to a lesser extent, on private lands. Alternatively, the majority of habitat in the southern portion of Zone 2 occurs primarily on State lands, with a small amount on private lands.

Threats

Murrelets remain subject to a variety of anthropogenic threats within the upland and marine environment. They also face threats from low population numbers, low immigration rates, high predation rates, and disease.

Threats in the Marine Environment

Threats to murrelets in the marine environment include declines in prey availability; mortality associated with exposure to oil spills, gill net and other fisheries; contaminants suspended in marine waters; and visual or sound disturbance from recreational or commercial watercrafts (57 FR 45328 [October 1, 1992]; (Ralph et al. 1995a; USFWS 1997b; McShane et al. 2004b). Activities, such as pile driving and underwater detonations, that result in elevated underwater sound pressure levels may also pose a threat to murrelets.

Prey Availability

Many fish populations have been depleted due to overfishing, reduction in the amount or quality of spawning habitat, and pollution. As of 2004, only 50 percent of the Puget Sound herring stocks were classified as healthy or moderately healthy, with north Puget Sound's stock being considered depressed and the Strait of Juan de Fuca's stocks being classified as critical (McShane et al. 2004a). Natural mortality in some of these stocks has increased (e.g. the mean estimated annual natural mortality rate for sampled stocks from 1987 through 2003 averaged 71 percent, up from 20 to 40 percent in the late 1970s) (WDFW 2005a). There is currently only one commercial herring fishery which operates primarily in south and central Puget Sound (WDFW 2005c) where herring stocks are healthier. Unfortunately, the decline of some herring stocks may be affecting the forage base for murrelets in Puget Sound. There is limited information available for the coastal herring populations (Willapa Bay and Grays Harbor), but these populations appear to have relatively high levels of abundance (WDFW 2005b). There are herring fisheries in Willapa Bay and Grays Harbor, but no direct harvest is allowed in the coastal waters.

While there are commercial and recreational fisheries for surf smelt, the amount of harvest does not appear to be impacting the surf smelt stocks. There are no directed commercial fisheries for sand lance (Bargmann 1998). Anchovies are taken commercially within coastal and estuarine waters of Washington. While the current harvest level doesn't appear to be impacting anchovy stocks, there is no current abundance information (Bargmann 1998).

In addition to fishing pressure, oceanographic variation can influence prey availability. While the effects to murrelets from events such as El Niño have not been well documented, El Niño events are thought to reduce overall prey availability and several studies have found that El Niño events can influence the behavior of murrelets (McShane et al. 2004b). Even though changes in prey availability may be due to natural and cyclic oceanographic variation, these changes may exacerbate other threats to murrelets in the marine environment.

Shoreline development has affected and will continue to effect coastal processes. Shipping, bulkheads, and other shoreline developments have contributed to the reduction in eelgrass beds and other spawning and rearing areas for forage species.

Oil Spills

Murrelet mortality from oil pollution is a conservation issue in Washington (USFWS 1997b). Most oil spills and chronic oil pollution that can affect murrelets occur in areas of high shipping traffic, such as the Strait of Juan de Fuca and Puget Sound. There have been at least 47 oil spills of 10,000 gal or more in Washington since 1964 (WDOE 2004). However, the number of oil spills has generally declined since passage of the U.S. Oil Pollution Act in 1990. The estimated annual mortality of murrelets from oil spills in Washington has decreased from 3 to 41 birds per year (between 1977 and 1992) to 1 to 2 birds per year (between 1993 and 2003) (McShane et al. 2004b).

Since the murrelet was listed, the amount of oil tanker and shipping traffic has continued to increase (USFWS 1997b; USFWS 1997d). Large commercial ships, including oil tankers, cargo ships, fish processing ships, and cruise ships, enter Washington waters more than 7,000 times each year, bound for ports in Puget Sound, British Columbia, Grays Harbor, and the Columbia River (WDOE 2004). Additionally, 4,500 tank-barge transits, 160,000 ferry transits, and military vessel traffic occur in these same waters each year (WDOE 2004). Individually these vessels may carry up to 33 M gal of crude oil or refined petroleum products, but collectively, they carry about 15.1 B gal across Puget Sound waters each year (WDOE 2004). These numbers are expected to increase as the human population and commerce continues to grow. Currently, there are State and Federal requirements for tug escorts of laden oil tankers transiting the waters of Puget Sound east of Dungeness Spit. However, the Federal requirements do not apply to double-hulled tankers and will no longer be in effect once the single-hull tanker phase-out is complete (WDOE 2005). Washington State is considering revising their tug escort requirements (WDOE 2005); however, the current tug escort requirements remain in place until the Washington State Legislature makes a change.

The U.S. Coast Guard rated the Dungeness area in the Strait of Juan de Fuca as being in the top five high-risk areas of the United States for being impacted by oil spills (USFWS 2003). Therefore, even though the threat from oil spills appears to have been reduced since the murrelet was listed, the risk of a catastrophic oil spill remains, and could severely impact adult and/or juvenile murrelets in Conservation Zones 1 and 2.

Gillnets

Murrelet mortality from gillnet fishing has been considered a conservation issue in Washington (USFWS 1997b; Melvin et al. 1999). Murrelets can also be killed by hooking with fishing lures and entanglement with fishing lines (Carter et al. 1995). There is little information available on murrelet mortality from net fishing prior to the 1990s, although it was known to occur (Carter et al. 1995). In the mid 1990s, a series of fisheries restrictions and changes were implemented to address mortality of all species of seabirds, resulting in a lower mortality rate of murrelets (McShane et al. 2004b). Fishing effort has also decreased since the 1980s because of lower catches, fewer fishing vessels, and greater restrictions (McShane et al. 2004b), although a regrowth in gill net fishing is likely to occur if salmon stocks increase. In most areas, the threat from gill net fishing has been reduced or eliminated since 1992, but threats to adult and juvenile murrelets are still present in Washington waters due to gill net mortality (McShane et al. 2004b).

Entanglement in derelict fishing nets, which are nets that have been lost, abandoned or discarded in the marine environment, may also pose a threat. Derelict gear can persist in the environment for decades and poses a threat to marine mammals, seabirds, shellfish, and fish. A recent survey estimated 3,900 derelict nets need to be removed from Puget Sound annually (Northwest Straits Foundation 2007) and each year the number of new derelict nets increases faster than the number removed. Over 50 percent of the derelict nets in Puget Sound occur in waters where murrelet densities are the highest in Washington. Derelict fishing gear also occurs along the Washington coast and the outer Straits of Juan de Fuca. While this high energy environment may reduce the time a derelict net remains suspended compared to a lower energy environment like the inner Puget Sound where gear may persist for years (NRC 2007), the amount of time a derelict net poses a threat to marine species depends on the length and type of the net and cause of entanglement.

Marine Contaminants

The primary consequence from the exposure of murrelets to contaminants is reproductive impairment. Reproduction can be impacted by food web bioaccumulation of organochlorine pollutants and heavy metals discharged into marine areas where murrelets feed and prey species concentrate (Fry 1995). However, murrelet exposure is likely a rare event because murrelets have widely dispersed foraging areas and they feed extensively on transient juvenile and subadult midwater fish species that are expected to have low pollutant loads (McShane et al. 2004b). The greatest exposure risk to murrelets may occur at regular feeding areas near major pollutant sources, such as those found in Puget Sound (McShane et al. 2004b).

Disturbance

In coastal and offshore marine environments, vehicular disturbance (e.g., boats, airplanes, personal watercraft) is known to elicit behavioral responses in murrelets of all age classes (Kuletz 1996; Speckman 1996; Nelson 1997a). Aircraft flying at low altitudes and boating activity, in particular motorized watercraft, are known to cause murrelets to dive and are thought to especially affect adults holding fish (Nelson 1997a). It is unclear to what extent this kind of disturbance affects the distribution, movements, foraging efficiency, and overall fitness of murrelets. However, it is unlikely this type of disturbance has decreased since 1992 because the shipping traffic and recreational boat use in the Puget Sound and Strait of Juan de Fuca has continued to increase.

Marine projects that include seismic exploration, pile driving, detonation of explosives and other activities that generate percussive sounds can expose murrelets to elevated underwater sound pressure levels (SPLs). High underwater SPLs can have adverse physiological and neurological effects on a wide variety of vertebrate species (Yelverton et al. 1973; Yelverton and Richmond 1981b; Steevens et al. 1999; Fothergill et al. 2001; Cudahy and Ellison 2002; U.S. Department of Defense 2002; Popper 2003). High underwater SPLs are known to injure and/or kill fish by causing barotraumas (pathologies associated with high sound levels including hemorrhage and rupture of internal organs), as well as causing temporary stunning and alterations in behavior (Turnpenny and Nedwell 1994; Turnpenny et al. 1994; Popper 2003; Hastings and Popper 2005b). During monitoring of seabird response to pile driving in Hood Canal, Washington, a pigeon guillemot (*Cepphus columba*) was observed having difficulty getting airborne after being exposed to underwater sound from impact pile driving (Hastings and Popper 2005a). In controlled experiments using underwater explosives, rapid change in SPLs caused internal hemorrhaging and mortality in submerged mallard ducks (*Anas platyrhnchos*) (Yelverton et al. 1973). Risk of injury appears related to the effect of rapid pressure changes, especially on gas filled spaces in the bodies of exposed organisms (Turnpenny et al. 1994). In studies on ducks (*Anas spp.*) and a variety of mammals, all species exposed to underwater blasts had injuries to gas filled organs including eardrums (Yelverton and Richmond 1981b). These studies indicate that similar effects can be expected across taxonomical species groups.

Physical injury may not result in immediate mortality. If an animal is injured, death may occur several hours or days later, or injuries may be sublethal. Sublethal injuries can interfere with the ability of an organism to carry out essential life functions such as feeding and predator avoidance. Diving birds are able to detect and alter their behavior based on sound in the underwater environment (Yelverton and Richmond 1981a) and elevated underwater SPLs may cause murrelets to alter normal behaviors, such as foraging. Disturbance related to elevated underwater SPLs may reduce foraging efficiency resulting in increased energetic costs to all murrelet age classes in the marine environment and may result in fewer deliveries or lower quality food being delivered to nestlings.

Threats in the Terrestrial Environment

Habitat

Extensive harvest of late-successional and old-growth forest was the primary reason for listing the murrelet as threatened. Due primarily to extensive timber cutting over the past 150 years, at least 82 percent of the old-growth forests existing in western Washington and Oregon prior to the 1840s have been harvested (Teensma et al. 1991; Booth 1991; Ripple 1994; Perry 1995). About 10 percent of pre-settlement old-growth forests remain in western Washington (Norse 1990; Booth 1991). Although the Northwest Forest Plan has reduced the rate of habitat loss on Federal lands, the threat of continued loss of suitable nesting habitat remains on Federal and non-Federal lands through timber harvest and natural events such as wildfire, insect outbreaks, and windthrow.

Natural disturbance has the potential to affect the amount and quality of murrelet nesting habitat. Wildfire and windthrow result in immediate loss of habitat and can also influence the quality of adjacent habitat. Global warming, combined with long-term fire suppression on Federal lands, may result in higher incidences of stand-replacing fires in the future (McShane et al. 2004b). As forest fragmentation increases, the threat of habitat loss due to windthrow is likely to increase. In addition, insects and disease can kill complete stands of habitat and can contribute to hazardous forest fire conditions.

Between 1992 and 2003, the loss of suitable murrelet habitat totaled 22,398 acres in Washington, Oregon, and California combined, of which 5,364 acres resulted from timber harvest and 17,034 acres resulted from natural events (McShane et al. 2004b). The data presented by McShane represented losses primarily on Federal lands, and did not include data for most private lands within the murrelets' range. Habitat loss and fragmentation is expected to continue in the near future, but at an uncertain rate (McShane et al. 2004b). Raphael et al. (2006) recently completed a change analysis for marbled murrelet habitat on both Federal and non-Federal lands for the period from 1992 to 2003, based on stand disturbance map data developed by Healey et al. (2003). Raphael et al. (2006) estimated that habitat loss ranging from 60,000 acres up to 278,000 acres has occurred across the listed range of the species, with approximately 10 percent of habitat loss occurring on Federal lands, and 90 percent occurring on non-Federal lands. The variation in the acreage estimates provided by Raphael et al. (2006) are dependant upon the habitat model used (Table 4.8) to evaluate habitat change over time.

Gains in suitable nesting habitat are expected to occur on Federal lands over the next 40 to 50 years, but due to the extensive historic habitat loss and the slow replacement rate of murrelets and their habitat, the species is potentially facing a severe reduction in numbers in the coming 20 to 100 years (USFS and USBLM 1994a; Beissinger 2002). In addition to direct habitat removal, forest management practices can fragment murrelet habitat; this reduces the amount and heterogeneous nature of the habitat, reduces the forest patch sizes, reduces the amount of interior or core habitat, increases the amount of forest edge, isolates remaining habitat patches, and creates “sink” habitats (McShane et al. 2004b). There are no estimates available for the amount of suitable habitat that has been fragmented or degraded since 1992. However, the ecological consequences of these habitat changes to murrelets can include effects on population viability and size, local or regional extinctions, displacement, fewer nesting attempts, failure to breed, reduced fecundity, reduced nest abundance, lower nest success, increased predation and parasitism rates, crowding in remaining patches, and reductions in adult survival (Raphael et al. 2002).

Predation

Predation is expected to be the principal factor limiting murrelet reproductive success and nest site selection (Nelson and Hamer 1995a; Ralph et al. 1995a). Murrelets are believed to be highly vulnerable to nest predation compared to other alcids and forest nesting birds (Nelson and Hamer 1995a; USFWS 1997b). Murrelets have no protection at nest sites other than the ability to remain hidden. Nelson and Hamer (1995a) hypothesized that small increases in murrelet predation will have deleterious effects on murrelet population viability due to their low reproductive rate (one egg clutches).

Known predators of adult murrelets in the forest environment include the peregrine falcon (*Falco peregrinus*), sharp-shinned hawk (*Accipiter striatus*), common raven (*Corvus corax*), northern goshawk (*Accipiter gentilis*), and bald eagle (*Haliaeetus leucocephalus*). Common ravens and Steller’s jays (*Cyanocitta stelleri*) are known to take both eggs and chicks at the nest, while sharp-shinned hawks have been found to take chicks. Common ravens account for the majority of egg depredation, as they appear to be the only predator capable of flushing incubating or brooding adults from a nest (Nelson and Hamer 1995a). Suspected nest predators include great horned owls (*Bubo virginianus*), barred owls (*Strix varia*), Cooper’s hawks (*Accipiter cooperi*), northwestern crows (*Corvus caurinus*), American crows (*Corvus brachyrhynchos*), and gray jays (*Perisoreus canadensis*) (Nelson and Hamer 1995a; Nelson 1997a; Manley 1999). Predation by squirrels and mice has been documented at artificial nests and these animals cannot be discounted as potential predators on eggs and chicks (Luginbuhl et al. 2001; Raphael et al. 2002; Bradley and Marzluff 2003).

Losses of eggs and chicks to avian predators have been determined to be the most important cause of nest failure (Nelson and Hamer 1995a; McShane et al. 2004b). The risk of predation by avian predators appears to be highest in complex structured landscapes in proximity to edges and human activity, where many of the corvid (e.g., crows, ravens) species are in high abundance. Predation rates are influenced mainly by habitat stand size, habitat quality, nest placement (on the edge of a stand versus the interior of a stand), and proximity of the stand to human activity centers. The quality of murrelet nest habitat decreases in smaller stands because forest edge increases in relation to the amount of interior forest, while forest stands near human activity centers (less than 0.62 mi or 1 km), regardless of size, are often exposed to a higher density of corvids due to their attraction to human food sources (Marzluff et al. 2000). The loss of nest contents to avian predators increases with habitat fragmentation and an increase in the ratio of forest edge to interior habitat (Nelson and Hamer 1995a; McShane et al. 2004b). For example, Nelson and Hamer (1995a) found successful nests were farther from edges (greater than 55 m) and were better concealed than unsuccessful nests.

The abundance of several corvid species has increased dramatically in western North America as a result of forest fragmentation, increased agriculture, and urbanization (McShane et al. 2004b). It is reasonable to infer that as predator abundance has increased, predation on murrelet chicks and eggs has also increased, and murrelet reproductive success has decreased. It is also reasonable to assume that this trend will not be interrupted or reversed in the near future, as forest fragmentation, agriculture, and urbanization continue to occur.

Other Threats

Murrelets are subject to additional threats from diseases, genetics, low population numbers, and low immigration rates. To date, inbreeding (mating between close genetic relatives) and/or hybridizing (breeding with a different species or subspecies) have not been identified as threats to murrelet populations. However, as abundance declines, a corresponding decrease in the resilience of the population to disease, inbreeding or hybridization, and other perturbations may occur. Additionally, murrelets are considered to have low recolonization potential because their low immigration rate makes the species slow to recover from local disturbances (McShane et al. 2004b).

The emergence of fungal, parasitic, bacterial, and viral diseases has affected populations of seabirds in recent years. West Nile virus disease has been reported in California which is known to be lethal to seabirds. While the amount of negative impact this disease may bring is unknown, researchers agree that it is only a matter of time before West Nile virus reaches the Washington seabird population. Effects for murrelets from West Nile virus and other diseases are expected to increase in the near future due to an accumulation of stressors such as oceanic temperature changes, overfishing, and habitat loss (McShane et al. 2004b).

Murrelets may be sensitive to human-caused disturbance due to their secretive nature and their vulnerability to predation. There are little data concerning the murrelet's vulnerability to disturbance effects, except anecdotal researcher observations that indicate murrelets typically exhibit a limited, temporary behavioral response (if any) to noise disturbance at nest sites and are able to adapt to auditory stimuli (Long and Ralph 1998; Golightly et al. 2002; Singer et al. 1995 in McShane et al. 2004b). In general, responses to auditory stimuli at nests sites have been modifications of posture and on-nest behaviors (Long and Ralph 1998). While the unique breeding biology of the murrelet is not conducive to comparison of the reproductive success of other species, studies on other alcid and seabird species have revealed detrimental effects of disturbance to breeding success and the maintenance of viable populations (Cairns 1980; Pierce and Simons 1986; Piatt et al. 1990; Beale and Monaghan 2004).

Research on a variety of other species, including other seabirds, indicate an animal's response to disturbance follows the same pattern as its response to encountering predators, and anti-predator behavior has a cost to other fitness enhancing activities, such as feeding and parental care (Frid and Dill 2002). Some authors indicate disturbance stimuli can directly affect the behavior of individuals and indirectly affect fitness and population dynamics through increased energetic costs (Carney and Sydeman 1999; Frid and Dill 2002). Responses by murrelet adults and chicks to calls from corvids and other potential predators include no response, alert posturing, aggressive attack, and temporarily leaving a nest (adults only) (McShane et al. 2004b). However, the most typical behavior of chicks and adults in response to the presence of a potential predator is to flatten against a tree branch and remain motionless (Nelson and Hamer 1995a; McShane et al. 2004b). Therefore, researcher's anecdotal observations of little or no physical response by murrelets are consistent with the behavior they will exhibit in response to a predator. In addition, there may have been physiological responses researchers cannot account for with visual observations. Corticosterone studies have not been conducted on murrelets, but studies on other avian species indicate chronic high levels of this stress hormone may have negative consequences on reproduction or physical condition (Wasser et al. 1997; Kitaysky et al. 2001; Marra and Holberton 1998 in McShane et al. 2004b).

Although detecting effects of sub-lethal noise disturbance at the population level is hindered by the breeding biology of the murrelet, the effect of noise disturbance on murrelet fitness and reproductive success should not be completely discounted (McShane et al. 2004b). In recently completed analyses, the Service concluded the potential for injury associated with disturbance (visual and sound) to murrelets in the terrestrial environment includes flushing from the nest, aborted feeding, and postponed feedings (McShane et al. 2004c). These responses by individual murrelets to disturbance stimuli can reduce productivity of the nesting pair, as well as the entire population (USFWS 1997b).

Conservation Needs

The Recovery Plan outlines the conservation strategy for the species. In the short-term, specific actions necessary to stabilize the population include maintaining occupied habitat, maintaining large blocks of suitable habitat, maintaining and enhancing buffer habitat, decreasing risks of nesting habitat loss due to fire and windthrow, reducing predation, and minimizing disturbance.

Long-term conservation needs include increasing productivity (abundance, the ratio of juveniles to adults, and nest success) and population size; increasing the amount (stand size and number of stands), quality, and distribution of suitable nesting habitat; protecting and improving the quality of the marine environment; and reducing or eliminating threats to survivorship by reducing predation in the terrestrial Environment and anthropogenic sources of mortality at sea. The Service estimates recovery of the murrelet will require at least 50 years (USFWS 1997b).

The Recovery Plan states that four of the six Conservation Zones (Zones) must be functional in order to effectively recover the murrelet in the short- and long-term; that is, to maintain viable populations that are well-distributed. However, based on the new population estimates, it appears only three of the Zones contain relatively robust numbers of murrelets (Zones 1, 3, and 4). Zones 1 and 4 contain the largest number of murrelets compared to the other four Zones. This alone would seem to indicate a better condition there, but areas of concern remain. For example, the population in Zone 4 was impacted when oil spills killed an estimated 10 percent of the population (Bentivoglio et al. 2002; Ford et al. 2002), small oil spills continue to occur in

Zone 1, and the juvenile ratios in both of these Zones continue to be too low to establish stable or increasing populations (Beissinger and Peery, *in litt.* 2003).

Murrelets in Zones 3, 5, and 6 have suffered variously from past oil spills which killed a large number of murrelets (Zone 3) (Ford et al. 2001b), extremely small population sizes (Zones 5 and 6), and alarmingly low reproductive rates (Zone 6) (Ford et al. 2001a). These factors have brought the status of the species to a point where recovery in Zones 5 and 6 may be precluded (Beissinger 2002). The poor status of murrelet populations in the southern Zones emphasizes the importance of supporting murrelet populations in Zones 1 and 2 in order to preserve the opportunity to achieve murrelet recovery objectives.

Conservation Strategy

Marine Environment

Protection of marine habitat is a component of the recovery strategy. The main threat to murrelets in the marine environment is the loss of individuals through death or injury, generally associated with oil spills and gill-net entanglements. The recovery strategy recommends providing protection within marine waters in such a way as to reduce or eliminate murrelet mortality (USFWS 1997b). The recovery strategy specifically recommends protection within all waters of Puget Sound and Strait of Juan de Fuca, and within 1.2 mi of shore along the Pacific Coast from Cape Flattery to Willapa Bay. However, newer information indicates the majority of murrelet activity along the Washington Coast occurs within 5 mi (8 km) of shore (Raphael et al. 2007), suggesting that protections should be extended to encompass this area. Management strategies could include exclusion of vessels, stricter hull requirements, exclusion of net fisheries, or modification of fishing gear.

In Washington State, the Washington Fish and Game Commission requires the use of alternative gear (i.e., visual alerts within the upper 7 ft of a multifilament net), prohibits nocturnal and dawn fishing for all non-treaty gill-net fisheries, and closes areas to gill-net fishing in order to reduce by-catch of murrelets. The Olympic Coast National Marine Sanctuary was established in 1994 along the outer Washington coast from Cape Flattery south to approximately the Copalis River and extending between 25 mi and 40 mi offshore. Oil exploration and development are prohibited within this Sanctuary (NOAA 1993).

Terrestrial Habitat Management

The loss of nesting habitat (old-growth/mature forest) has generally been identified as the primary cause of the murrelet population decline and disappearance across portions of its range (Ralph et al. 1995a). Logging, urbanization, and agricultural development have all contributed to the loss of habitat, especially at lower elevations.

The recovery strategy for the murrelet is contained within the Marbled Murrelet Recovery Plan (Recovery Plan) (USFWS 1997b) relies heavily on the Northwest Forest Plan (NWFP) to achieve recovery on Federal lands in Washington, Oregon, and California. However, the Recovery Plan also addresses the role of non-Federal lands in recovery, including Habitat

Conservation Plans, State forest practices, and lands owned by Native American Tribes. The importance of non-Federal lands in the survival and recovery of murrelets is particularly high in Conservation Zones, where Federal lands, and privately held conservation lands (e.g., The Nature Conservancy Teal Slough, Ellsworth, Washington), within 50 mi of the coastline are sparse, such as the southern half of Conservation Zone 2.

Lands considered essential for the recovery of the murrelet within Conservation Zones 1 and 2 are 1) any suitable habitat in a Late Successional Reserve (LSR), 2) all suitable habitat located in the Olympic Adaptive Management Area, 3) large areas of suitable nesting habitat outside of LSRs on Federal lands, such as habitat located in the Olympic National Park, 4) suitable habitat on State lands within 40 mi of the coast, and 5) habitat within occupied murrelet sites on private lands (USFWS 1997b).

Northwest Forest Plan

When the U.S. Forest Service (USFS) and Bureau of Land Management incorporated the NWFP as the management framework for public lands, a long-term habitat management strategy for murrelets (USFS and USBLM 1994a; USFS and USBLM 1994b) was established. The NWFP instituted pre-project surveys of murrelet habitat in areas planned for timber harvest and the protection of existing habitat at sites determined through surveys to be occupied by murrelets.

In the short-term, all known-occupied sites of murrelets occurring on USFS or Bureau of Land Management lands under the NWFP are to be managed as Late Successional Reserves (LSRs). In the long-term, unsuitable or marginally suitable habitat occurring in LSRs will be managed, overall, to develop late-successional forest conditions, thereby providing a larger long-term habitat base into which murrelets may eventually expand. Thus, the NWFP approach offers both short-term and long-term benefits to the murrelet.

Over 80 percent of murrelet habitat on Federal lands in Washington occurs within land management allocations that protect the habitat from removal or significant degradation. Scientists predicted implementation of the NWFP would result in an 80 percent likelihood of achieving a well-distributed murrelet population on Federal lands over the next 100 years (USFS and USBLM 1994a). Although the NWFP offers protection of known-occupied murrelet sites, concerns over the lingering effects of the historic widespread removal of suitable habitat will remain until the habitat recovers to late-successional characteristics. Habitat recovery will require over 100 years in many LSRs.

Habitat Conservation Plans

Four Habitat Conservation Plans (HCP) addressing murrelets in Washington have been completed for private/corporate forest land managers within the range of the murrelet: West Fork Timber Corporation (Murray Pacific Corporation 1993; Murray Pacific Corporation 1995; USFWS 1995b) (Mineral Tree Farm HCP); Plum Creek Timber Company (USFWS 1995a; USFWS 1996a; Plum Creek Timber Company, L.P. 1999; USFWS 1999) (Cascades HCP; I-90 HCP); Port Blakely Tree Farms, L.P. (Port Blakely Tree Farms, L.P. 1996; USFWS 1996b) (R.B. Eddy Tree Farm HCP); and Simpson Timber Company (Simpson Timber Company 2000;

USFWS 2000b) (Olympic Tree Farm HCP). Habitat Conservation Plans have also been completed for two municipal watersheds, City of Tacoma (Tacoma Public Utilities 2001; USFWS 2001a) (Green River HCP) and City of Seattle (USFWS 2000a; City of Seattle 2001) (Cedar River HCP), and the Washington Department of Natural Resources (USFWS 1997a; WDNR 1997b). The HCPs which address murrelets cover approximately 500,000 acres of non-Federal (private/corporate) lands, over 100,000 acres of municipal watershed, and over 1.6 million acres of State-managed lands. However, only a portion of these lands contain suitable murrelet habitat.

The WDNR HCP addresses murrelets in Conservation Zones 1 and 2. All of the others address murrelets in Conservation Zone 1. Most of the murrelet HCPs in Washington employ a consistent approach for murrelets by requiring the majority of habitat to be surveyed prior to timber management. Only poor-quality marginal habitat (with a low likelihood of occupancy) is released for harvest without survey. All known occupied habitat is protected to varying degrees, but a "safe-harbor-like" approach is used to address stands which may be retained as, or develop into, suitable habitat and become occupied in the future. This approach would allow future harvest of habitat which is not currently nesting habitat.

Washington State Forest Practices Regulations

Under Washington Forest Practices Rules, which apply to all non-Federal lands not covered by an HCP (WDNR 1997a), surveys for murrelets are required prior to the harvest of suitable nesting habitat. These criteria vary depending on the location of the stand. For stands found to be occupied or known to be previously occupied, the WDNR makes a decision to issue the permit based upon a significance determination. If a determination of significance is made, preparation of a State Environmental Policy Act Environmental Impact Statement is required prior to proceeding. If a determination of non-significance or mitigated determination of non-significance is reached, the action can proceed without further environmental assessment.

Tribal Management

The management strategy of the Bureau of Indian Affairs for the murrelet focuses on working with Tribal governments on a government-to-government basis to develop management strategies for reservation lands and trust resources. The Bureau of Indian Affairs' management strategy typically focus on avoiding harm to murrelets when feasible, to facilitate the trust responsibilities of the United States. However, other factors must be considered. Strategies must foster Tribal self-determination, and must balance the needs of the species and the environmental, economic, and other objectives of Indian Tribes within the range of the murrelet (Renwald 1993). For example, one of the Bureau of Indian Affairs' main goals for murrelet protection includes assisting Native American Tribes in managing habitat consistent with tribal priorities, reserved Indian rights, and legislative mandates.

Summary

Demographic modeling results indicate murrelet populations are declining within each Conservation Zone and throughout the listed range. The juvenile to adult ratios observed at sea in the Conservation Zones are too low to obtain a stable population in any Conservation Zone, which indicates murrelet abundance in all Conservation Zones will continue to decline until reproductive success improves. In other words, there is insufficient recruitment of juveniles to sustain a murrelet population in the listed range of the species.

Some of the threats to the murrelet population may have been reduced as a result of the species' listing under the Act, such as the passage of the Oil Pollution Act and implementation of the NWFP. However, no threats have been reversed since listing and in some areas threats, such as predation and West Nile Virus, may be increasing or emerging. Threats continue to contribute to murrelet population declines through adult and juvenile mortality and reduced reproduction. Therefore, given the current status of the species and background risks facing the species, it is reasonable to assume that murrelet populations in Conservation Zones 1 and 2 and throughout the listed range have little resilience to deleterious population-level effects and are at high risk of extirpation.

Considering the life history characteristics of the murrelet, with the aggregate effects of inland habitat loss and fragmentation and at-sea mortality, the species' capability to recover from lethal perturbations at the population or metapopulation (Conservation Zone) scale is extremely low. The low observed reproductive rates make the species highly susceptible to local extirpations when exposed to repeated perturbations at a frequency which exceeds the species' loss-replacement rate. Also troublesome is the ineffectiveness of recovery efforts at reversing the ongoing lethal consequences in all demographic classes from natural and anthropogenic sources. Despite the relatively long potential life span of adult murrelets, the annual metapopulation replacement rates needed for long-term metapopulation maintenance and stability is currently well below the annual rate of individuals being removed from each metapopulation. As a result, murrelet metapopulations are currently not self-sustaining or self-regulating.

Accordingly, the Service concludes the current environmental conditions for murrelets in the coterminous United States appear to be insufficient to support the long-term conservation needs of the species. Although information is not sufficient to determine whether murrelets are nesting at or near the carrying capacity in the remaining nest habitat, activities which degrade the existing conditions of occupied nest habitat or reduce adult survivorship and/or nest success of murrelets will be of greatest consequence to the species. Actions resulting in the further loss of occupied nesting habitat, mortality to breeding adults, eggs, or nestlings will reinforce the current murrelet population decline throughout the coterminous United States.

4.5 Status of Bull Trout Critical Habitat (Rangewide)

This Biological Opinion does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 CFR 402.02. Instead, we have relied upon the statute and the August 6, 2004, Ninth Circuit Court of Appeals decision in Gifford Pinchot Task Force v. U.S. Fish and Wildlife Service (No. 03-35279) to complete the following analysis with respect to critical habitat.

Legal Status

The Service published a final critical habitat designation for the coterminous United States population of the bull trout on September 26, 2005 (70 FR 56212); the rule became effective on October 26, 2005. The scope of the designation involved the Klamath River, Columbia River, Coastal-Puget Sound, and Saint Mary-Belly River population segments (also considered as interim recovery units). Rangewide, the Service designated 143,218 acres of reservoirs or lakes and 4,813 stream or shoreline miles as bull trout critical habitat (Table 4.9).

Table 4.9 Stream/shoreline distance and acres of reservoir or lakes designated as bull trout critical habitat by state.

	Stream/shoreline Miles	Stream/shoreline Kilometers	Acres	Hectares
Idaho	294	474	50,627	20,488
Montana	1,058	1,703	31,916	12,916
Oregon	939	1,511	27,322	11,057
Oregon/Idaho	17	27		
Washington	1,519	2,445	33,353	13,497
Washington (marine)	985	1,585		

Although critical habitat has been designated across a wide area, some critical habitat segments were excluded in the final designation based on a careful balancing of the benefits of inclusion versus the benefits of exclusion (see Section 3(5)(A) and Exclusions under Section 4(b)(2) in the final rule). This balancing process resulted in all proposed critical habitat being excluded in 9 proposed critical habitat units: Unit 7 (Odell Lake), Unit 8 (John Day River Basin), Unit 15 (Clearwater River Basin), Unit 16 (Salmon River Basin), Unit 17 (Southwest Idaho River Basins), Unit 18 (Little Lost River), Unit 21 (Upper Columbia River), Unit 24 (Columbia River), and Unit 26 (Jarbidge River Basin). The remaining 20 proposed critical habitat units were designated in the final rule. It is important to note that the exclusion of waterbodies from designated critical habitat does not negate or diminish their importance for bull trout conservation.

Conservation Role and Description of Critical Habitat

The conservation role of bull trout critical habitat is to support viable core area populations (70 FR 56212). The core areas reflect the metapopulation structure of bull trout and are the closest approximation of a biologically functioning unit for the purposes of recovery planning and risk analyses. Critical habitat units generally encompass one or more core areas and may include foraging, migration, and overwintering (FMO) areas, outside of core areas, that are important to the survival and recovery of bull trout.

Because there are numerous exclusions that reflect land ownership, designated critical habitat is often fragmented and interspersed with excluded stream segments. These individual critical habitat segments are expected to contribute to the ability of the stream to support bull trout within local populations and core areas in each critical habitat unit.

The primary function of individual critical habitat units is to maintain and support core areas which 1) contain bull trout populations with the demographic characteristics needed to ensure their persistence and contain the habitat needed to sustain those characteristics (Rieman and McIntyre 1993c); 2) provide for persistence of strong local populations, in part, by providing habitat conditions that encourage movement of migratory fish (Rieman and McIntyre 1993c; MBTSG 1998); 3) are large enough to incorporate genetic and phenotypic diversity, but small enough to ensure connectivity between populations (Rieman and McIntyre 1993c; Hard 1995; Healey and Prince 1995; MBTSG 1998); and 4) are distributed throughout the historic range of the species to preserve both genetic and phenotypic adaptations (Rieman and McIntyre 1993c; Hard 1995; MBTSG 1998; Rieman and Allendorf 2001).

The Olympic Peninsula and Puget Sound critical habitat units are essential to the conservation of amphidromous bull trout, which are unique to the Coastal-Puget Sound bull trout population. These critical habitat units contain nearshore and freshwater habitats, outside of core areas, that are used by bull trout from one or more core areas. These habitats, outside of core areas, contain Primary Constituent Elements (PCEs) that are critical to adult and subadult foraging, overwintering, and migration.

Within the designated critical habitat areas, the PCEs for bull trout are those habitat components that are essential for the primary biological needs of foraging, reproducing, rearing of young, dispersal, genetic exchange, or sheltering. Note that only PCEs 1, 6, 7, and 8 apply to marine nearshore waters identified as critical habitat; and all except PCE 3 apply to FMO habitat identified as critical habitat.

The PCEs are as follows:

(1) Water temperatures that support bull trout use. Bull trout have been documented in streams with temperatures from 32º to 72 ºF (0º to 22 ºC) but are found more frequently in temperatures ranging from 36º to 59 ºF (2º to 15 ºC). These temperature ranges may vary depending on bull trout life-history stage and form, geography, elevation, diurnal and seasonal variation, shade, such as that provided by riparian habitat, and local groundwater influence. Stream reaches with temperatures that preclude bull trout use are specifically excluded from designation.

(2) Complex stream channels with features such as woody debris, side channels, pools, and undercut banks to provide a variety of depths, velocities, and instream structures.

(3) Substrates of sufficient amount, size, and composition to ensure success of egg and embryo overwinter survival, fry emergence, and young-of-the-year and juvenile survival. This should include a minimal amount of fine substrate less than 0.25 inch (0.63 centimeter) in diameter.

(4) A natural hydrograph, including peak, high, low, and base flows within historic ranges or, if regulated, currently operate under a Biological Opinion that addresses bull trout, or a hydrograph that demonstrates the ability to support bull trout populations by minimizing daily and day-to-day fluctuations and minimizing departures from the natural cycle of flow levels corresponding with seasonal variation.

(5) Springs, seeps, groundwater sources, and subsurface water to contribute to water quality and quantity as a cold water source.

(6) Migratory corridors with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and foraging habitats, including intermittent or seasonal barriers induced by high water temperatures or low flows.

(7) An abundant food base including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.

(8) Permanent water of sufficient quantity and quality such that normal reproduction, growth, and survival are not inhibited.

Critical habitat includes the stream channels within the designated stream reaches, the shoreline of designated lakes, and the inshore extent of marine nearshore areas, including tidally influenced freshwater heads of estuaries.

In freshwater habitat, critical habitat includes the stream channels within the designated stream reaches, and includes a lateral extent as defined by the ordinary high-water line. In areas where ordinary high-water line has not been defined, the lateral extent will be defined by the bankfull elevation. Bankfull elevation is the level at which water begins to leave the channel and move into the floodplain and is reached at a discharge that generally has a recurrence interval of 1 to 2 years on the annual flood series. For designated lakes, the lateral extent of critical habitat is defined by the perimeter of the water body as mapped on standard 1:24,000 scale topographic maps.

In marine habitat, critical habitat includes the inshore extent of marine nearshore areas between mean lower low-water (MLLW) and minus 10 meters (m) mean higher high-water (MHHW), including tidally influenced freshwater heads of estuaries. This refers to the area between the average of all lower low-water heights and all the higher high-water heights of the two daily tidal levels. The offshore extent of critical habitat for marine nearshore areas is based on the extent of the photic zone, which is the layer of water in which organisms are exposed to light. Critical habitat extends offshore to the depth of 33 ft (10 m) relative to the MLLW.

Adjacent stream, lake, and shoreline riparian areas, bluffs, and uplands are not designated as critical habitat. However, it should be recognized that the quality of marine and freshwater habitat along streams, lakes, and shorelines is intrinsically related to the character of these adjacent features, and that human activities that occur outside of the designated critical habitat can have major effects on physical and biological features of the aquatic environment.

Activities that cause adverse effects to critical habitat are evaluated to determine if they are likely to "destroy or adversely modify" critical habitat by altering the PCEs to such an extent that critical habitat would not remain functional to serve the intended conservation role for the species (70 FR 56212, USFWS 2004g). The Service's evaluation must be conducted at the scale of the entire critical habitat area designated, unless otherwise stated in the final critical habitat rule (USFWS 2004b). Therefore, adverse modification of bull trout critical habitat is evaluated at the scale of the final designation, which includes the critical habitat designated for the Klamath River, Columbia River, Coastal-Puget Sound, and Saint Mary-Belly River population segments.

Current Condition Rangewide

The condition of bull trout critical habitat varies across its range from poor to good. Although still relatively widely distributed across its historic range, the bull trout occurs in low numbers in many areas, and populations are considered depressed or declining across much of its range (67 FR 71240). This condition reflects the condition of bull trout habitat.

There is widespread agreement in the scientific literature that many factors related to human activities have impacted bull trout and their habitat, and continue to do so. Among the many factors that contribute to degraded PCEs, those which appear to be particularly significant and have resulted in a legacy of degraded habitat conditions are as follows: 1) fragmentation and isolation of local populations due to the proliferation of dams and water diversions that have eliminated habitat, altered water flow and temperature regimes, and impeded migratory movements (Rieman and McIntyre 1993b; Rieman and McIntyre 1993c); 2) degradation of spawning and rearing habitat and upper watershed areas, particularly alterations in sedimentation rates and water temperature, resulting from forest and rangeland practices and intensive development of roads (Rieman and McIntyre 1993a; MBTSG 1998); 3) the introduction and spread of nonnative fish species, particularly brook trout and lake trout, as a result of fish stocking and degraded habitat conditions, which compete with bull trout for limited resources and, in the case of brook trout, hybridize with bull trout (Leary et al. 1993; Rieman et al. 2006); 4) in the Coastal-Puget Sound region where amphidromous bull trout occur, degradation of mainstem river FMO habitat, and the degradation and loss of marine nearshore foraging and migration habitat due to urban and residential development; and 5) degradation of FMO habitat resulting from reduced prey base, roads, agriculture, development, and dams.

4.6 Environmental Baseline (Bull Trout, Bull Trout Critical Habitat, Marbled Murrelet)

Regulations implementing the Act (50 CFR 402.02) define the environmental baseline as the past and present impacts of all Federal, State, or private actions and other human activities in the action area. Also included in the environmental baseline are the anticipated impacts of all proposed Federal projects in the action area that have undergone section 7 consultation, and the impacts of State and private actions which are contemporaneous with the consultation in progress.

The environmental baseline section includes a description of the action area. We have organized this information into six smaller areas (Willapa Bay, Grays Harbor, South Puget Sound, North Puget Sound, Hood Canal, and Samish Bay), when possible, to correspond to the primary groupings of aquaculture locations. Limited information does not always permit us to provide this level of detail for the status of bull trout and murrelets associated with each of these areas. For bull trout, the discussion may be further broken down according to the limiting factors for each core population within each action area, when that information is available.

4.6.1 North and South Puget Sound, Samish Bay, and Hood Canal

The Puget Sound Action Team (PSAT) recently completed a comprehensive report of the conditions of Puget Sound referred to as the "2007 Puget Sound Update" (PSAT 2007d). Ongoing monitoring and research in the Puget Sound basin via the Puget Sound Assessment and Monitoring Program (PSAMP) were the basis for this report. The report also includes research findings from a variety of additional monitoring and research efforts conducted by local governments, research institutions, Tribes, State and Federal agencies, and citizen monitoring groups. The scope of the report is the marine and freshwater ecosystems of the Puget Sound Region focusing on water quality, toxic contamination, nearshore habitat, and marine species. The following excerpts, unless otherwise cited, have been taken from the 2007 Puget Sound Update. A similar document is not available for Grays Harbor or Willapa Bay. Therefore, less detailed information is provided for these areas.

4.6.1.1 Physical Environment and Habitat

Puget Sound is a large inland fjord carved by glaciers, fed by over 10,000 rivers and streams that flow into it from the encircling Cascade and Olympic mountain ranges. The Puget Sound is deep, with an average depth of 450 ft (137 meters), and the maximum depth of 930 ft (283 meters) occurring immediately north of Seattle. Ten large rivers (the Nooksack, Skagit, Snohomish, Stillaguamish, Cedar/Lake Washington Canal, Green/Duwamish, Puyallup, Nisqually, Skokomish, and Elwha) flow into Puget Sound and contribute nearly 85 percent of the fresh water that enters it. The unique geology and large dynamic river systems help shape the shoreline, which consists of 2,500 miles (4,023 km) of beaches, bluffs, bays, estuaries, mudflats, salt marshes, and wetlands.

The Strait of Juan de Fuca connects Puget Sound with the Strait of Georgia to the north and Pacific Ocean to the west. Within this region are numerous basins, sub-basins, passages, and bays. To develop a common basis for monitoring and reporting, PSAMP has delineated six main basins in Puget Sound. From the north, the basins are the San Juan Archipelago, the Strait of Juan de Fuca, North Puget Sound (Whidbey Basin and Admiralty Inlet), Central Puget Sound, Hood Canal, and South Puget Sound. The boundaries of many basins coincide with sills; for others the demarcation is arbitrary.

Key findings of the 2007 Puget Sound Update (PSAT 2007d) for the physical environment and habitat include the following:

- Average global sea surface temperature has increased by 1.7 °F (0.9 °C) since 1921.
- Hood Canal, Budd Inlet, Penn Cove, Saratoga Passage, and Possession Sound are locations of highest concern, based on Washington Department of Ecology's (Ecology) index of water quality for Puget Sound. Eleven other areas are of high concern.
- Overall dissolved oxygen (DO) concentrations in Puget Sound appear to be continuing a downward trend. Very low DO was observed at 14 stations, seven of which had higher DO concentrations in the period from 1998 to 2000. Another seven stations with previously high DO concentrations experienced low DO during 2001-2005.
- Hood Canal DO levels measured during 2004 were at the historical low point for any recorded observations. Comparisons of oxygen data from 1930 to 1960s with data from 1990 to 2006 indicate that in recent years the area of low DO is getting larger and spreading northwards. Periods of hypoxia are persisting longer through the year.
- Tidal wetland losses were documented throughout Puget Sound and approximately 82 percent of the historic extent of tidal wetlands in the region has been lost due to development and other land uses.

4.6.1.2 Biological Resources

Puget Sound's biological resources include all living organisms that inhabit the marine waters and shorelines. These resources are plankton, invertebrates, fish, birds, mammals, and aquatic vegetation, including species that are either residential or migratory. Many biological stressors are affecting or have affected biota in Puget Sound in ways that we are only beginning to understand. These include climate change, toxic contamination, eutrophication (low oxygen due to excess nutrients), and nearshore habitat alteration.

Significant changes in the biological communities of Puget Sound have occurred in the past 30 years, including declines in population numbers of forage fish, salmonids, bottomfish, marine birds, and orcas. These changes have resulted in restricted and closed fisheries, listings of species under state programs and the Act, and development of recovery and management plans for several species. Coordinated efforts by PSAMP and other monitoring and research programs are underway to evaluate the declines, identify the stressors affecting the populations, and develop actions and solutions to stem the declines and begin rebuilding populations of species at risk.

A recent study (Gaydos et al. 2004) identified 47 marine species of concern in Puget Sound (3 invertebrates, 23 fishes, 1 reptile, 11 birds, and 9 mammals). Contaminants, habitat loss, and over-harvest were the most frequent causes cited for species declines in status reviews conducted for the 14 species of fish and wildlife listed as threatened or endangered by Washington State or the Federal government, Key findings of the 2007 Puget Sound Update (PSAT 2007d) regarding biological resources include, but are not limited to, the following:

- The total herring spawning biomass from Puget Sound's 19 stocks decreased between 2002 and 2005 and increased in 2006. The Cherry Point stock in North Puget Sound has experienced a dramatic decrease from a high of 12,000 tons in 1976 to a low of 800 tons in 2000, followed by a gradual increase to 2,200 tons in 2006.
- Native eelgrass has declined in Hood Canal for four consecutive years since 2001. The San Juan Archipelago has experienced eelgrass declines in small embayments. In eleven of its embayments, approximately 83 acres of eelgrass were lost between 1995 and 2004.
- Restoration of the Olympia oyster, a native shellfish species, has been successful in expanding the oyster's historic range in Puget Sound.
- Nearly 60 percent of groundfish stocks in Puget Sound are in good condition. Those in decline include middle-trophic level predators such as rockfish, spiny dogfish, Pacific cod, and hake.
- Spawning potential for copper and quillback rockfish dropped by nearly 75 percent between 1970 and 1999, and more recent information confirms a continued decline. Although the overall number of groundfish has not changed significantly in the last few decades, many popular harvest species have sharply declined while others species of groundfish have increased.
- Southern resident orcas were listed on the Federal endangered species list in 2005. The population currently consists of 86 whales, down from a peak of 98 in 1975.
- The pinto abalone, a once fairly abundant native species in Hood Canal, north Puget Sound and the San Juan Islands, appears to be critically depressed and in such low abundance that this species may be unable to naturally reproduce. In the San Juan Archipelago, between 1992 and 2005, abalone has declined from 351 animals per site to 103 animals per site at 10 long-term monitoring stations.
- Results from monitoring marine reserves in Puget Sound have shown that, within a decade, lingcod have become abundant. As top predators, they are keystone species that help characterize the trophic and ecological structures of rocky habitats.
- Fifty-two non-native species have been documented in Puget Sound; a large number of these were probably introduced via ship ballast. The European green crab, Chinese mitten crab, and zebra mussel are non-native species that could arrive at anytime and threaten Puget Sound's biological resources.

4.6.1.3 Toxic Contamination

In the past 150 years, people have released a wide variety of chemicals into Puget Sound and watersheds, 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.

Puget Sound is unique among North American estuaries, because of its geologically young, deep, narrow, fjord-like structure. Several shallow sills restrict the entry of deep oceanic water into Puget Sound, which reduces flushing of these inland marine and estuarine waters compared to the other urbanized estuaries of North America. Thus, toxic chemicals that enter Puget Sound remain longer in the system, and increasing exposure to aquatic organism. This hydrologic isolation also puts Puget Sound at higher risk from nutrients and pathogens that may enter the system.

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 ecosystem. For example, 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 populations along the West Coast. Another disturbing indication of this is found in 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, PSAMP scientists have shown high body burdens of PCBs in this species from the central and southern basins of Puget Sound to be comparable to herring from northern Europe's severely contaminated Baltic Sea.

The toxic contaminants that harm or threaten the health of Puget Sound 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).

Key findings of the 2007 Puget Sound Update (PSAT 2007d) regarding toxic contamination include the following:

- Approximately 1 percent of Puget Sound sediments are highly degraded, 31 percent are of intermediate quality, and 68 percent are of high quality. The degraded sediments (as measured by toxicity, chemistry, and benthic infauna) are mainly associated with urban embayments that are often located near river deltas and other highly productive nearshore habitat of importance to Puget Sound species.
- Chinook salmon from Puget Sound have nearly three to five times the PCB levels of individuals from Alaska, British Columbia, and Oregon.

- Flame retardants [polybrominated diphenyl ethers (PBDEs)] occurred in 17 percent of sediment sites sampled in Hood Canal in 2004, and were detected in 16 percent of samples from 10 Puget Soundwide sediment sampling sites in 2005.
- PBDEs are now second to PCBs in order of importance in the Puget Sound food web. PBDEs levels in English sole from urban areas are almost 10 times higher than those levels measured in sole from the Georgia Basin. herring from Puget Sound have nearly three times the levels of PBDEs in Georgia Basin herring. Harbor seals from Puget Sound have over twice the PBDEs found in seals near Vancouver, British Columbia. Scientists estimate that PBDE levels are doubling every four years in marine mammals, including harbor seals and orcas, and will surpass PCB levels in these species by 2020.
- In Puget Sound sediments, levels of polycyclic aromatic hydrocarbons (PAHs), such as creosote, have not changed significantly over the past decade, except in Bellingham Bay, Port Gardner, and Anderson Island, where levels have increased. Point Pully (in central Puget Sound) had a significant decrease in PAHs during this same period.
- In Dungeness crab, PAH exposure was six times higher in urban areas than in non-urban areas. English sole had three to four times the PAH exposure in urban areas, compared to non-urban areas.
- English sole from Elliott Bay and the Foss Waterway had four to six times the risk of developing liver lesions, typically associated with PAH exposure, compared to sole from Hood Canal or the Strait of Georgia.
- Six endocrine-disrupting compounds (bisphenol A, estradiol, ethynylestradiol, and three phthalates) were detected in more than 20 percent of surface-water samples collected in King County's lakes, rivers, streams, and stormwater discharges.
- Male English sole from several Puget Sound locations (including 30 percent of the males from Elliott Bay) are producing an egg protein (vitellogenin) normally found only in female fish. This finding suggests that these fish have been exposed to endocrine disrupting compounds.
- Pre-spawn mortality occurred in 25 to 90 percent of female coho salmon returning to urban streams in the Puget Sound region between 2002 and 2005, suggesting that contaminants from stormwater pose a threat to the spawning success of salmon in urban streams.

4.6.1.4 Nutrients and Pathogens

Water quality is a primary factor affecting the health of marine and freshwater species in the Puget Sound region. As Washington's population grows and urbanization of the Puget Sound 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. Generally, phosphorus tends to be the limiting nutrient in freshwater systems, and nitrogen tends to be the limiting nutrient in marine systems. Increased loadings of these nutrients can have significant effects on the character and condition of these respective systems.

Human activities have profoundly affected the cycling of nutrients worldwide and nutrient pollution in the Puget Sound basin. Nutrient availability in Puget Sound 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 such as prolonged algae blooms, depressed oxygen levels, fish kills, and losses of aquatic vegetation throughout the ecosystem and food web. Eutrophication is one the most important challenges facing Puget Sound and coastal ecosystems worldwide.

Pathogen pollution is an equally significant water quality problem in the Puget Sound basin. 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 septic systems, 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.

Pathogens also disrupt ecosystem functions and affect populations of freshwater, marine and terrestrial species. Increases in development around Puget Sound have prompted many investigations into the sources, loadings, pathways, and effects of nutrient and pathogen pollution. This information is needed to understand the nature and scope of the problems, and to inform management plans and efforts to prevent and control the pollution sources.

Key findings of the 2007 Puget Sound Update (PSAT 2007d) regarding nutrients and pathogens include, but are not limited to, the following:

- Hood Canal, Budd Inlet, Penn Cove, Saratoga Passage, and Possession Sound are locations of highest concern, based on Ecology's Water Quality Index for Puget Sound.
- Stations in Hood Canal, Penn Cove, Possession Sound, and Saratoga Passage had very high sensitivity to eutrophication. This suggests that these locations are at greatest risk for further declines in water quality due to human additions of nutrients.

- The most recent Water Quality Assessment lists 76 water bodies in Puget Sound with fecal coliform problems. However, fecal coliform data collected at marine ambient stations suggest a general decline in fecal coliform contamination from 2001 through 2005. The highest levels of fecal contamination occurred in Budd Inlet, Commencement Bay, Elliott Bay, and near West Point (north of Elliott Bay), Possession Sound, and Port Angeles harbor.
- Washington State Department of Health determined that 31 of 98 shellfish growing areas in Puget Sound experienced significant fecal pollution in 2005. Those with the greatest impact were Drayton Harbor, Dungeness Bay, and Henderson Inlet. Samish Bay and Burley Lagoon show no evidence of change in fecal pollution since 2002.
- Between 1995 and 2005, the condition of over 12,500 acres of shellfish-growing areas was upgraded and 5,000 acres were downgraded, for a net increase of 8,500 acres. Because of Kitsap County's Pollution Identification and Correction Program, parts of four shellfish harvest areas [Burley Lagoon, Cedar Cove (part of Port Gamble), Illahee State Park, and Dyes Inlet] have been cleaned up and reopened for harvest.
- Twenty percent of 428 recreational beaches in 12 Puget Sound counties are threatened by fecal pollution. Five percent of these beaches are closed because of biotoxins. Within King County, trends at 21 recreational beaches indicate that fecal pollution has declined since 1997. Ecology's Beach Environmental Assessment, Communication and Health Program indicates that central Puget Sound beaches, most notably in Dyes and Sinclair Inlets, typically have the highest measured bacterial pollution.
- Eighteen of 29 paralytic shellfish poisoning (PSP) sampling sites (62 percent) had at least some PSP impact in 2005. Burley Lagoon ranked highest in PSP impact in 2005. The year 2003 appeared to be lowest in PSP activity throughout Puget Sound.
- In 2003, a short-lived *Pseudo-nitzschia* (pennate diatom) bloom occurred at Fort Flagler near Port Townsend. Mussels from the sentinel monitoring cage contained domoic acid slightly above the U.S. Food and Drug Administration's action level, and Washington State Department of Health closed the area to shellfish harvest. In October 2005, *Pseudo-nitzschia* blooms occurred at four places in north Puget Sound (Sequim Bay, Port Townsend, Holmes Harbor, and Penn Cove). Several shellfish species were affected. All four areas were closed to shellfish harvest.

4.6.1.5 Summary

The current baseline status for the Puget Sound basin is complex and dynamic. It is impossible to analyze the environmental baseline as a moment in time because past development and its associated effects are ongoing and will continue to affect Puget Sound natural resources in the future. Throughout Puget Sound, the threat of habitat loss increases as growth and associated urbanization, agriculture, and resource extraction convert the landscapes and seascapes from native flora and fauna to a human-altered one. As a result, many native habitats have been dramatically reduced. This has significant effects on the quantity and quality of habitats that native species depend upon.

Increasing human development and sprawl in the Puget Sound, triggered by an increasing population, have fragmented and destroyed habitats, and will continue to contribute to the decline of many species and their habitats. The development and degradation of aquatic lands and the associated loss of fish and wildlife habitat is anticipated to continue, although certain plans, guidance, regulation, and marine reserves have been created to help reduce the impacts. Habitat loss and habitat degradation are expected to continue as the need for developed lands continues.

Lingering effects of past pollution and ongoing delivery of pollutants affect species and habitats, and the effects are expected to continue. Certain previously-banned chemicals continue to be found at elevated levels in many top predators such as orcas. Poor air and water quality, as well as hazardous wastes and oil spills have diminished the quality and usability of fish and wildlife habitats. Potential impacts include displacement and loss of individuals of some species, as well as decreased habitat quality. Recovery of fully functioning habitat conditions in many areas, if possible, will take much time and effort, and new problem areas will certainly be detected in the near-term future.

To counter these impacts, certain rules and guidance (e.g., Shoreline Management Act) have been enacted and adopted by some jurisdictions. More recently, in July 2007, the Puget Sound Partnership was formed (ESSB 5372) with a mandate to create a healthy Puget Sound ecosystem by 2020 fulfilling six specific goals:

- Fresh and marine waters and sediments of a sufficient quality so that the waters in the region are safe for drinking, swimming, shellfish harvest and consumption, and other human uses and enjoyment, and are not harmful to the native marine mammals, fish, birds, and shellfish of the region.
- An ecosystem that is supported by ground water levels as well as rivers and stream flow levels sufficient to sustain people, fish, wildlife, and the natural functions of the environment.
- A healthy Puget Sound where freshwater, estuary, nearshore, marine, and upland habitats are protected, restored, and sustained.
- Healthy and sustaining populations of native species in Puget Sound, including a robust food web.
- A healthy human population supported by a healthy Puget Sound that is not threatened by changes in the ecosystem.
- A quality of human life that is sustained by a functioning Puget Sound ecosystem.

An Action Agenda has been developed by the Puget Sound Partnership that identifies measurable parameters and target values that represent full achievement of each ecosystem goal associated with a healthy Puget Sound, as well as the necessary strategies and management activities to achieve those targets by 2020.

4.6.2 Grays Harbor and Willapa Bay

The Chehalis Basin, which drains to Grays Harbor, has been impacted by a wide variety of disturbances. Logging, agriculture, and grazing in the basin have degraded habitat by removing riparian vegetation, increasing silt loads, and decreasing woody debris (Hiss and Knudsen 1993). Impacts from current forest management will likely still occur on private and Olympic National Forest lands, but the Northwest Forest Plan Aquatic Conservation Strategy and more protective State forest practice rules should reduce the severity of these impacts. Ongoing dredging and reduced water quality continues to impede the recovery of bull trout.

Grays Harbor and Willapa Bay have a low to moderate risk of eutrophication. Moderate levels of ammonia and high levels of fecal coliform and persistent stratification due to water density differences were found at stations near the Chehalis River in Grays Harbor and Willapa River in Willapa Bay. However, water quality sampling in both waterbodies did not indicate low DO concentrations. This is likely due to the shallow and generally well-mixed water, and strong tidal exchange with the Pacific Ocean (PSAT 2007d, p. 112).

Significant eradication efforts have occurred in Willapa Bay to control/eliminate *Spartina* sp. Eradication efforts have included both chemical and mechanical treatments.

Willapa Bay is monitored for *V. parahaemolyticus*. There have been at least two confirmed illnesses due to this organism over the past three years from sites within Willapa Bay (PSAT 2007d, p. 223).

4.6.3 Status of the Species in the Action Areas (Bull Trout, Bull Trout Critical Habitat, Marbled Murrelet)

This consultation includes multiple action areas. The status of the bull trout and murrelet will be provided for each of the action areas, when possible. Due to limited information, some action areas may be combined for the species.

4.6.3.1 Status of Bull Trout in the Action Areas

Bull trout from eight core areas that are connected to nearshore marine waters and three FMO areas outside of core areas are present in the action area. Core areas represent the closest approximation of a biologically functioning unit for bull trout. Core areas consist of habitat that could supply all the necessary elements for every life stage of bull trout (e.g., spawning, rearing, migration, overwintering, foraging), and have one or more local populations of bull trout. Core areas are the basic units upon which to gauge recovery within a bull trout interim recovery unit. Bull trout from the Puyallup, Stillaguamish, Snohomish/Skykomish, Lower Skagit, Nooksack, Skokomish, Dungeness and Elwha River core areas are expected to be present in the action areas. FMO habitat is also present in the action area.

Unique to the Coastal-Puget Sound Interim Recovery Unit (IRU), bull trout occur in marine nearshore waters and these areas support the complex migratory behaviors and requirements of the anadromous form of bull trout. As such, these areas are critical to the persistence of that life history form. Within the marine nearshore FMO areas, there is little or no documentation of bull trout in the marine waters of Puget Sound south of the Nisqually River, and little documentation of bull trout near Vashon Island, west of Whidbey Island, and the Kitsap Peninsula. It is unlikely for bull trout to be in those areas.

Anadromous adult and subadult bull trout utilize marine waters of the action area for FMO. In two recent telemetry studies documenting the extent of anadromy in bull trout within portions of the Coastal-Puget Sound IRU, approximately 55 percent of the fish tagged in freshwater emigrated to saltwater (Brenkman and Corbett 2005; Goetz et al. 2007). Results from these studies also demonstrate that anadromous bull trout inhabit a diverse range of estuarine, freshwater, and marine habitats.

Marine waters provide important habitat for anadromous bull trout for extended periods of time. Data for bull trout from Puget Sound indicate that the majority of anadromous bull trout tend to migrate into marine waters in the spring and return to rivers in the summer and fall period. Although much less frequent, tagged fish have been detected in Puget Sound nearshore marine waters during December and January, which indicates that some fish remain in marine waters during the winter (Goetz et al. 2004; USGS, *in litt.* 2008). It is thought that warmer water temperatures in the summer may be an environmental cue that stimulates bull trout to return to freshwater. Other factors that may influence marine residency for bull trout include prey availability, predation risks, or spawn timing.

In general, anadromous bull trout use shallow nearshore, subtidal, and intertidal waters. In the study by Goetz and others (2004) the greatest bull trout densities were at depths greater than 2.0 to 2.5 meters (6.5 ft to 8.2 ft). Upon entering marine waters bull trout can make extensive, rapid migrations, usually in nearshore marine areas. During the majority of their marine residency, anadromous bull trout have been found to occupy territories ranging in length from approximately 10 m to more than 3 km (32 ft to 9,842 ft) within 100 to 400 m (328 ft to 1312 ft) of the shoreline (USGS, *in litt.* 2008). Aquatic vegetation and substrate common to all or most bull trout areas includes eelgrass, green algae, sand, mud, and mixed fine substrates. These habitat features are also correlated with forage fish occurrence.

Some level of mixing or interaction within marine waters occurs among anadromous individuals from various core areas. Based on recent studies it is likely that bull trout from several core areas may be present within the action areas simultaneously (Goetz et al. 2004; Brenkman and Corbett 2005; Brenkman et al. 2007; Goetz et al. 2007). It is expected that bull trout from the Puyallup, Stillaguamish, Snohomish/Skykomish, Lower Skagit, Nooksack, Skokomish, Dungeness and Elwha Rivers are likely to be present within the action areas. Thus, the status of each of these core areas is discussed below. Most of the information for the status of the core areas was developed in our draft recovery plan, listing packages, the science information gathered for the bull trout 5-year review, and other recent documents that depict the baselines such as county and watershed or subbasin plans.

4.6.3.1.1 Willapa Bay

There is documented presence of bull trout in the Willapa River. One bull trout was caught by a Washington State Department of Fish and Wildlife technician 1 mile downstream of the Willapa/Forks Creek State Salmon Hatchery in 2002 (Ken Berg, Western Washington Fish and Wildlife Office, USFWS, *in litt.* 2002). It is likely that the bull trout followed migrating salmonids through the entrance of Willapa Bay past Tokeland and up the Willapa River. No other occurrences of bull trout have been recorded, although there are no efforts to monitor for them in this system. Based on the infrequent reports of bull trout in the bay and river, it is highly unlikely that there is a spawning population in this watershed and there is a low likelihood of bull trout being present in the project area (Berg, *in litt.* 2002). The closest core area is the Quinault core area, more than 50 miles up the coast from this action area.

4.6.3.1.2 Grays Harbor

Grays Harbor is part of the Lower Chehalis River/Grays Harbor foraging, migration, and overwintering habitat. Although bull trout have been documented in Grays Harbor and the Chehalis River, the nearest spawning population is likely the Quinault core area.

There have been several recent studies describing bull trout marine residency timing. From 1954 through 1980 more than 4,000 beach seine/tow net surveys targeting juvenile salmonids were conducted in the lower Chehalis/Grays Harbor (Jeanes and Morello 2006). The surveys were primarily focused on the period of time that juvenile salmonids were likely to be present (February through October). During this sampling period, 15 native char were captured in various years during the period from March 4 through July 14. The majority of captures occurred during the months of March, April, and May. The survey site in Grays Harbor located farthest from the mouth of the Chehalis River was near Moon Island. Several native char were captured at that site, including one fish captured during the month of July.

In a more recent study conducted during seven separate capture periods that began in June of 2001 and concluded in March 2004, 15 native char were captured from February through June during the study periods. All of the capture sites were located in the lower Chehalis River and in Grays Harbor near the mouth of the Chehalis River. In April 2003, a single bull trout was captured in the lower Chehalis River and surgically implanted with a sonic tag. Preliminary data indicated that this fish left the Chehalis River system shortly after it was tagged and did not return to the basin (Jeanes et al. 2003). The relationship between bull trout observed in these rivers and the harbor and bull trout populations in the coastal core areas is not well understood.

In 1994 and 1995, Washington Department of Ecology collected temperature data for Grays Harbor at five different sites (Newton et al. 1997, pp. 150-154). Water temperatures were warmest during July, with temperatures of 19 °C recorded at four of the five sites. Although it is unlikely that bull trout would reside in waters with these temperatures for extended periods, they might utilize these sites periodically if forage were available. At the N. Whitcomb Flats site, the temperature measured in July at a depth of 30 m was 16.6 °C, within the range of temperatures used by adult bull trout.

4.6.3.1.3 South Puget Sound

In South Puget Sound, bull trout have only been detected as far south as the Nisqually River (USFWS 2004g). There are very few natal basins in South Puget Sound. The Nisqually River was probably a historical natal basin and the Puyallup River is currently a natal basin although the population is much depressed. It is unknown whether a remnant bull trout population continues to persist in the lower Nisqually River drainage.

Essentially, a spawning population needs to be in close proximity for fish to use near shore marine areas. The Puyallup core area contains the southernmost population of bull trout in the Puget Sound Management Unit. This core area is critical to maintaining the overall distribution of migratory bull trout within the management unit, since it is the only anadromous bull trout population in south Puget Sound. However, the Puyallup core population is depressed. Since it is the southernmost population, we suspect that even if bull trout are using south Puget Sound they are not very abundant.

4.6.3.1.4 Hood Canal

The Skokomish core area is the only bull trout core area on the eastern portion of the Olympic Peninsula and the only core area draining into Hood Canal. Bull trout in this action area are likely to originate from this core population. Fluvial, adfluvial, and, possibly, anadromous and resident life history forms of bull trout occur in the Skokomish Core Area. This is likely the only core population of bull trout that use Hood Canal. Historically, bull trout migrated into Hood Canal to overwinter and feed from the Skokomish River Core population. Bull trout have been observed in the lower Skokomish River and the estuary of the Skokomish River, although the current extent of the reduced population's use of Hood Canal is unknown (Haw and Buckley, in litt. 1973 cited in USFWS 2004g, p. 66).

The bull trout population in Skokomish core area is one of the most depressed in the Olympic Peninsula Management Unit. The decline in numbers of adult bull trout in the North Fork Skokomish River and the low number of spawning adults in the South Fork Skokomish River indicate that the bull trout in this core area is at increased risk of extirpation and adverse effects from random naturally occurring events.

The known distribution of bull trout is based on observations and information on the status of the various populations. Snorkel counts averaged only 95 adult bull trout and indicated a decline in numbers of adult bull trout counts from 1998 through 2002 (Brenkman 2003). In the South Fork Skokomish River, fluvial bull trout occupy the river from its mouth upstream to a natural barrier at river mile 23.5. Snorkel surveys counted one to two bull trout per mile. The total number of adult bull trout in the South Fork Skokomish River local population is estimated by the Olympic National Forest to be around 60 individuals (WSCC 2003). Although bull trout occur throughout the mainstem South Fork and in a majority of tributaries, the highest densities are found above river mile 18.3. Juvenile bull trout have been observed in the South Fork Skokomish River downstream as far as river mile 0.2 and in every tributary upstream from river mile 0.2.

The Skokomish watershed provides an example of the threats to bull trout that can occur from the interaction of multiple past and present activities. The degraded condition of the stream corridors, especially conditions related to road networks, timber harvest, diking, and conversion of floodplains into agricultural land and residential development, have resulted in even greater flood damage and the reduced ability of the Skokomish River to recover natural fluvial function (USFWS 2004g, p. 70). After each flood event, increasingly severe modifications have been made to protect roads, residences, and agricultural land in the floodplain (USDA 1995), resulting in greater flood damage and reduced ability to recover natural fluvial function.

4.6.3.1.5 Samish Bay

Samish Bay is likely to be most heavily used by anadromous bull trout from the Nooksack, Lower Skagit, and Upper Skagit core areas due to their close proximity to this system. The Nooksack Core Area bull trout population is considered to be at risk of genetic drift. Although the deleterious effects of inbreeding are minimized in these two local populations, the other eight local populations with few adults are considered at risk of inbreeding depression.

The Lower Skagit core area, with a spawning population of migratory bull trout that numbers in the thousands, is probably the largest population in Washington (Kraemer 2001; USFWS 2006a, p. 655). Consequently, the bull trout population in this Core Area is not considered to be at risk from genetic drift.

Adult and subadult bull trout have been caught on the mainstem Samish upstream of the confluence with Friday Creek as well as in the lower river, but potential use likely extends to the uppermost reaches of anadromous salmonid use. In the past, most bull trout were observed during the winter steelhead season, primarily December through February (Curtis Kraemer, pers. comm. 2003; Dean Toba, WDFW, pers. comm. November 9, 2003).

4.6.3.1.6 North Puget Sound

The bull trout core areas in this action area include the Elwha, Dungeness, Lower Skagit, Upper Skagit, Stillaguamish, and Snohomish/Skykomish. The Elwha and Dungeness Core Areas are located in the Olympic Peninsula Management Unit and are connected to the Strait of Juan de Fuca FMO. The other core areas flow into Puget Sound, and are part of the Puget Sound Management Unit. Although marine waters connect these two Management Units, there is no evidence that bull trout migrate between these two areas (USFWS 2004g, p. 19).

The Dungeness core area is comprised of the Dungeness and Gray Wolf Rivers and associated tributaries. Bull trout occur throughout the Dungeness and Gray Wolf Rivers downstream of impassable barriers, which are present on both rivers. They also occur in the Dungeness River estuary and Gold Creek, a Dungeness River tributary. Twenty-five char sampled in the Dungeness River were all bull trout (Spruell and Maxwell 2002). However, 50 char sampled upstream of the barrier at river mile 24 were all Dolly Varden (Young 2001).

Fluvial and anadromous life history forms of bull trout occur in the Dungeness River core area. Mainstem rivers within the core area provide spawning, rearing, foraging, migration, and overwintering habitats.

The Elwha core area comprises the Elwha River and its tributaries, which include Boulder, Cat, Prescott, Stony, Hayes Godkin, Buckinghorse, and Delabarre Creeks; Lake Mills, Lake Aldwell; and the estuary of the Elwha River. There is no upstream passage at either the Elwha Dam or Glines Canyon Dam, which has fragmented the core area.

Anadromous, fluvial, adfluvial, and resident life history forms probably occupy the Elwha core area; however, the anadromous form has largely been eliminated due to the two dams. No spawning sites have been identified above the two dams, and there probably is little habitat suitable for bull trout spawning and incubation downstream from the dams. Elevated stream temperatures caused by the two dams likely limit reproducing populations of bull trout in both the lower and middle reaches of the Elwha River.

4.6.3.2 Conservation Role of the Action Areas for Bull Trout

Within the Olympic Management Unit, the marine foraging areas associated with Grays Harbor and Hood Canal are considered to be essential and biologically important for maintaining the anadromous life form of bull trout (USFWS 2004g, p. 45). However, Willapa Bay, because of the low likelihood of bull trout use, has no specific role for conservation of the species identified in the recovery plan.

The majority of the remainder of the action area within the Puget Sound Management Unit (portions of North Puget Sound, South Puget Sound, and Samish) has been identified as bull trout foraging, migration, and overwintering habitat important for bull trout recovery. These marine waters are also considered critical to the persistence of the anadromous life history form of the Coastal-Puget Sound Interim Recovery Unit (USFWS 2004g, p. 20). Additionally, the Strait of Juan de Fuca, which is within the Olympic Management Unit, also has been identified as providing essential and biologically important foraging and migration habitat for bull trout.

4.6.4 Status of Bull Trout Critical Habitat in the Action Areas

Critical habitat in the action areas are all located within marine nearshore habitat. These nearshore marine waters are important for subadult and adult bull trout migration, forage, and refugia. Critical habitat for bull trout within the actions area is designated in the inshore extent of marine nearshore areas mean higher high water (MHHW) line, including tidally-influenced freshwater heads of estuaries. This refers to the average of all the higher high-water heights of the two daily tidal levels. The offshore extent of critical habitat for marine nearshore is based on the extent of the photic zone, which is the layer of water in which organisms are exposed to light. Critical habitat extends offshore to the depth of 33 ft (10 m) beyond the mean lower low water (MLLW) (average of all the lower low-water heights of the two daily tidal levels). This area between MHHW and -10 MLLW is considered the habitat used most consistently by bull trout in marine waters. This is based on known use, forage fish availability, and ongoing migrations studies, and the area captures geological and ecological processes important to maintaining these habitats. The area contains essential foraging habitat and migration corridors such as estuaries, bays, inlets, shallow subtidal areas, and intertidal flats.

Within the designated critical habitat areas, the PCEs for bull trout are those habitat components that are essential for the primary biological needs of foraging, reproducing, rearing of young, dispersal, genetic exchange, or sheltering. The following PCEs apply to marine nearshore waters identified as critical habitat (70 FR 56212):

- (i) Water temperatures that support bull trout use.
- (vi) Migratory corridors with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and foraging habitats, including intermittent or seasonal barriers induced by high water temperatures or low flows.
- (vii) An abundant food base including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.
- (viii) Permanent water of sufficient quantity and quality such that normal reproduction, growth, and survival are not inhibited.

4.6.4.1 Status of Critical Habitat Units

The action area is within the Coastal-Puget Sound IRU and includes two critical habitat units: Olympic Peninsula (Unit 27) and Puget Sound (Unit 28), which are discussed below.

4.6.4.1.1 Olympic Peninsula: Unit 27

Critical habitat has been designated in streams and rivers in all core areas within this unit and in the marine nearshore of the Pacific Ocean, Strait of Juan de Fuca, and Hood Canal. In the Elwha core area, critical habitat has also been designated in the Little River potential local population. Critical habitat has also been designated in the following FMO habitat outside of core areas: Bell, Cedar, Ennis, Goodman, Joe, Kalaloch, Morse, Mosquito, and Steamboat Creeks; Canyon, Chehalis, Copalis, Humptulips, Moclips, Satsop, and West Fork Satsop Rivers; and Grays Harbor, Hood Canal, Pacific Coast, and Strait of Juan de Fuca marine FMO habitats.

On the Olympic Peninsula, a significant portion of the major river basins, particularly the upper river portions where most bull trout spawning and rearing occurs, lie within the Olympic National Park. Spawning and rearing critical habitat has been designated in these areas within the Park. However, FMO critical habitat conditions are often degraded downstream of the park boundary (WCC 2000). In the largely rural setting of the Olympic Peninsula, habitat effects are primarily related to past logging and associated roading and, to a lesser degree, dams and agricultural practices. Habitat conditions have improved to some extent over the past decade with more protective forest practices and declining timber harvest on public lands. Although riverine migratory corridors are still functional, especially on the west side of the Olympic Peninsula, critical habitat conditions related to suitable temperatures, floodplain connectivity, substrate, timing and magnitude of flows, and habitat complexity related to large woody material have been degraded by historical land-management practices.

Critical habitat has been designated in the marine nearshore of the Pacific Ocean, Strait of Juan de Fuca, and Hood Canal. The condition of critical habitat in the Pacific Ocean has been impacted by roads and rural development. However, human population density is low, there is little industrial development, and the impacts to Pacific Ocean critical habitat are relatively minor. In Hood Canal extensive shoreline development has occurred, including diking and filling, shoreline armoring, and urbanization. Critically low DO levels have recently been observed in Hood Canal. Reasons for the low DO are unknown, but human activities and natural geography (e.g., excessive nutrient input, reduced freshwater input, low flushing rate) may be factors. Low dissolved oxygen zones have the potential to impede fish migration and forage fish health. In the eastern Strait of Juan de Fuca armoring occurs along 54 percent of the shoreline. Highway 101 is a significant constraint, and railroads follow much of the shoreline from Discovery Bay to Port Angeles. The damming of the Elwha River has reduced sediment loads to a portion of the central Straits and likely has accelerated erosion in some places. Shoreline development, urbanization, diking and filing, transportation related spills and discharges have impacted much of the marine nearshore and associated estuaries. A portion of PCEs 6, 7, and 8 within the designated marine critical habitat have been degraded, although the severity of degradation varies on a site-specific basis.

4.6.4.1.2 Puget Sound: Unit 28

Critical habitat has been designated in streams and rivers throughout the Puget Sound Critical Habitat Unit. Critical habitat has also been designated outside of core areas in the marine nearshore waters of Puget Sound.
The urban rivers of Puget Sound have effects comparable to those on the Olympic Peninsula from past logging and logging roads in the upper reaches, but critical habitat has been further degraded in the lower floodplains. Intensive channelization to protect urban development and agricultural areas has resulted in permanent loss of floodplain functions in most of the lower rivers. The loss of riparian vegetation, increasing discharge of municipal and industrial wastewater and urban stormwater runoff, has resulted in degraded water quality. Ecology has placed a large number of waterways throughout Puget Sound on the 303(d) list of impaired waters. In addition to affecting water quality through flow alterations, hydroelectric dams block migration and have isolated bull trout populations in several core areas while water-control structures in the floodplains have effectively eliminated most of the estuaries and wetlands that historically provided rearing and foraging areas. Throughout Puget Sound shoreline development, urbanization, diking and filling, spills, and wastewater and stormwater discharges are stressors that have degraded critical habitat. Railroads follow portions of the shoreline and much of the shoreline is armored. Concentrations of commercial and recreational overwater structures such as ramps, piers and docks can be found in Tacoma and Commencement Bay, the Lower Duwamish River and Elliot Bay. The establishment of *Spartina* colonies is a concern in the Padilla/Samish Bay sub-basin. PCEs 6, 7 and 8 within the designated marine critical habitat have been degraded, although the severity of degradation varies on a site specific basis.

4.6.4.2 Conservation Role of Critical Habitat in the Action Area

The action area includes most of the Coastal-Puget Sound IRU, including the Puget Sound MU encompassed by and connected to Puget Sound and that portion of the Olympic Peninsula MU encompassed by and connected to Hood Canal and Strait of Juan de Fuca. The draft recovery plan states that maintaining viable populations of the bull trout is essential to the conservation of species within each of the core areas, the interim recovery units, and the coterminous listing (USFWS 2004g). To maintain or restore the likelihood of long-term persistence of self-sustaining, complex, interacting groups of bull trout within the action area, the Service has identified the following needs: 1) maintain the current distribution of bull trout and restore distribution in previously occupied areas, 2) maintain stable or increasing trends in abundance of bull trout, 3) restore and maintain suitable habitat conditions for all bull trout life history stages and strategies, and 4) conserve genetic diversity and provide opportunities for genetic exchange.

FMO areas are central to the survival and recovery of the bull trout. The draft recovery plan states that although use of FMO habitat by bull trout may be seasonal or very brief (as in some migratory corridors), it is a critical habitat element. The plan also states that bull trout need at least the following habitat conditions in FMO:

- Water temperatures ranging from -2 ºC to 22 ºC , depending on life history stage and form, geography, elevation, diurnal and seasonal variation, and local groundwater influence (PCE #1).
- Migratory corridors with no physical, biological or chemical barriers between spawning, rearing, overwintering, and foraging habitats (PCE #6).
- An abundant food base including prey items such as macroinvertebrates, crayfish, and forage fish (PCE #7).
- Permanent water of sufficient quantity and quality such that normal reproduction, growth, and survival, are not inhibited (PCE #8).

The intended recovery function of critical habitat is to support the core areas and ensure that the habitat requirements of bull trout are met, now and in the future. The primary constituent elements provide a measure of the habitat conditions and are essential components of critical habitat.

4.6.5 Status of Marbled Murrelets in the Action Areas

The proposed action is located within Conservation Zones 1 (Puget Sound) and 2 (Western Washington Coast Range). Murrelet presence in the action area is documented by several sources. The most accurate information comes from the consistent sampling used to estimate population size and trends under the Northwest Forest Plan Murrelet Effectiveness Monitoring Plan (Raphael et al. 2007). For the purposes of the Northwest Forest Plan Murrelet Effectiveness Monitoring Plan, Conservation Zone 1 is subdivided into three strata and each stratum is divided into “Primary Sampling Units”. Each Primary Sampling Unit is a rectangular area approximately 20 km long composed of inshore and offshore subunits that are sampled between May 15 and July 31 each year (Raphael et al. 2007).

Since 2000, the estimated population size for Conservation Zone 1 has ranged from a low of 5,500 murrelets in 2004 to a high of 9,700 in 2002. The most recent (2007) estimated population size for Conservation Zone 1 is 6,985 murrelets (4,105 - 10,382) (95 percent CI). Since 2000, the estimated murrelet density in Conservation Zone 1 has ranged from 1.56 to 2.78 murrelets per km^2.

4.6.5.1 Nesting Habitat

The majority of the activities associated with the proposed project will occur in the marine environment, except for the helicopter departure points and flight paths associated with the carbaryl spraying. Suitable nesting habitat occurs within the action area, in close proximity to shellfish beds within Willapa Bay. Suitable nesting habitat is limited to small patches within the action area. No nesting habitat removal is proposed as part of the proposed action, therefore a more detailed description of the nesting habitat is not warranted.

4.6.5.2 Marine Habitat

Murrelets use the marine environment for courtship, loafing, and foraging. For information regarding the marine environment in Conservation Zones 1 and 2, refer to the Status of the Species – rangewide discussion.

The recovery plan has identified all water of Puget Sound, Strait of Juan de Fuca, including the waters of the San Juan Islands and river mouths, and the nearshore waters (within 1.2 miles of the shore) along the Pacific Coast from Cape Flattery to Willapa Bay, including rivers mouths, as essential for murrelet foraging and loafing (USFWS 1997b, p. 135).

4.6.5.2.1 Grays Harbor and Willapa Bay

Limited information is available regarding murrelet use of the marine environment within Grays Harbor and Willapa Bay. Murrelets likely occur year-round within Willapa Bay and Grays Harbor. The Washington Department of Fish and Wildlife (WDFW) conducts surveys for murrelets in nearshore environments along the coast where the birds forage. Murrelets generally forage in shallow waters within 1.25 miles of shore (Strachan et al. 1995). Traditional feeding areas (nurseries) are used consistently on a daily and yearly basis (Carter and Sealy 1990b). Foraging locations are characterized by physical processes that concentrate prey. In general, small schooling fish and large pelagic crustaceans are the main prey items. Pacific sand lance, northern anchovy, immature Pacific herring, capelin, and surf smelt (Osmeridae) are the most common fish species taken, and are eaten year round. There is an anchovy fishery in Willapa Bay, although these fish are likely in deeper waters until night when they come to the surface.

Marine observations of murrelets during the nesting season generally correspond to the presence of large blocks of nesting habitat. Studies have found that during the nesting season murrelets are more numerous along Washington's northern coast and less abundant along the southern coast. This distribution appears to be associated with the proximity to old growth forest, the distribution of rocky shoreline versus sandy shoreline, and the abundance of kelp and prey items (Carter and Sealy 1990a, p. 26258). Murrelets, therefore, would not be expected to forage regularly in the project vicinity during the nesting season. Observations documented by Speich and Wahl (1995) support this conclusion. They found that murrelets are generally present in Grays Harbor during the fall, winter, and spring; they are rarely seen in August and September.

The highest numbers occurred generally in the Grays Harbor channel out to the 50 meter depth contour.

4.6.5.2.2 Hood Canal

Murrelets occur year-round in marine waters throughout the Hood Canal action area. Murrelet presence and abundance in the marine environment is highly variable, but there appears to be one peak in late summer coincidental with the fledging period (Raphael et al. 2002) and another peak in fall (Merizon et al. 1997).

Most areas of Hood Canal provide suitable foraging habitat and murrelets move throughout the area depending on local conditions. Fall survey data collected by the Sustainable Ecosystem Institute (SEI) found that murrelets in Hood Canal were detected in consistently higher densities than other locations they surveyed in Washington. In Hood Canal, murrelets tended to form loose aggregations, but there was little predictability in the distribution of these aggregations (Merizon et al. 1997).

During the breeding season, murrelet numbers in Hood Canal are generally highest in July. There is another potential peak in the fall. High counts were recorded in the Hood Canal Bridge vicinity (Nineteen 2 km transect segments on both sides of the canal and including Port Gamble) in July of 1997 (148 birds) and July of 1998 (102 birds) (Raphael et al. 2002).

In the fall of 1996, boat surveys documented a mean of 2 to 15 murrelets per km (linear transects) in the vicinity of the Hood Canal Bridge. In summer, the mean number of murrelets detected was 0 to 5 per km (Raphael et al. 2002).

In winter, aerial surveys conducted by the WDFW/PSAMP detected 1 to 5 murrelets in the vicinity of the Hood Canal Bridge (WDFW/PSAMP 1993-2000 data). However, aerial surveys probably underestimate murrelet abundance (Varoujean and Williams 1995).

4.6.5.2.3 South Puget Sound

Murrelets are observed in small numbers at various seasons as far south as the Nisqually Reach and Budd Inlet.

4.6.5.2.4 North Puget Sound

Murrelets are found most commonly in the nearshore waters of the San Juan Islands, Rosario Strait, the Strait of Juan de Fuca, and Admiralty Inlet. They are more sparsely distributed elsewhere in Conservation Zone 1, and are found in smaller numbers in Possession Sound, Skagit Bay, Bellingham Bay, and along the eastern shores of Georgia Strait.

Many murrelets breeding on exposed outer shores of Vancouver Island, British Columbia appear to move into more sheltered waters in Puget Sound and the Strait of Georgia, where numbers increase in fall and winter (Burger 1995). Surveys along the southern shore of the Strait of Juan de Fuca conducted by the WDFW from 1996 - 1997 (Thompson 1997) showed an increase in the number and group size of murrelets in August in the eastern Strait of Juan de Fuca, although numbers declined in the western portion of the Strait of Juan de Fuca (USFWS 2001b). Surveys conducted by the Forest Service and collaborators (Ralph et al. 1996; Cooper et al. 1999) in the nearshore waters of the San Juan Islands showed a similar increase in abundance in August and September. Increases in abundance have been detected as well in September and October during surveys of Admiralty Inlet, Hood Canal, Saratoga Passage, and Possession Sound (Merizon et al. 1997). A breeding murrelet, banded in Desolation Sound in summer, was captured near Orcas Island in September, and then recaptured in Desolation Sound the following year (Beauchamp et al. 1999).

4.6.5.3 Conservation Role of the Action Areas for Murrelets

The action areas fall primarily within the marine waters of Conservation Zones 1 and 2. The Marbled Murrelet Recovery Plan (USFWS 1997b, pp. 134, 140-141) outlines the conservation strategy for the murrelet. Of the primary recovery plan recommendations, the following are most pertinent to the needs of murrelets in the action areas:

1. Protect the quality of the marine environment essential for murrelet recovery.
2. Reduce adult and juvenile mortality in the marine environment.
3. Minimize nest disturbances to increase reproductive success.

4.6.6 Forage Fish (Pacific Herring, Surf Smelt and Pacific Sand Lance)

The status of forage fish is specifically described here because of their importance to bull trout and murrelets and their link to the sensitive habitats that are affected by shellfish aquaculture activities. Forage fish play a key role in the food web of the marine environment and make up a significant proportion of the diets for bull trout and murrelets. Forage fish are loosely defined as small, schooling fishes that form critical links between the marine zooplankton community and larger predatory fish, seabirds, and marine mammals in the marine food web (Penttila 2007; PSAT 2007d). They feed mainly on zooplankton and phytoplankton and reside in the upper levels of the water column and nearshore areas (PSAT 2007d, p.51). The three most common forage fish species are herring, surf smelt, and sand lance. These three fish and their spawning habitat all commonly occur within the nearshore zone of Pacific Northwest beaches.

Within Puget Sound, each species appears to use approximately ten percent of the shoreline as spawning habitat. Some species tend to use the same beaches annually. All three species use the adjacent near-shore habitats as nursery grounds (Penttila 2007). Three other less important species (northern anchovy, eulachon or Columbia River smelt (*Thaleichthys pacificus*), and longfin smelt (*Spirinchus thaleichthys*), also contribute to the overall biomass of forage fish in the Puget Sound region (Penttila 2007).

4.6.6.1 Pacific Herring

WDFW recognizes 19 different stocks of herring in Puget Sound, based on the timing and location of spawning activity (Stick 2005; PSAT 2007d). The grounds are well defined and the timing of spawning is very specific, seldom varying more than seven days from year to year (Bargmann 1998). Puget Sound herring are thought to be a mix of "resident" and "migratory" stocks, with the migratory populations cycling between winter spawning grounds in the inside waters and summer on the continental shelf off the mouth of the Strait of Juan de Fuca (Penttila 2007). However, which fish or stocks are migratory and which are resident is unknown. It appears as though neither post-spawning adult herring nor pre-recruit herring persist in numbers in the immediate vicinity of any spawning ground during nonspawning times of year (Penttila 2007).

For the period of 2003 to 2004 only 50 percent of all Puget Sound herring stocks were classified as "healthy" or "moderately healthy," whereas 71 percent and 83 percent of stocks were considered healthy or moderately healthy in 2000 and 2002, respectively. One stock was added to the critical list in 2004. South and central Puget Sound stocks have maintained a healthy stock status since 1994, while north Puget Sound's combined stocks have declined from a healthy status in 1994 to depressed since 1998. The Strait of Juan de Fuca's status has been consistently classified as critical since 1994.

Some months before the onset of spawning activity, ripening fish begin to assemble adjacent to spawning sites in pre-spawning holding areas (Penttila 2007). Herring spawn by depositing their eggs on eelgrass, algae, hard substrates, and occasionally polychaete tubes. Most egg deposition occurs from 0 to -10 ft in tidal elevation (Bargmann 1998), but in some areas spawning can occur as deep as 32 ft (-10 m) (Penttila 2007). The eggs incubate for 10 to 14 days prior to hatching. Following hatching, the larvae drift in the currents. Following metamorphosis, young herring spend their first year in Puget Sound; some then spend their entire lives within Puget Sound, while others migrate to the open ocean as they become larger. After reaching sexual maturity (2 to 4 years), herring migrate back to the spawning grounds. Most spawning occurs between mid-January and March.

The Washington Department of Fish and Wildlife monitors herring spawning in Washington State and publishes stock status reports on herring and other important commercial fisheries. The table below presents the density of herring spawn (eggs) on eelgrass in each action area.

Table 4.10 Percent of herring spawn by intensity within each action area.

Herring Spawn intensity	**Willapa Bay**	**Grays Harbor**	**South Puget Sound**	**Hood Canal**			**North Puget Sound**			**Samish Bay**
			Squaxin Pass	Port Gamble	Seabeck	Quilcene Bay	Discovery Bay	Sequim Bay	Dungeness Bay	
Very Light	92	78	48	66	38	64	60	85	98	100
Light	8	17	26	21	17	13	22	15	2	
Light/Med		2	10	7						
Medium		3	9	4	22	9	6			
Med/Heavy			4	1	11					
Heavy			3		8	3	2			
Very Heavy					6		0			

WDFW Unpublished data 2008

Herring are visual feeders that forage on planktonic macro-zooplankton, primarily arthropods that may be found anywhere from "bank to bank" across the width of Puget Sound. Herring can generally be found in a scattering layer mixed with their prey and predators at 30 fathoms to 40 fathoms depth (180 ft to 240 ft), perhaps commonly associated with convergence zones that concentrate prey. However, they undergo diurnal depth migrations, i.e., deep during the day and shallow at night. In shallower waters, they would be closely appressed to the bottom. During the daytime, a certain proportion of the herring, most commonly juveniles, may occur in midwater or surface water depths. Juvenile herring rearing along the shoreline may occur in shallow depths (a few feet), even in the daytime.

4.6.6.2 Surf Smelt

Surf smelt are common, year-round residents in the nearshore areas of Puget Sound. They are a short-lived fish with most spawning populations comprised of 1- and 2-year old fish. Spawning occurs at high tides on mixed-sand and gravel substrates in the upper tidal zone generally higher than plus 7 ft in tidal elevation. Smelt eggs incubate for two to six weeks (WDFW 2000). They feed on plankton macrozooplankton, primarily arthropods, and are closely associated with the shoreline, spending their entire lives shoreward of 10-fathom contour (60 ft). There is no information on movement patterns and no evidence of seasonal ocean-ward migration out the Strait of Juan de Fuca. Their home ranges are unknown and there has been no assessment of stock status.

Surf smelt spawn year-round in Puget Sound. The WDFW has documented spawning habitat on 195 lineal statute miles of Puget Sound shoreline; however, the surveys are incomplete (Bargmann 1998). At this time, there is little concern over the overall status of Puget Sound surf smelt stocks (Bargmann 1998).

4.6.6.3 Pacific Sand Lance

Pacific sand lance are common, year-round residents in the nearshore areas of Puget Sound. The WDFW has documented spawning habitat on 129 lineal statute miles of Puget Sound shoreline; however, the surveys are incomplete (Bargmann 1998). Several spawnings may occur at any given spawning site during the November to February spawning season. Pacific sand lance use the same stretches of beach as surf smelt at the same time of year (Bargmann 1998).

Pacific sand lance spawning is confined to the upper tidal zone, generally higher than plus 5 ft in tidal elevation. The incubation period for sand lance eggs is about 30 days (WDFW 2000). Pacific sand lance feed on macro-zooplankton, primarily arthropods. During spring and summer months, these fish are considered epibenthic, schooling pelagically during the day to forage and burrowing in the benthic substrate at night (Hobson 1986).

During the winter, these fish may remain buried in the sediment in a state of dormancy (Robards and Piatt 1999 in Robards et al. 1999); however, sand lance may emerge from the sediments if oxygen conditions in the sediment become too low (Quinn 1999). Schools can be commonly encountered in waters over 100 ft deep. However, juveniles may be more closely associated with shorelines and protected bays, in mixed schools with herring and surf smelt of similar age and size. There is no information on movement patterns and no evidence of seasonal ocean-ward migration out the Strait of Juan de Fuca. Their home ranges are unknown and there has been no assessment of stock status.

4.7 Effects of the Action (Bull Trout, Bull Trout Critical Habitat, and Marbled Murrelet)

The regulations implementing the Act define "effects of the action" as "the direct and indirect effects of an action on the species or critical habitat, 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 Section 402.02).

4.7.1 Approach to the Analysis

We analyzed the effects of the proposed action on reproduction, numbers, and distribution of bull trout and marbled murrelets. The first step involves identifying aspects of the proposed action that are likely to generate stressors that result in direct and indirect effects on listed species and/or the environment upon which they depend in the action area. Stressors are considered to be any physical, chemical, or biological effect on the environment resulting directly or indirectly from the proposed action, per the Service's advanced section 7 training curriculum (USFWS 2004a). Stressors, as used in the context of this analysis, may result in positive, negative or neutral effects. The subsequent analysis will identify and characterize stressors associated with the proposed action.

The concept of "stressors" is also commonly cited in the scientific literature (Wenger 2008). The framework of this analysis is linear:

Activities → Stressors → Effects

The delineation of activities and the stressors they produce establishes the *action area.*

The second step, referred to as the *exposure analysis*, identifies the listed species that are expected to co-occur with the identified stressors. The next step is to describe the nature (timing, duration, frequency, intensity, etc.) of that exposure and how the listed species are likely to respond to those stressors. The response analysis requires a thorough examination of the available scientific and commercial data. Prior to arriving at our conclusion, the final steps involve an analysis of risk posed to the listed species based upon their response to the stressors caused by the action.

The risk analysis for a listed species begins by identifying the consequences to individuals exposed to stressors. These consequences can be lethal, sublethal, or immeasurable. Any identified risks to individuals are then integrated into an analysis designed to identify risks to the populations those individuals represent. Similarly, the analysis concludes with an analysis of the consequences of action at the listed entity scale. In this case, that is the coterminous listed range of the bull trout, the listed range of the murrelet, and the scale of the coterminous listed range of bull trout for designated bull trout critical habitat.

Risk to listed individuals is measured by the expected change in "fitness" of individuals caused by their exposure to the project stressors. Maintaining the fitness[3] or the growth, survival, annual reproductive success, and lifetime reproductive success of individuals is a necessary attribute of viable populations. We determine whether the stressors are likely to result in lethal, sublethal, or behavioral consequences that reduce the fitness of individuals and whether reductions in fitness are likely to reduce the viability of the affected population that, in turn, could affect the viability of the listed species.

In particular, we assess fitness reductions of a species by describing the expected changes, if any, in a species' reproduction, numbers, and distribution to describe the overall risk of species extinction or probability of species survival and recovery. Our final determination is based upon whether or not the species is likely to experience a reduction in viability and whether or not the reduction is likely to be appreciable.

We used the best scientific and commercial evidence available to analyze the effects of the action. The growers, through the Corps, provided information on the type and scale of shellfish aquaculture. Some of the information provided was incomplete or very general. However, it is the only information we have available to determine the scope of the action. Three parameters necessary to evaluate the scale and level of impact, acres and species under cultivation and type of cultivation method, were rarely available. In the absence of specific information, we assumed that an entire parcel, or the maximum allowable acreage, was under cultivation. We acknowledge that, in many cases, this may overestimate potential effects. We also assumed that all of the activities could occur in all the action areas. This analytical approach is consistent with direction in the section 7 regulations at 50 CFR Section 402 that "In formulating its Biological Opinion, the Service must provide the "benefit of the doubt" to the species concerned.

Given the nature of the interagency coordination process for PCNs, as described in section 4.1, there is no assurance that additional restrictions will be applied to minimize impacts to aquatic

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[3] Fitness is a measure of the response of a population of organisms to natural selection, based upon the number of offspring contributed to the next generation in relation to the number of offspring required to maintain the subject population at its' current size (Abercrombie et al. 1980).

resources, including bull trout or marbled murrelets. Consequently, we could not assume that any additional requirements would be imposed by the Corps to minimize or avoid potential effects, and our analysis reflects this.

In addition to site-specific information provided by the growers via the Corps, we relied on grey and peer reviewed literature as key sources of information. We conducted literatures searches, contacted professionals in the field of marine ecology, collaborated with ENVIRON and NOAA Fisheries staff, and relied on literature searches conducted by, ENVIRON (2007) and NOAA Fisheries (Kerry Griffin, NOAA Fisheries, Office of Habitat Conservation, *in litt.* 2008). Additionally, we supplemented this information with reports and other documents such as Federal Register notices, recovery plans, and scientific reviews and summaries.

4.7.2 Activities with Insignificant or Discountable Effects

Shellfish aquaculture involves specific activities that follow the progression of standard farming practices, and as such involve numerous sequential steps. The potential effects of the individual activities listed below on bull trout and murrelets are expected to be insignificant (immeasurable) or discountable (extremely unlikely to occur). Therefore, they will not be addressed further in the opinion.

Little Neck, Manila and Butter Clams Ground Culture
- Seeding by hand spreading or from a boat
- Bed maintenance and survey to determine the need for additional seeding

Little Neck, Manila and Butter Clams Bag Culture
- Monitoring during low tide and occasional turning
- Removing bags from 1-2 ft of water

Mussel Raft Culture
- Removing tubes and transfer to shore using a boat

Oyster Long-line Culture
- Attaching spat to the lines by hand
- Periodic checking to determine if oysters and structures are secure

Oyster Rack and Bag Culture
- Placing seed in bags or racks
- Releasing bags to a boat or transporting them to shore by wheelbarrow

Oyster Stake Culture
- Seeding and placing stakes
- Hand harvesting

Oyster Bottom Culture

- Hand harvesting

Oyster Suspended Culture

- Seeding and size sorting
- Harvesting by collecting lines using a vessel

Geoduck Culture

- Tube and net placement and removal

The direct effects of conducting these specific activities were considered discountable because many are conducted during low tide or when water is shallow:

Little Neck, Manila and Butter Clams Ground Culture

- Seeding by hand spreading or from a boat
- Bed maintenance and survey to determine the need for additional seeding

Little Neck, Manila and Butter Clams Bag Culture

- Monitoring during low tide and occasional turning
- Removing bags from 1 -2 ft of water

Oyster Long-line Culture

- Attaching spat to the lines by hand
- Periodic checking to determine if oysters and structures are secure

Oyster Rack and Bag Culture

- Placing seed in bags or racks
- Releasing bags to a boat or transporting them to shore by wheelbarrow

Oyster Stake Culture

- Seeding and placing stakes
- Hand harvesting

Oyster Bottom Culture

- Hand harvesting

Oyster Suspended Culture

- Seeding and size sorting

Geoduck Culture

- Tube and net removal

Geoduck harvest

- Harvesting by water jet

Little Neck, Manila and Butter Clams Ground Culture

- Seeding by hand spreading or from a boat

Mussel Raft Culture

- Removing tubes and transfer to shore using a boat

Oyster Rack and Bag Culture

- Releasing bags to a boat or transporting them to shore by wheelbarrow

Oyster Suspended Culture

- Harvesting by collecting lines using a vessel

Because most of these activities are conducted during low tide, bull trout and marbled murrelets are not expected to be present. In some cases, the activities are conducted by boat. We do not expect that bull trout or marbled murrelet will be disturbed by the presence of small boats in the intertidal area as this is common in the marine environment.

The indirect effects (ecosystem level) of these shellfish culture methods are considered further in this report as they may affect eelgrass beds, the benthic community and the aquatic food web and ultimately listed species.

4.7.3 Activities with Adverse (Measurable) Effects

Activities that potentially pose the greatest risk are those that involve bed preparation and mechanical harvest and, in some cases, the temporal effects of shellfish grow-out. Due to the spatial scale of the proposed action (the intertidal waters of Puget Sound, the Strait of Juan de Fuca, Willapa Bay and Grays Harbor), the overall effects of these activities are considered at an ecosystem level first and then specifically for bull trout, bull trout critical habitat, and murrelets. When addressed collectively, we refer to these three listed entities as “listed resources.”

4.7.3.1 Timing and Duration of Activities

Shellfish aquaculture operations are conducted throughout the year, because harvest is driven by market demand. Shellfish seeding takes place from early spring to late summer. Depending on the species, growth to maturity can take 2 to 4 years; local conditions and the growing method also affect the time to maturity.

In most cases, ground-based culture activities are conducted when tides are low enough to expose the shellfish bed, but this is not always the case. Some activities, such as mechanical dredge harvesting, are performed from a boat when the beds are submerged. The lowest low tides (minus tides) typically occur for a number of days twice each lunar month, at the full moon and again at the new moon. These tides occur near midnight in December, near noon in June, and at corresponding intermediate times in the other months. Work on the beds occurs day or night in order to take advantage of the minus tides no matter what time of day or night. Consistent with the length of the low tide and the culture activities, workers or mechanical harvesters may be on the bed for 3 to 6 hours.

Carbaryl application, an interrelated activity, is the one activity that is seasonally restricted. Carbaryl must be applied during extreme low tides, usually in July or August. Spraying is usually completed within a week.

4.7.4. Bull Trout Exposure Analysis

Anadromous adult and subadult bull trout utilize nearshore marine waters, including estuaries and shoreline areas, within most of the action areas. This nearshore environment provides habitat critical to both bull trout and salmon for foraging, refuge (from predation, seasonal high flows, winter storms, etc.), and migration.

In two recent telemetry studies documenting the extent of anadromy in bull trout within portions of the Coastal-Puget Sound IRU, approximately 55 percent of the fish tagged in freshwater emigrated to saltwater (Brenkman and Corbett 2005; Goetz et al. 2007). Some level of mixing or interaction within marine waters occurs among anadromous individuals from various core areas. Based on recent studies it is likely that bull trout from several core areas may be present within a nearshore area simultaneously (Goetz et al. 2004; Brenkman and Corbett 2005; Brenkman et al. 2007; Goetz et al. 2007). Results from these studies also demonstrate that anadromous bull trout inhabit a diverse range of estuarine, freshwater, and marine habitats.

Marine waters provide important habitat for anadromous bull trout for extended periods of time. Data for bull trout from Puget Sound indicate that the majority of anadromous bull trout tend to migrate into marine waters in the spring and return to rivers in the summer and fall periods. Although much less frequent, tagged fish have been detected in Puget Sound nearshore marine waters during December and January, which indicates that some fish remain in marine waters during the winter (Goetz et al. 2004; USGS, *in litt.* 2008). Warmer water temperatures in the summer may be one environmental cue that stimulates bull trout to return to freshwater. Other factors that may influence marine residency for bull trout include prey availability, predation risks, or spawn timing.

In a study by Goetz et al. (2004), the greatest bull trout densities were at depths greater than 2.0-2.5 m. Upon entering marine waters bull trout can make extensive, rapid migrations, usually in nearshore marine areas. During the majority of their marine residency, anadromous bull trout have been found to occupy territories ranging in size from approximately 10 m to more than 3 km and located within 100 m to 400 m of the shoreline (USGS, *in litt.* 2008). Aquatic vegetation and substrate common to all or most bull trout areas includes eelgrass, green algae, sand, mud, and mixed fine substrates. These habitat features are also correlated with forage fish occurrence.

We expect that bull trout will be exposed to aquaculture activities conducted in all action areas with the exception of Willapa Bay.

4.7.5 Bull Trout Critical Habitat Exposure Analysis

With the exception of the South Puget Sound and Willapa Bay action areas, shellfish aquaculture overlaps bull trout critical habitat in most locations (Figure 4.13 and 4.14).

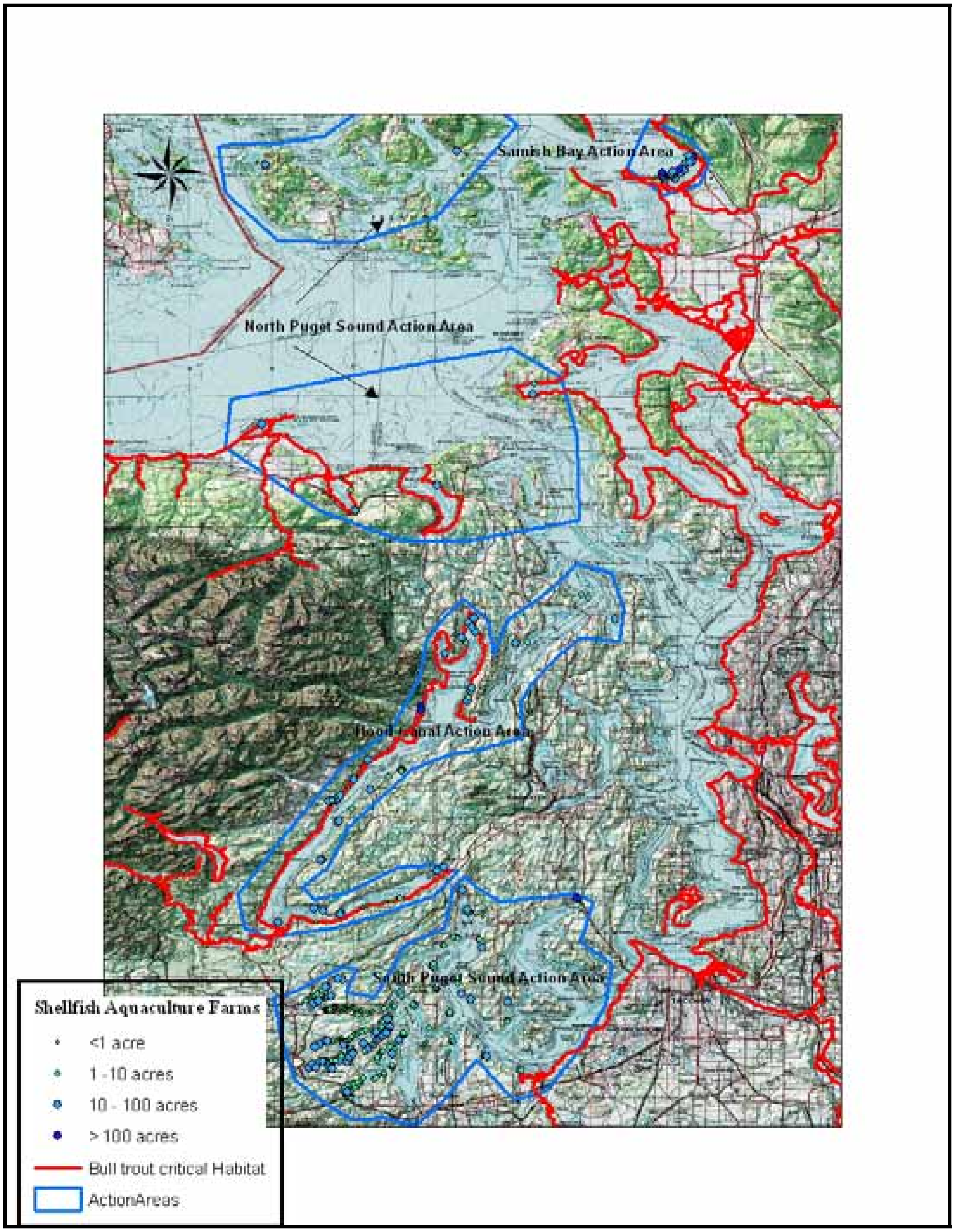

Figure 4.13 Bull Trout Critical Habitat in the Hood Canal, Samish Bay, and North Puget Sound Action Areas

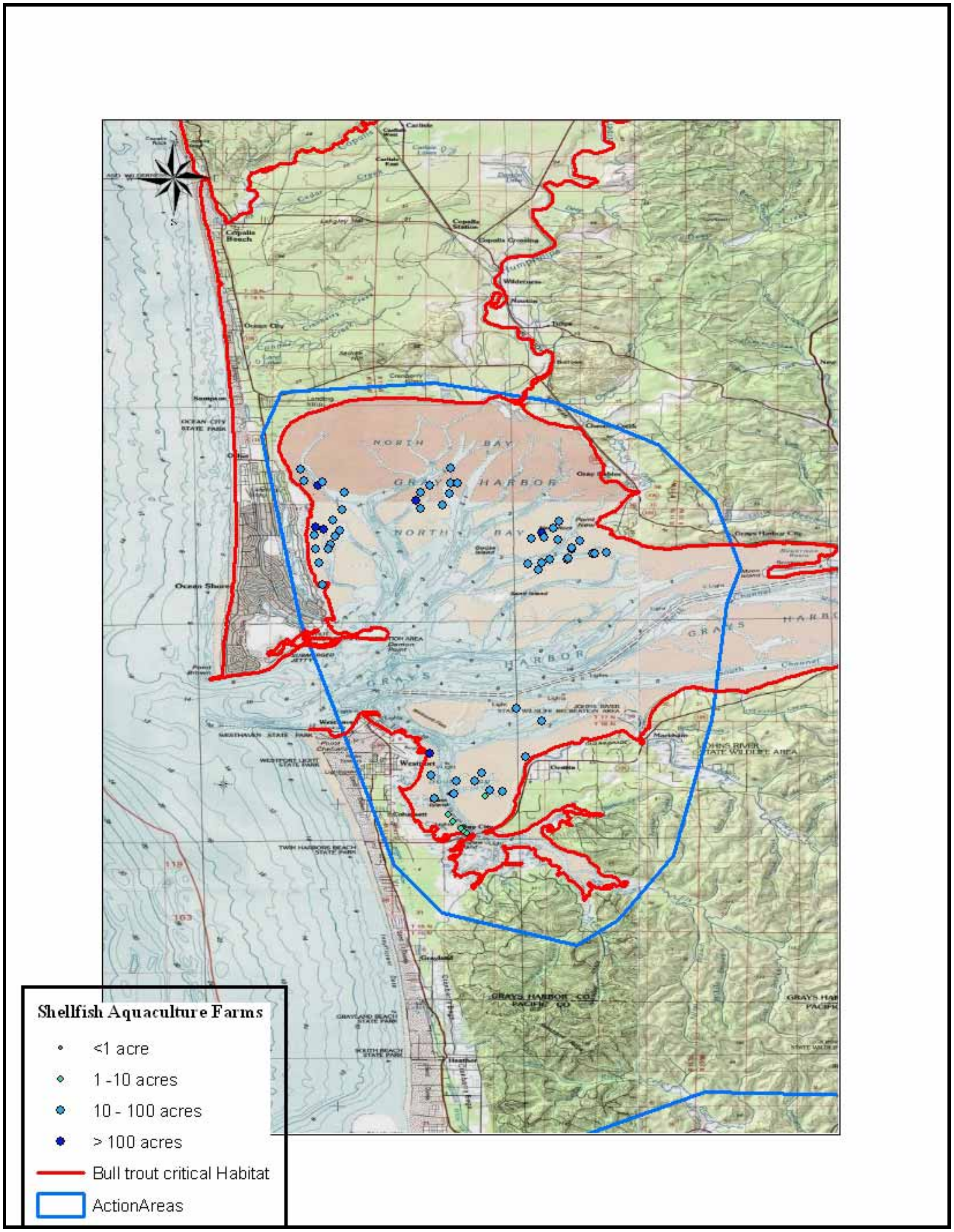

Figure 4.14 Bull Trout Critical Habitat in the Grays Harbor Action Area.

In the Hood Canal action area, more than half of the shellfish farms are located within bull trout critical habitat (Figure 4.11). Table 4.1 in Section 4.2.14 presents the approximate density of shellfish farms in each action area. There are approximately 200 parcels consisting of approximately 7,300 acres in the action areas where critical habitat has been designated. The action areas with the highest density of shellfish farms, Willapa Bay and South Puget Sound, support approximately 923 and 398 parcels, respectively, and do not contain critical habitat.

Because this overlap exists, critical habitat is exposed to all activities described in sections 4.2 (Project Description) and 4.7.3 (Effects of the Action). The potential effects to the critical habitat PCEs presented above are discussed in Section 4.9.4.11.

The application of carbaryl is interrelated to the action under consultation. This particular activity takes place only in the Grays Harbor and Willapa Bay action areas. Because critical habitat was not designated in Willapa Bay, the exposure of critical habitat to the application of carbaryl only occurs in Grays Harbor; as such, effects to critical habitat will be evaluated in this action area alone (see Section 4.9.4.12.1.2).

4.7.6 Marbled Murrelet Exposure Analysis

Murrelets are present in all of the action areas evaluated in this Biological Opinion. Many of their daily activities, including courtship, foraging, loafing, molting, and preening, occur in marine waters.

During the breeding season (April 1st to September 15th), the marbled murrelet tends to forage in well-defined areas along the coast in relatively shallow marine waters (Strachan et al. 1995). Murrelets forage at all times of day and in some cases at night when light conditions are bright enough to see prey (Strachan et al. 1995). Murrelets typically forage in waters less than 550 yd (500 m) from shore, and less than 100 ft (30 m) deep (Burkett 1995). They will forage in waters as shallow as 3 ft (1 m). Juveniles are generally found closer to shore than adults (Beissinger 1995) and forage without the assistance of adults (Strachan et al. 1995).

We expect that murrelets will be exposed to shellfish aquaculture activities conducted in the intertidal areas of all action areas. The likelihood of exposure is not equal in all action areas. Survey data are unavailable for Willapa Bay and Grays Harbor, although suitable nesting habitat is present adjacent to these water bodies, and it is reasonable to assume the species occurs in those areas throughout the year. The South Puget Sound action area is expected to support the fewest murrelets. However, just to the west, Hood Canal is an important area and supports higher densities. North Puget Sound and Samish Bay also support murrelets.

4.7.7 Response Analyses (Bull Trout, Bull Trout Critical Habitat, and Marbled Murrelet)

In the exposure analyses above, we presented evidence that describes how murrelets and anadromous bull trout utilize the nearshore habitat. In the following sections, we examine the activities in greater detail to assess the potential stressors generated by the activities authorized under NWP 48, their potential effects on ecosystem functions important for the conservation of bull trout and murrelets, and the specific consequences to each listed resource. We also describe the potential stressor-generating activities and link those stressors to critical habitat primary constituent elements. Throughout this analysis, we rely on the best scientific information available to determine the direct and indirect effects of stressors caused by the activities, and the response of species to those stressors.

4.7.7.1 Potential Stressor-Generating Activities

In December 2007, the Washington Sea Grant hosted a workshop to "…identify the current state of knowledge regarding on-bottom intertidal aquaculture and its interactions with the environment. The goal was to identify the information and research needed for sustainable management of geoduck and other shellfish resources." Out of this workshop came a list of research recommendations designed to address concerns, uncertainties, and data gaps related to large scale geoduck aquaculture. In addition, Dethier and Leitman (Megan N. Dethier et al. *in litt.* 2007) prepared a document identifying "concerns and questions relevant to infaunal and epibenthic impacts of geoduck aquaculture." These materials focused on geoduck aquaculture, as it is increasing rapidly in the Puget Sound area and the environmental effects from stressors associated with its unique farming practices are mostly unknown.

We relied on both the Sea Grant Workshop recommendations and Diethier and Leitman (Dethier et al., *in litt.* 2007) to identify potential stressors from geoduck aquaculture on listed species. Obviously, geoduck clams are only one of many species of shellfish grown in Puget Sound. We identified the potential stressors associated with aquaculture practices for geoduck and other shellfish species through literature reviews, direct observation during site visits, and collaboration with experts in academia, the private sector, consulting firms, and State and Federal governments.

The stressors associated with the various activity types may affect, directly or indirectly, components of the aquatic environment important to murrelets and bull trout. These components include 1) functional migratory corridors and supporting habitats, 2) an abundant food base, which is linked to the lowest levels of the aquatic food web, and 3) sufficient water quality. The types of stressors anticipated and evaluated in this Opinion are presented below.

Aquaculture methods for growing specific shellfish species were presented in the description of the proposed action section. Each of these culture methods consists of activities conducted at each stage of the growing process, including bed preparation, seeding, grow out, and harvest. These activities generate stressors on the aquatic environment that may directly or indirectly affect listed resources.

The primary stressors (as defined in Section 4.7.1) anticipated and evaluated in this Opinion associated with farming shellfish in the intertidal zone include the following:

- Removal or reduction of eelgrass leading to a reduction in herring spawning habitat and fish and aquatic invertebrate nursery habitat.
- Changes in the benthic community structure.
- Changes to intertidal foraging and migration habitat.
- Generation of a turbidity plume through mechanical dredge harvest.

- Disturbance/compaction of forage fish spawning areas.
- Use of a wide spectrum insecticide (carbaryl) to control ghost shrimp in the intertidal areas of Willapa Bay and Grays Harbor.
- Improvement in water quality and light penetration.

Table 4.11 presents the stressors to be evaluated in this Opinion. Each of these stressors will be presented in more detail in the effects analysis where the overlap of the listed resources and stressors will be discussed. We acknowledge that various species of submerged aquatic vegetation may be affected by aquaculture activities; however our analysis focuses specifically on native eelgrass (*Zostera marina*) as spatial data were only available to display the overlap between eelgrass beds and aquaculture facilities.

Table 4.11 Potential Stressors Considered to be Associated with Shellfish Aquaculture.

	Stressors according to Culture Method and Farming Stage			
Culture Method	**Bed Preparation and staging**	**Seeding**	**Grow-out**	**Harvest**
Clam Ground/Bag	Cover benthic invertebrates; change benthic community structure; forage fish spawning area disturbance (staging)	None	None	Sediment Plume; changes in the benthic community composition
Mussel Raft	None	None	Shading eelgrass, anoxic sediments; change in benthic community structure	None
Oyster and Mussel Long-line	Reduction of eelgrass; carbaryl application	None	Fertilization of eelgrass; improvement in water clarity; physical structure ”habitat” feature	Trampling eelgrass
Oyster Rack and Bag	Reduction of eelgrass; cover benthic invertebrates; change substrate structure; forage fish spawning area disturbance (staging)	None	Cover benthic invertebrates; reduction in eelgrass; physical structure ”habitat” feature	None
Oyster stake	Change benthic community type; reduction of eelgrass; forage fish spawning area disturbance (staging); carbaryl application	None	Reduction of eelgrass; fertilization of eelgrass; improvement in water clarity; physical structure “habitat” feature	None
Oyster Bottom	Removal of eelgrass; carbaryl application	change substrate structure ; provides habitat structure for some inveretebrates	fertilization of eelgrass; increase in water clarity	Changes in the benthic community and reduction of eelgrass through dredge harvest; increased turbidity through dredge harvest
Oyster Suspended	None	None	Bioturbation; Shading eelgrass; fertilization of eelgrass; increase in water clarity; physical structure “habitat” feature	None
Geoduck	Forage fish spawning area disturbance (staging); benthic community disturbance	Habitat exclusion from tubes/nets; changes in benthic community composition	Temporary habitat exclusion from tubes/nets	Sediment plume; disruption of benthic community

4.7.8 Effects on Eelgrass Beds and the Associated Ecosystem Services

Effects to eelgrass occur through a variety of shellfish culture activities as depicted in Figure 4.15. The most notable include bed clearing and preparation (tilling or harrowing, levelling) for bed culture of clams (including geoduck) and oysters, and long-line oyster culture. Eelgrass grows back into previously colonized areas that have been cleared over time, but its presence is temporary as it is removed during or after harvesting.

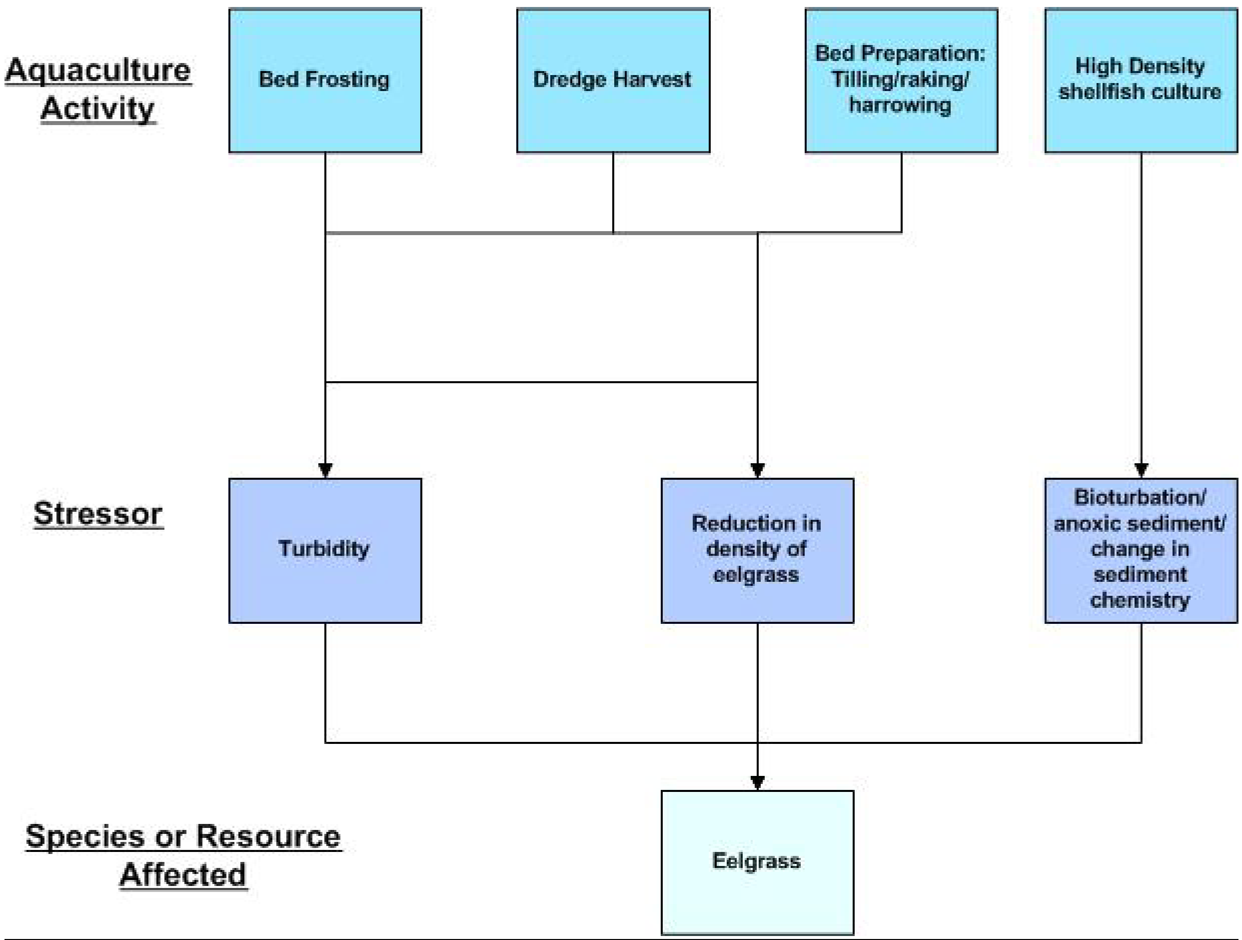

Figure 4.15 Aquaculture activity anticipated stressors and affected species or resource - Eelgrass

Intertidal zones and their associated eelgrass (*Zostera marina*) habitats provide the following ecological functions (Blackmon et al. 2006, p. 1):

- Structure for a complex intertidal food web.
- Spawning habitat for Pacific herring.
- Habitat for forage fish species.
- Cover for migrating juvenile salmonids.

Eelgrass supports the most complex food web of those studied by Simenstad et al. (1979, p. 33). In addition to providing the surface area for growth of epiphytic algae, eelgrass beds reduce wave energy, allowing for the deposition of fine sediments and detrital material, which support the base of a complex food web (Figure 4.16) (Simenstad et al. 1979, p. 31). As presented in Figure 4-17 and Blackmon et al. (2006, p. 5), micro-invertebrates associated with eelgrass beds, which include harpacticoid copepods, gammarid amphipods, and cumaceans, are commonly reported to be important components in the diets of juvenile Pacific salmonids, herring, smelts and flatfishes (Naiman and Sibert 1979; Simestad et al. 1980, 1988; D'Amours 1987; Thom et al. 1989; Webb 1989; Simestad and Cordell 1992; and Wyllie-Echeverria et al. 1995, all as cited in Blackmon et al. 2006, p. 5).

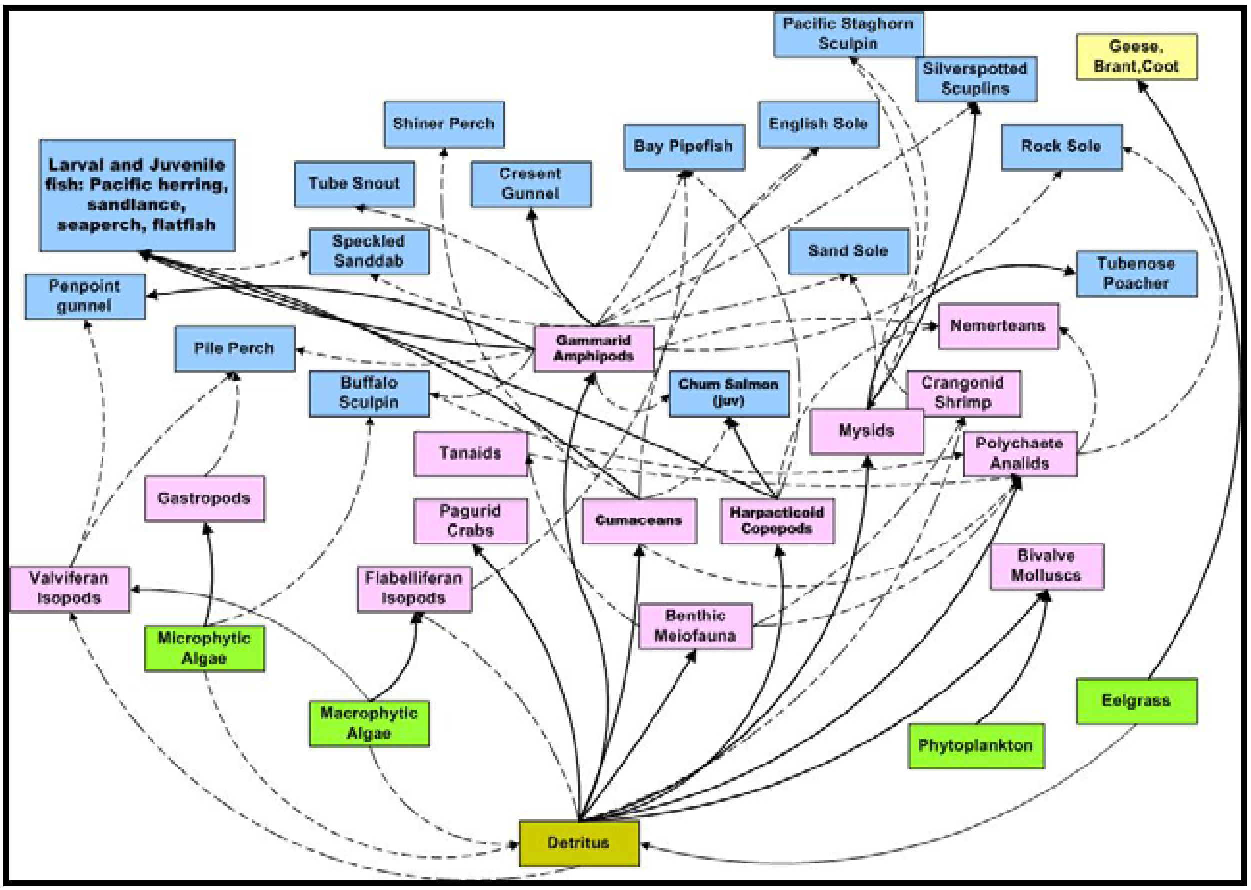

Figure 4.16 Composite food web characteristic of an eelgrass community (adapted from Simenstad et al. 1979).

Throughout most of the Puget Sound region, eelgrass is of primary importance as a herring spawning substrate (Mumford 2007, p. 6) (Phillips 1984 in Blackmon et al. 2006, p. 9). The presence of perennial vegetation tends to be more important than location for selection of spawning habitat by herring (Penttila 2007, p. 6). In some locations in the Puget Sound Basin, especially western Whatcom County, herring spawn on dozens of species of red, green, and brown algae (Millikan and Penttila 1973 as cited in Mumford 2007, p. 6). In somewhat deeper water, and in areas where eelgrass beds do not predominate, the red alga *Gracilariopsis* sp. (often referred to as *Gracilaria*) may be the dominant substrate for spawning.

In a small fraction of the documented herring spawning areas, more atypical spawning substrates are used. This coincides with anecdotal evidence that herring spawn on aquaculture equipment, as herring will use non-vegetative structures. Some areas noted by Mumford (2007, p. 6) include middle intertidal boulder/cobble rock surfaces with little or no macroalgae; current-swept subtidal gravel beds in the near absence of macro-vegetation; amassed beds of tubes of the polychaete worm *Phyllochaetopterus* sp.; and dock pilings (WDFW unpublished data in Mumford 2007, p. 6).

Once the herring have hatched and survived their planktonic stage, they remain in the Puget Sound nearshore through the first several months of life (Penttila 2007, p. 7). During their early life stages, herring feed primarily on eelgrass-associated invertebrates such as copepods and amphipods (Levings 1983 as cited in Blackmon et al. 2006, p. 9). As herring mature, they feed on shellfish larvae, copepods, and other larval fish (Hart 1973 in Blackmon et al. 2006, p. 9). Other important forage fish species including sand lance and surf smelt feed on calenoid copepods and other epi-benthic crustaceans associated with the eelgrass food web (See Figure 4.16).

To date, the most comprehensive effort to characterize the Puget Sound food web was completed in 1979. Although dated, this work is the most complete to date on the trophic relationships in the nearshore. The species assemblages that were critical to upper trophic level species were identified through this effort, and included calanoid copepods and gammarid amphipods. Gammarid amphipods are the principal prey of the nearshore consumers. The calanoid copepods are the primary prey item for herring, Pacific sand lance, and juvenile Pacific salmon (Figure 4.17) (Simenstad et al. 1979, p. 4). Other detritivores, including harpactacoid copepods, flabelliferan isopods, cumaceans, mysids and shrimp, significantly support upper level consumers (Simenstad et al. 1979, p. 4).

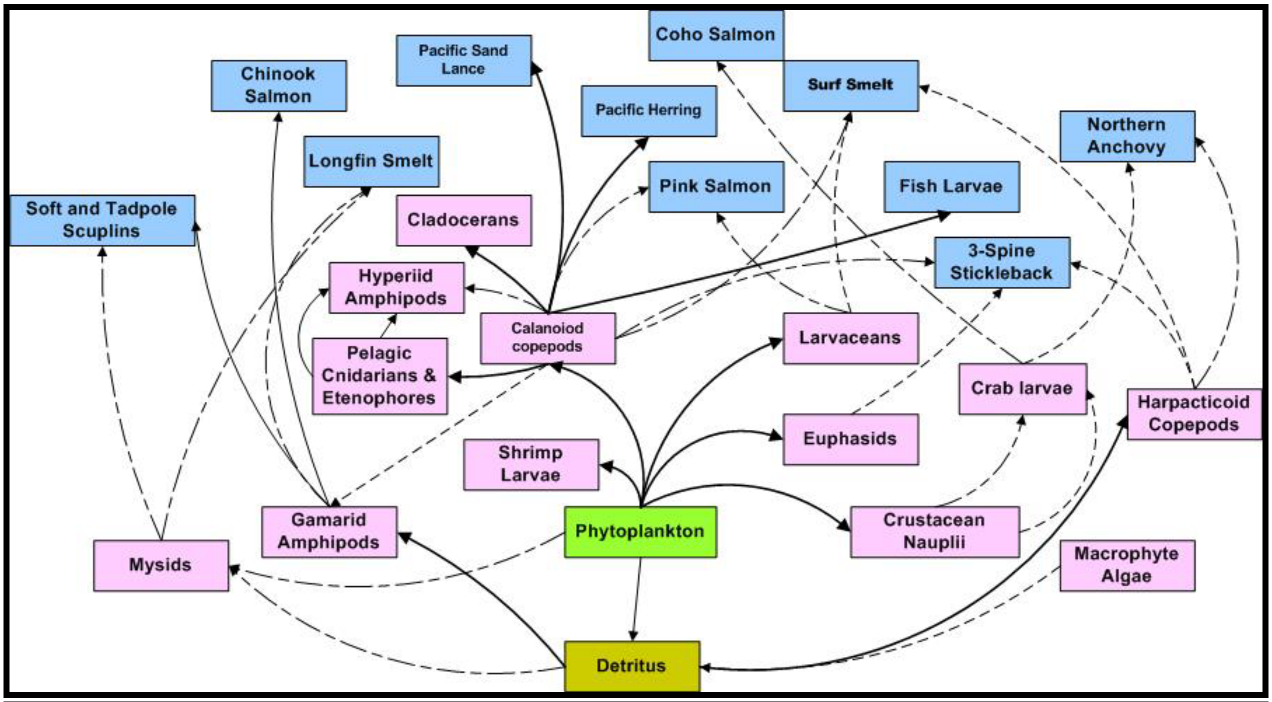

Figure 4.17 Composite food web characteristic of nearshore habitats in northern Puget Sound and the Strait of Juan de Fuca (adapted from Simenstad et al. 1979).

Out-migrating juvenile salmonids utilize a variety of habitats during their migration through Puget Sound. Eelgrass is commonly used because it provides cover, refuge and a prey base for small fish at this vulnerable life stage.

Shellfish are an integral member of the intertidal community, including eelgrass beds. When abundant, suspension-feeding bivalve mollusks provide important links between benthic and pelagic processes. This is known as benthic pelagic coupling. Shellfish filter large volumes of suspended particles from the water column and expel them as both uningested pseudofeces and feces which sink to the bottom (Newell 2004, p.52). This conversion of phytoplankton to nutrients, including phosphorus and ammonia (nitrogen), then becomes biologically available in the sediments to eelgrass and other aquatic vegetation. For this reason, eelgrass growth may be enhanced by the presence of shellfish in aquaculture plots. Additionally, through the removal of suspended particles, shellfish improve water clarity and therefore light penetration, which can enhance eelgrass photosynthesis (Peterson and Heck 2001; Newell and Koch 2004, p. 794; as cited in Wisehart et al. 2007, p. 72). On the West Coast the interaction between bivalves and eelgrass appears to be weak for light or nutrient pathways, based on current information (Dumbauld et al. 2009, p. 15).

4.7.8.1 Importance of Eelgrass Habitats to Bull Trout

Upon entering marine waters, bull trout can make extensive, rapid migrations, usually within nearshore marine areas. Aquatic vegetation and substrate common to all or most of the nearshore marine areas frequently used by bull trout includes eelgrass, green algae, sand, mud, and mixed fine substrates (USGS, *in litt.* 2008, p. 22). Not surprisingly, these habitat features are also correlated with forage fish occurrence.

USGS (, *in litt.* 2008, p. 22) suggested that shallow water habitats with prey may be the key focus of bull trout, and other variables may be less important. However, movement data were inadequate to determine if bull trout actively select specific vegetative habitats. Green algae and eelgrass were the most common vegetation types where bull trout were found in Skagit Bay (USGS, *in litt.* 2008, p. 17).

4.7.8.2 Importance of Eelgrass Habitats to Murrelets

Murrelets do not depend directly on eelgrass, as their association occurs primarily through their prey. In general, small schooling fish and large pelagic crustaceans are the main prey items of marbled murrelets. Pacific sand lance, northern anchovy, immature herring, capelin, Pacific sardine, juvenile rockfishes (*Sebastas* spp.) and surf smelt are the most common fish species eaten. Squid (*Loligo* spp.), euphausiids, mysid shrimp, and large pelagic amphipods are the main invertebrate prey. A number of these species are associated with the nearshore food web (Figure 4.17) and many of them utilize eelgrass during larval and juvenile stages (Figure 4.16).

Herring are particularly important to murrelets as an energy rich prey item. Murrelets are able to shift their diet throughout the year and over years in response to prey availability (Becker et al. 2007). However, long-term adjustment to less energetically-rich prey resources (such as invertebrates) appears to be partly responsible for poor marbled murrelet reproduction in California (Becker and Beissinger 2006). Prey types are not equal in the energy they provide. For example, parents delivering fish other than age-1 herring may have to increase deliveries by to up 4.2 times to deliver the same energy value (Kuletz 2005b). This may result in marbled murrelets preferring to forage in marine areas in close proximity to their nesting habitat. However, if adequate or appropriate foraging resources (i.e., "enough" prey, and/or prey with the optimum nutritional value for themselves or their young) are unavailable in close proximity to their nesting areas, marbled murrelets may be forced to forage at greater distances or to abandon their nests (Huff et al. 2006, p. 20).

4.7.9 Effects of Aquaculture on Eelgrass

Aquaculture farms are often located within eelgrass beds (see figure 4.18). Various types of aquaculture activities affect distribution, density, and biomass of eelgrass. Off-bottom culture results in shading, biodeposition and buildup of feces and pseudo feces, silt buildup, and anoxic conditions in the sediment. Off-bottom and rack culture results in erosion or sedimentation that appears to be the primary cause of eelgrass depletion in areas where this type of aquaculture is practiced (Everett et al. 1995, p. 205). Additionally, the intertidal areas of Samish Bay have been rototilled in the past during the spring to disrupt the life cycle of the Atlantic oyster drill (*Urosalpinx cinerea*) (Brian Williams, WDFW, pers. comm. 2008). This invasive oyster drill was first reported in Samish Bay in 1937 and was likely introduced through shipments of Atlantic oyster for aquaculture (Cohen 2005, p. 1). If the oyster drill continues to be a problem, and rototilling is successful in disrupting its lifecycle, the continuation of this activity is likely.

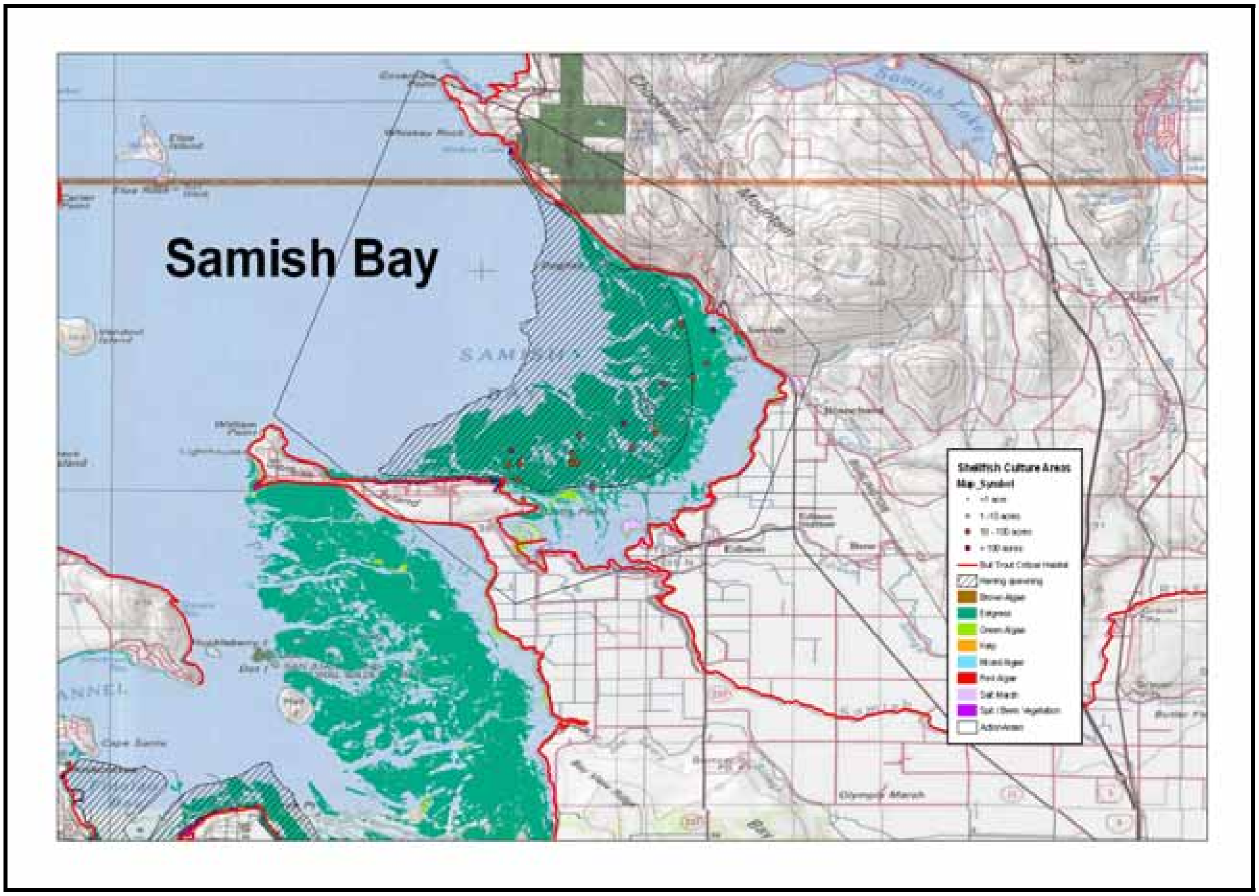

Figure 4.18. Locations of aquaculture farms within eelgrass beds in the Samish Bay action area.

Both rack and stake culture cause a reduction in eelgrass density, primarily through shading (Everett et al. 1995, as cited in Landry et al. 2006, p. 98). Stake culture also provides substrate, resulting in an increase in algae such as *Ulva* (sea lettuce) and *Enteromorpha.* These species are suspected of having an adverse effect on eelgrass (Waddell 1964; Geyer et al. 1990; Cowper 1978 all in Griffin 1997, p. 13).

Off-bottom culture of oysters and other mussels (depending on the depth of culture) may contribute to the exclusion of eelgrass through an increase of sulphide and organic matter in the sediment. This occurs through production of feces and pseudofeces, which creates conditions that favor growth of sulphide-producing bacteria (Ingold and Havill 1984; Castel et al. 1989; de Zwaan and Babarso 2001, all as cited in Kelly et al. 2008, p. 58).

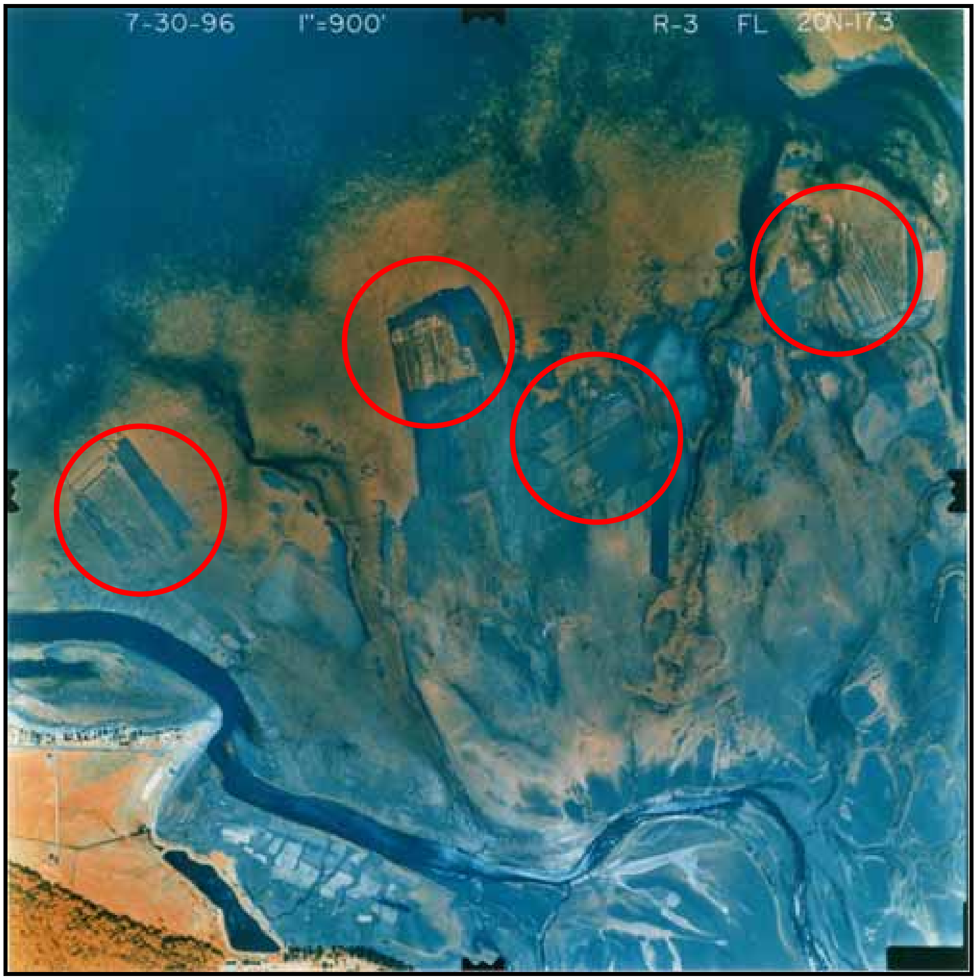

Figure 4.19 1996 Infrared photograph of aquaculture activities in eelgrass beds in Samish Bay. Photo courtesy of Washington State Department of Natural Resources.

Elevated sulphide levels are associated with reduced photosynthesis and growth in eelgrass (Goodman et al. 1995; Holmer and Bondgaard 2001 all as cited in Kelly et al. 2008, p. 58). Nevertheless, eelgrass is able to coexist with low densities of oysters used in bottom culture in soft sediments (Dumbauld et al. 2009, p.17).

At high densities, these filter feeders are capable of influencing the plankton community (abundance, biomass, and species composition), water clarity, primary production (through nutrient contribution and cycling), and food webs (Cloern 1982; Officer et al. 1982; Cohen et al. 1984; Yamamuro and Koike 1993; Dame 1996, all as cited in McKindsey et al. 2006, p. 5). When present at natural densities, filter feeders are in integral part of the intertidal community for the same benefits described above.

Bed preparation is one of a sequence of activities that comprises cultivation of shellfish (Section 4.2). It is done at the initial stage of oyster (rack and bag; stake and bottom) culture. It is also conducted for clam culture. Of the species of shellfish grown in the action areas, the activities conducted for oyster culture have the greatest potential for overlap with eelgrass beds. Although these specific activities have not been directly investigated, it reasonable to assume that bed preparation activities such as tilling, disking, raking, harrowing, and dragging in eelgrass beds would directly impact them (Figure 4.19) (Rumrill and Poulton 2004, p. 3; Jennifer Ruesink, University of Washington, pers. comm. January 14, 2009). These activities are part of the overall process of shellfish aquaculture, and it is apparent that intensive commercial cultivation of oysters typically results in ongoing and variable levels of disturbance to eelgrass beds and their related communities (Simenstad and Fresh 1995; Griffin 1997; Dumbauld 1997, as cited in Rumrill and Poulton 2004, p. 3).

Aquaculture activities are conducted on a year-round basis. Therefore, impacts to eelgrass beds could occur at any time. The seasonal effects of operation (e.g., during the growing vs. dormant season) have not been studied. Data are not available to determine whether impacts would be more severe during the growing or the dormant season. We are assuming, however, that if disturbance were to occur at a time when the amount of aboveground vegetation was greater (growing season), there would be more impact to the bed. This assumption is predicated on the fact that the leaf and shoot density would be greater; effects to the underground component of the plants (rhizomes) would be expected to be equivalent regardless of season. We discussed this with Dr. Ruesink (Ruesink, pers. comm. 2009), but are not able to confirm the validity of this assumption.

However, it is expected that, even during the dormant season, bed preparation activities would reduce the biomass generated during the following growing season (Ruesink, pers. comm. 2009; Ron Thom, Batelle Pacific Northwest Laboratories, pers. comm. January 14, 2009). This assumption is based on the reproductive biology of eelgrass. Eelgrass reproduces both asexually (via rhizomes) and sexually (via seed generation). The rhizomes store carbohydrates generated by the plant during photosynthesis. These carbohydrates are used in the winter to sustain the plant during the dormant (non-growing) season. If, because of bed preparation, the rhizomes are severed, the translocation of carbohydrates to the plant would be interrupted (Thom, pers. comm. 2009). Indeed, according to Ruesink (Ruesink, pers. comm. 2009), biomass may be reduced the following growing season by working beds and removing shoots.

While the case can be made that a reduction in biomass will occur the following growing season if the beds are prepared during the dormant season, we assumed that the overall effect would be lower than if these activities were conducted during the growing season because the amount of above-ground vegetation would be less. Additionally, during the growing season aquatic organisms use the eelgrass for the structural habitat functions it provides. Therefore, bed preparation activities conducted at this point in the plants lifecycle would have a greater detrimental effect on the organisms that utilize this habitat.

After disturbance, a reduction in eelgrass density can persist for some time. Oyster stake and rack culture has been shown to significantly reduce eelgrass density, in some cases up to 75 percent if stakes and/or racks are positioned too closely to limit light penetration (Carlton et al. 1991; Pregnall 1993; as cited in Landry et al. 2006, p. 98). This reduction in percent cover and shoot density was still evident after one year; eelgrass was also eliminated from the treatment sites after 17 months (Everett et al. 1995, p. 205). In a longer term study, eelgrass biomass was reduced from 30 percent to 96 percent based on a culture period from one to four years (Waddell 1964 as cited in Landry et al. 2006, p. 98).

Available evidence indicates it is reasonable to assume a temporary loss of eelgrass as a result of shellfish aquaculture. We used a GIS to map the overlap of eelgrass beds and shellfish aquaculture farms and predict the potential reduction of eelgrass as a result of the overlap. We calculated the total amount of eelgrass in each action area along with the estimated acreage of shellfish aquaculture farms that overlap eelgrass beds. The Willapa Bay and Samish Bay action areas had the greatest amount of eelgrass and aquaculture overlap. The remaining action areas are expected to experience less significant impacts.

Table 4.12 Area of Eelgrass beds and Shellfish Aquaculture and Predicted Overlap of Eelgrass.

Action Area	**Eelgrass (acres)**	**Shellfish Aquaculture Farms in Eelgrass Beds (acres)**	**Percent Overlap of Eelgrass and Aquaculture**
Willapa Bay	44,986	17,430	39
Grays Harbor	36,396	3,204	0.09
South Puget Sound	0	0	0
Hood Canal	2,388	106	0.04
Samish Bay	3,629	2,688[a]	74
North Puget Sound	53	0	0

[a] This value includes an estimate of approximately 2,300 acres of shellfish farms were not reported for this action area.

Eelgrass plays a pivotal role in the ecology of the nearshore community. Approximately one third of the eelgrass beds in Puget Sound have been lost since they were first inventoried (PSWQAT 2001, p. 1). This loss could represent a significant ecosystem impact, as eelgrass provides the following ecosystem functions:

- Supports the base of the food web harboring important prey species for forage fish and juvenile salmonids.
- Offers protection as a nursery habitat for herring and other developing aquatic organisms.
- Controls erosion and attenuates wave action to allow for settling out of fine material that builds up the organic content of the sediment.

Shellfish are an integral member of the intertidal community, including eelgrass beds. When present in natural densities, the niche they fill is critical to the health of coastal estuaries. When present in low densities used in oyster bottom culture they coexist with eelgrass. Shellfish reefs provide structure for aquatic plants and habitat for aquatic animals. Shellfish are critical to the recycling of nutrients and maintaining the health of sediment-associated organisms (such as eelgrass and benthic invertebrates).

Aquaculture activities are expected to cause a reduction in eelgrass through direct displacement from bed preparation (mechanical dredging, tilling, raking and harrowing[4]), and shellfish harvesting (mechanical dredging, water injection). Eelgrass may recover, although it may take an extended period of time and densities are expected to be lower. Eelgrass will encroach on shellfish beds over time, but it is reasonable to assume it will provide limited and ephemeral habitat given the subsequent harvesting that will take place. The quality (density and biomass) of the eelgrass that may be present in shellfish beds is likely to be lower than the density of the native bed displaced when the shellfish bed was first created. Therefore, while some of the functions may be restored, it is unlikely that the recovering eelgrass will completely offset the lost function of the displaced eelgrass due to its reduced quality and ephemeral nature.

The existing evidence indicates that eelgrass density and abundance is reduced in the presence of shellfish aquaculture. The significance of this temporal loss remains uncertain. We do not know if the reduction in eelgrass from increased bioturbation, shading, and physical disturbance is outweighed by the benefits to eelgrass from the presence of shellfish beds. The time required for the eelgrass beds to recover after re-planting can be considerable (from one to four years) if it returns at all. Considering that shellfish beds are harvested every three to five years, eelgrass may be available for only a few years before it is disturbed or removed again. This equates to a repeated perturbation that likely affects the ability of the bed to accommodate an established aquatic community. Some of these effects are likely offset by the increase in light penetration and fertilization provided by the shellfish, although this relationship is not robust along the West Coast (Dumbauld et al. 2009, p.15).

4.7.9.1 Aquaculture Structures as a Surrogate for Eelgrass Beds

According to the literature (Everett et al. 1995, p. 205; Everett et al. 1995; Carlton et al. 1991; Pregnall 1993; Peterson et al. 1987; Waddell 1964; all as cited in Landry et al. 2006, p. 98) there is a reduction in density and abundance of eelgrass associated with shellfish aquaculture plots. However, it has been suggested by some that this loss is not significant to the functioning of the intertidal community, because the physical structures supporting shellfish aquaculture (including the shellfish themselves) provides equivalent ecological functions to eelgrass beds. We reviewed the literature to determine if this supposition is borne out by observations in the field.

DeAlteris et al. (2004) compared modified rack and bag shellfish aquaculture gear (SAG) submerged aquatic vegetation (SUV) and nonvegetated seabed (NVSB). Specifically, they compared habitat structure in terms of emergent surface area (cm^2) per m^2 of seabed, species abundance and richness on a seasonal basis between eelgrass, oyster cages and unvegetated substrate (DeAlteris et al. 2004, p. 869). They found that species abundance was significantly greater on the SAG than the SAV and NVSB (DeAlteris et al. 2004, pp. 869-870) . They attributed the greater total abundance to the amount of surface area afforded by the SAG, which

[4] A preconstruction notification is required if, among other things , "the operation involves dredge harvesting, tilling or harrowing in area inhabited by submerged aquatic vegetation."

was approximately 60 times greater than the surface area of the SAV (DeAlteris et al. 2004, p. 873).

Emergent surface area also varies by season for SAV as eelgrass goes through a dormant season, thereby losing the structural component of the habitat in fall, winter and early spring. The SAG provides structure year round, although when the oyster cages are cleaned and the oysters are harvested, those organisms using the SAG as habitat are displaced. Consequently, the SAG also provides habitat on an ephemeral basis.

The SAG provided habitat for sessile organisms as well (DeAlteris et al. 2004, p. 873). As has been reported by others, the SAG developed a community of fouling organisms. These organisms are found on natural reefs as well and contribute to habitat complexity and food resources of the overall community. The SAV also attracts some sessile species, but does not provide the hard substrate and internal surface area that the oyster cage provides. The internal spaces of the cages provide shelter for juvenile species and cover from predation. SAV also provides these habitat functions but at a smaller scale compared to oyster cages, due to the lower surface area.

Although DeAlteris et al. (2004) found a significant difference in species abundance between SAG, SAV and NVSB, there was no significant difference in species diversity. In fact they point out that although species abundances may be greater in the SAG it is dominated by few species (DeAlteris et al. 2004, p. 873). It is clear that SAG, at least large structural gear such as rack and cage culture, provides habitat for large numbers of organisms. However, the community attracted to these structures was dominated by a few species while the SAV supported a more equal distribution of organisms. Therefore, although SAG provides similar habitat functions to SAV for some species, it may not, at least according to this study, satisfy the habitat needs of as great an assemblage of species as SAV.

Dumbauld et al. (2009, p. 18) present a summary of the literature describing the role of shellfish aquaculture as structured habitat for fish and invertebrates. They point out that the majority of studies investigate the role of natural assemblages of shellfish rather than aquacultural settings. In these studies oysters and mussels form 3-dimensional reefs that moderate water flow allowing colonization of algae and invertebrates and providing refugia and food resources. In most cases however, in standard aquacultural settings, shellfish are suspended or planted directly on the substrate and not allowed to form 3-dimensional reefs. Therefore, their role (particularly non-native species) in providing habitat should not be inferred from the studies of bivalve reefs (Dumbauld et al. 2009, p.18).

Pinnix et al. (2005) compared fish use between oyster longline culture areas, eelgrass, and mudflats in Humboldt Bay, California. They caught 49 fish species representing 22 families using six different types of capture gear. Depending on the capture gear type, species diversity was either greater in oyster long-line plots or in eelgrass. Clearly, there were gear type influences on the species collected (Pinnix et al. 2005, pp. 17, 19). While it is apparent that oyster long-line plots provide some of the same habitat functions as eelgrass, it is unlikely that they provide the same nursery functions. To the best of our knowledge, no one has evaluated juvenile fish use of eelgrass versus aquaculture plots.

Shellfish aquaculture plots also attract less mobile species as well. Suspended aquaculture (oyster long-line and rack culture, mussel rack culture) provides habitat for a group of organisms which make up what are termed fouling communities. Fouling communities consist of algae (red and brown), tunicates, sea squirts, annelids, mollusks and other sessile species. O'Beirn et al. (2004, p. 827) examined the species assemblage associated with floating mussel rafts. They consisted of worms, crabs, tunicates, sponges and fishes. No copepods, gammarids, or other prey species common to the eelgrass food web and important in the diets of forage fish and juvenile salmonids were listed. However, the mesh size of the collection baskets was larger than these microinvertebrates. Therefore, they may have escaped collection.

It is unlikely that these fouling communities and the species they attract provide the same trophic function that eelgrass beds provide to juvenile salmonids and forage fish. The species composition of these fouling communities is substantially different than the eelgrass community depicted in Figure 4.19 (eelgrass food web). According to McKindsey et al. (2006, p. 29) "…with respect to the infaunal and epifaunal organisms associated with bivalve culture, the installation acts more or less like a normal benthic hard-bottom community, what we refer to as a "pelagic hard-bottom community." Other authors also describe the conversion of the area under floating structures from soft bottom to hard bottom communities, and they note that hard bottom communities are more productive (Kaspar et al. 1985; Ricciardi and Bourget 1999; Cusson and Bourget 2005; Iglesias 1981; Chesney and Iglesias 1979; all as cited in McKindsey et al. 2006, p. 35). This may indeed be the case when the comparison is made between un-vegetated soft-bottom communities and hard-bottom communities. Eelgrass beds growing in soft bottom substrate such as sand or mud support a different biotic community than the benthic hard-bottom community mentioned above. The productivity of eelgrass beds is widely understood, leading to its preservation, conservation and restoration according to the Washington Administrative Code[5].

When comparing long-line mussel beds, un-vegetated sandy bottom substrate and eelgrass, Clynick et al. (2008, p. 207) found large difference in the fish and macroinvertebrate assemblages between mussel plots and eelgrass. Clynick et al. (2008) observed that a number of other species of fish, including the white hake (*U. tenuis)*, and Atlantic herring (*C. harengus*), were also almost exclusively present in eelgrass beds "suggesting that these species also have specific habitat requirements that seagrass beds provide and that are not mimicked by suspended mussel culture sites."

Some farming practices appear to provide some habitat function for fish and sessile species. These include long-line culture and raft, rack and cage culture. Long-line culture provides some habitat for adult demersal fishes and macrophytes. Aquaculture apparatus that forms a 3-dimensional structure (rack, raft and cage) provides significant surface area for colonization of sessile species, pockets of refugia for small fishes, and food resources. However, there tends to be high numbers of individuals from few species associated with this type of gear. The species

[5] WAC 173-26-221(2)(iii)(A) states that "Critical saltwater habitats include all kelp beds, eelgrass beds, spawning and holding areas for forage fish, such as herring, smelt and sandlance; subsistence, commercial and recreational shellfish beds; mudflats, intertidal habitats with vascular plants, and areas with which priority species have a primary association. Critical saltwater habitats require a higher level of protection due to the important ecological functions they provide. Ecological functions of marine shorelands can affect the viability of critical saltwater habitats. Therefore, effective protection and restoration of critical saltwater habitats should integrate management of shorelands as well as submerged areas".

composition in the culture methods described above differs from that found in eelgrass beds, which provides nursery habitat and supports a diverse community of aquatic organisms. Additionally, culture methods that suspended bivalves from floats, rafts or lines, or spread them along the substrate do not provide the same habitat features as 3-dimensional shellfish reefs, which are constructed primarily for restoration and are not used to grow robust individual shellfish for market.

4.7.10 Competition for Food Resources

Is it apparent that, at natural densities, shellfish fill a critical niche, and their presence is beneficial to the intertidal community. Of the 11 species commonly grown in the Pacific Northwest, only 4 are native, and it is questionable how frequently the Olympia oyster[6] (the only native oyster) is cultivated given its size relative to the Pacific oyster (Table 4.13).

Large shellfish operations growing large numbers of shellfish may cause a shift in the food web through reducing prey for primary consumers at the base of the food web. This is more likely to occur in sheltered embayments where flushing rates are low and foraging habitat for juvenile fish is limited or discontinuous. If shellfish are present at "natural" levels, their filtering activities would not upset the balance of the intertidal food web. However, aquaculture species are mostly non-native, planted at high densities, and filter larger quantities of water (phytoplankton) than the native oysters. Therefore, they may have a competitive advantage and reduce available food for other planktivores. This may be a more significant issue in confined or isolated embayments**.**

Cranford et al. (2008, p. 1) examined both the density of phytoplankton and a change in the size distribution in an enclosed estuary in Norway where mussel farming was ongoing. They found a 30 percent reduction in phytoplankton over a 3.8-hour period during high tide as the water moved through the mussel farm. They suggested that this rapid, bay-wide scale plankton depletion indicated that the mussels were exerting significant control over phytoplankton levels (Cranford et al. 2008, p. 3) . They also investigated the resulting shift in the size of phytoplankton, which dominated, to picophytoplankton (too small to be filtered by the mussels). According to Cranford et al (2008, p. 4) this shift in the size distribution of phytoplankton represents a "…significant destabilization of the basis of the marine food-web. A change in phytoplankton size can be expected to alter competition and predator-prey interactions between many resident species. In addition, the change in phytoplankton size can affect particle transport dynamics via reduced settling velocity and altered flocculation processes. The latter is dependant on particle size and the production of sticky exopolymers by diatoms, which are consumed by the mussels. These ecological effects need to be considered in the determination of the region's ecological carrying capacity for shellfish aquaculture." The degree to which filtration affects the density and size distribution of phytoplankton is site specific and depends on controlling factors such as current, wind speed, tidal range and water depth. Areas with a higher degree of susceptability are primarily semi-enclosed tidal lagoons and estuaries with low-energy hydrodynamics features and are shallow in depth (Cranford et al. 2008, p. 5). Areas within the south Puget Sound action area would likely meet this description, and if aquaculture were present at sufficient densities, similar effects would be expected.

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[6] By the early part of the 20th century, the Olympia oyster population had been severely reduced due to overfishing. The Pacific Oyster, three times its size, has since replaced it.

Dumbauld et al. (2009) present the results of a study in Willapa Bay (Wheat et al. in prep) which documents a reduction in phytoplankton of 10 percent per 100 meters as water moves over oyster beds there. A similar study conducted by Ruesink et al. (in prep) in the south Puget Sound region of Totton Inlet have documented no such reduction in this more confined region. Clearly a reduction in carrying capacity is controlled by numerous factors that vary on a site specific basis.

Shellfish can compete directly with forage fishes through consumption of copepods and amphipods. Recent studies have shown that shellfish may also consume larger benthic and pelagic organisms (Davenport et al. 2000; Lehane and Davenport 2002, both in McKindsey et al. 2006, p. 25). In a laboratory study by Davenport et al. (2000, as cited in McKindsey et al. 2006, p. 25), the authors found that 30-35 mm mussels (*M. edulis*) could consume both 300 µm *Artemia* sp. *nauplii* and 1-1.2 mm copepods. In field studies where a greater diversity of species was present, a wider variety of species were consumed by mussels. Davenport et al. 2000 (in McKindsey et al. 2006, p. 25) reported that mussels consumed copepods (less than 1.5 mm), crab zoeas (2 mm), fish eggs (1-2 mm), and amphipods (5-6 mm). A follow-up study (Lehane and Davenport 2002 in McKindsey et al. 2006, p. 25) again showed that mussels consumed organisms up to 3 mm in length.

Table 4.13 Shellfish Farmed in the Pacific Coast

Type	Common Name	Scientific Name	Native (Y/N)
Oysters	Pacific oyster	*Crassostrea gigas*	N
	Olympia oyster	*Ostrea conchaphila*	Y
	Kumamoto oyster	*Crassostrea sikamea*	N
	Eastern oyster/ American oyster	*Crassostrea virginica*	N
	European flat oyster	*Ostrea edulis*	N
Mussels	Blue Mussel	*Mytilus trossulus*	N
	Mediterranean/Gallo Mussel	*Mytilus galloprovincialis*	N
Clams	Pacific Littleneck	*Protothaca staminea*	Y
	Manila	*Venerupis philippinarum*	N
	butter clams	*Saxidomus giganteus*	Y
	Geoduck	*Panopea abrupta*	Y

According to ENVIRON (Fisher et al. 2008, p. 15) production estimates for oyster and clam aquaculture suggest the following filtration rates:

- Cluster Oyster Culture - 100 million Liters per acre per day (26,417, 205 gallons per acre per day)
- Single Oyster Culture - 20 million Liters per acre per day (5,283,441 gallons per acre per day)
- Geoduck Clam Culture - 4.6 million Liters per acre per day (1,215,191 gallons per acre per day)

These filtration estimates are substantial and could affect food resources for species in relatively isolated areas. Many of the organisms (amphipods, copepods) consumed by shellfish are also fed upon by juvenile salmonids and forage fish (Figure 4.16). This competition for food resources would likely not be a significant problem in areas where food resources are not limited. However, this competition could result in depleted prey resources for juvenile salmonids and forage fishes in areas where foraging habitat is limited and the density of shellfish is higher than the carrying capacity of the foraging habitat.

4.7.11 Benthic Community Structure

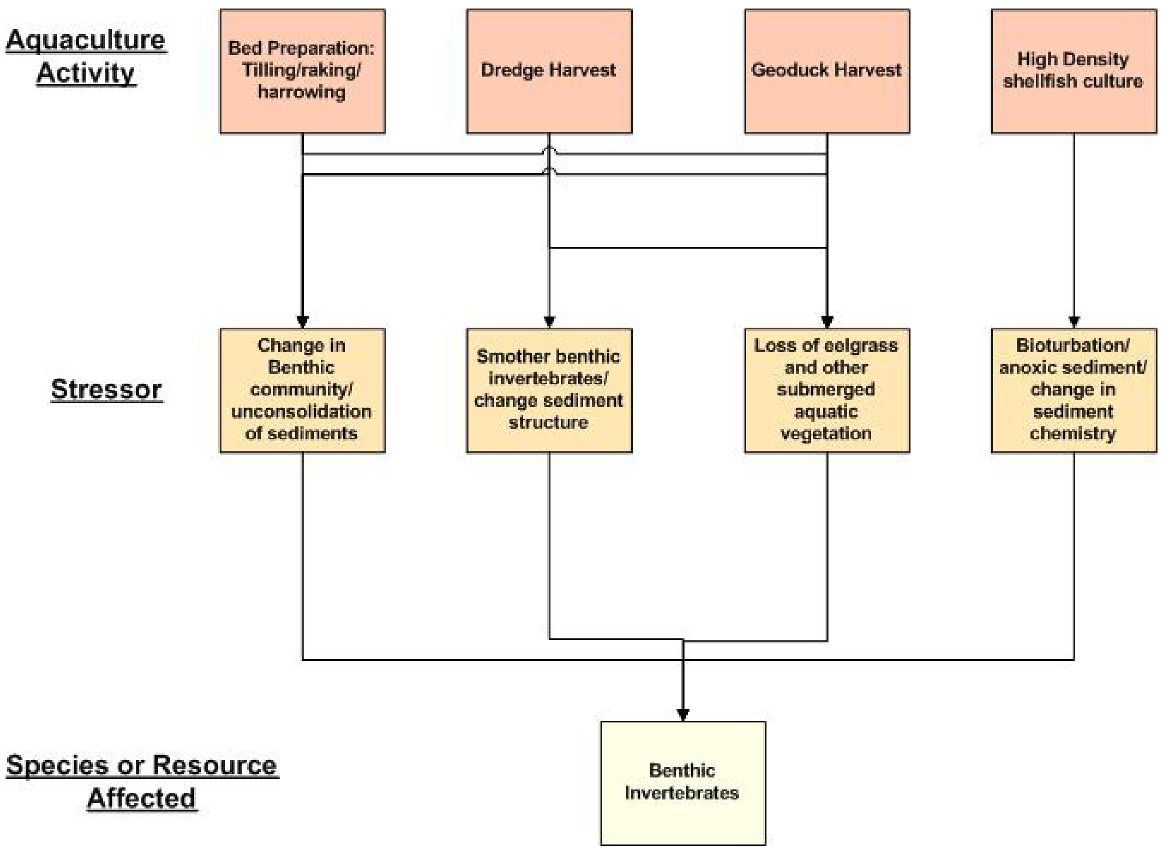

Figure 4.20 Aquaculture activity anticipated stressors and affected species or resource - Benthic Community

Changes to the benthic community occur through a variety of shellfish culture activities. The activity drawing the most attention from the public and marine scientists at present is the farming practices for geoduck clams. The process of harvest (water jets or stingers) and the scale of the shellfish beds (40,000 tubes per acre), coupled with the uncertainty regarding the long-term and repeated perturbations of the same intertidal area, have prompted much discussion and new research (See Figure 4.21). Additional questions center on the use of large expanses of anti-predator netting which cover significant portions of the intertidal area.

Photo Source: http://www.eco-pros.com/tubesintidelands.htm

Figure 4.21 Geoduck aquaculture site

Bed culture also affects the benthic community. Oyster bags are laid directly on the substrate over large areas of the intertidal shoreline covering the benthic community. Other structures such as kiddie pools designed as seed nurseries also cover benthic communities. These kiddie pools are only deployed in any great number at a few locations, specifically Spencer Cove and Cape Horn (Jeff Fisher, Environ International Corp., *in litt.* 2008b). Although they are there in abundance, these pools occupy less than an acre at these locations.

Other shellfish activities that may affect the benthic community include bed preparation techniques (discussed above) such as bed frosting. Frosting entails spraying gravel or oyster shell onto the intertidal area to make the bed more conducive to bottom culture of clams and oysters (Figure 4.17). Other activities that may affect the benthic community include high density farming such as mussel rafts and oyster rack culture. High numbers of individual shellfish in a concentrated area increase bioturbation [Cluster Oyster Culture 215 kg biodeposit (dry mass) per acre per day; Single Oyster Culture 43 kg biodeposit (dry mass) per acre per day; Geoduck Clam Culture 17.5 kg biodeposit (dry mass) per acre per day], which increases the organic content of the sediment and in extreme cases causes anoxic (total decrease in the level of oxygen) conditions (Fisher et al. 2008). Oyster longlines and rack culture may change the hydrology of the area and cause scouring which results in hardening the substrate (as discussed in section 4.9.4.3).

Bendell-Young (2006, p. 21) investigated the impact of intensive shellfish aquaculture on the intertidal community in Bayes Sound, British Columbia, Canada. She evaluated these impacts by focusing on several indices including ecosystem structure and select geochemical characteristics. These were contrasted among three intertidal areas, which represented a gradient of shellfish farming activities, specifically (1) no active aquaculture, (2) actively farmed for three years and (3) actively farmed for five years. Her investigation also included an assessment of predator exclusion netting and its effect on the intertidal community structure. Two of the beaches studied were covered with anti-predator nets at 10 percent (beach under cultivation for 3 years) and 80 percent (beach under cultivation for 5 years).

Bendell-Young's (2006, p. 26) major conclusions were that the greatest intensity of farming was "associated with a decrease in species richness, altered species abundance and distribution, change in community intertidal structure composed of surface species, sub-surface species and bivalves, to one composed primarily of bivalves, and greater accumulations of surface sediment silt and organic matter." Such findings were similar to other studies designed to examine benthic community changes. Bendell-Young (2006) indicated that "Other studies have reported intensive shellfish farming leading to loss of benthic diversity, increased sedimentation and anoxia (Sorokin et al. 1999; Bartoli et al. 2001; as cited in Bendell-Young 2006, p. 26) (Beadman et al. 2004) and change in species composition towards domination of netted regions of foreshore by deposit feeding worms (Spencer et al. 1997)." Although in some cases this change is localized in spatial scale (Beadman et al. 2004, p. 494). The increase in fine sediments tends to favor a shift towards polyeates (Mattson and Lindén 1983 in Landry et al. 2006, p. 93).

Others investigators have shown a shift to polycheates from the use of predator exclusion netting. Spencer et al. (1997 in Straus et al. 2008) found that the netting used to reduce Manila clam predation led to changes in benthic community composition consistent with organic enrichment, independent of the presence of clams. Particularly, they observed an increase in surface deposit-feeding worms. In the non-netted plots, the community dominant was a sub-surface deposit-feeding worm. Spencer et al. (1997) suggest that competition from surface deposit-feeding worms on the netted plots may have excluded the sub-surface deposit-feeding worm.

Netting also provides structure, which modifies community composition. Powers et al. (2007 in Straus et al. 2008, p. 25) found that macroalgal and epifaunal growth on clam netting could also modify the community composition by improving nursery habitat for juvenile fishes and motile invertebrates. Powers et al. (2007 in Straus et al. 2008) compared biomass and community structure at two clam lease sites, an eelgrass bed and unstructured sand flat. They found that macrofaunal and epifaunal biomass at the aquaculture sites were significantly greater than on the sand flat but were not significantly different from the eelgrass bed. Likewise, significantly, more mobile invertebrates and fishes were detected at the culture sites than the unstructured sand flat, and community structure on the clam culture sites was more similar to that of the eelgrass bed than to the unstructured sand flat. These results are not surprising when comparisons are made between sites which provide some structure to serve some habitat functions to sites (unstructured sand flat) that provides no structure at all.

As would be expected, frosting shifts the benthic community from ploychaetes to amphipods and copepods. Both Simenstad (1991 in Jamieson et al. 2001, p. 37) and Thompson (1995 in Jamieson et al. 2001, p. 37) detected an increase in gammarid amphipods (important prey species for juvenile salmon) on graveled plot versus a mud flat and control plot. The change in the benthic community from infaunal polycheates to epifaunal amphipods and copepods results in an improvement in the available prey to juvenile salmonids. However, the placement of gravel on a mudflat does have an effect on the intertidal ecosystem (Thom et al. 1994; Simenstad and Fresh 1995, both in Jamieson et al. 2001, p. 37). It should be noted that the studies on intertidal graveling or frosting were conducted on sites that had already been impacted. The initial effect of frosting has not yet been evaluated (Jamieson et al. 2001, p. 42).

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, p. 42). Small benthic invertebrates produce more than one generation per year and thus have rapid recolonization rates. But their ability to recolonize depends on sediment stability and exposure to waves and currents, in addition to the level of disturbance encountered (Jamieson et al. 2001, p. 42).

Limited research has shown that recolonization after geoduck harvest is relatively rapid and that the benthic community recovers fairly quickly. Pearce et al.(2007 in Fisher et al. 2008, p. 29) present preliminary data that suggest that species richness and relative abundance of benthic fauna at a geoduck aquaculture site in British Columbia, Canada was restored to pre-harvest levels after six months.

It should be emphasized that there is limited information on the resilience of benthic populations after geoduck harvest, as this in a new area of study due to the heightened scrutiny this practice is currently receiving in the Puget Sound region. To date, and to our knowledge, no one has studied the effect of repeated geoduck harvesting on the intertidal benthic community.

The link between changes in benthic community structure and listed species is as described above, a modification of the intertidal food web which could ultimately affect listed species (Jamieson et al. 2001, p. 42). Modifications in species diversity, biomass, and nutrient cycling [as pointed out by Bendell-Young (2006, p. 26) (Mattsson and Linden 1983, p. 93; Pearson and Rosenberg 1978, p. 92; Tenore et al. 1982, p. 92; Stenton-Dozey et al. 1999, p. 93; all as cited in Landry et al. 2006)] could reduce the resilience of the intertidal community such that the community would be less able to recover from repeated perturbations, natural or anthropogenic.

The factors that may have the greatest effect on juvenile salmonids and forage fish species relate to the timing and duration of the disruption and shift in community structure, and the availability of other foraging habitat within migrating distance. If juvenile salmonids and forage fish are required to travel long distances to find prey, their overall fitness may be reduced. Depending on the magnitude of these effects, there could be effects via the food chain to bull trout and murrelets.

4.7.12 Functional Migratory Corridors

Aquaculture structures in the intertidal area could constrain migratory pathways for juvenile fish that must utilize shallow water to avoid predation. However, unlike bulkheads where the young fish are forced into deep water with the incoming tide, they are able to swim over or around structures such as geoduck tubes and oyster bags. Additionally, the epiphytic vegetation and associated epibenthic fauna present on predator avoidance nets will, over time, likely provide a food source for these migrating fish. To date, we have not seen any literature that addresses whether shellfish aquaculture equipment presents an obstacle to migrating fish. Indeed, the Canadian government scientists have identified this as an area requiring study (Department of Fisheries and Oceans 2006, p. 8):

> "Shellfish aquaculture often occurs in sheltered bays and estuaries because they offer suitable substrate. Such areas are often highly productive environments and key habitats or many migratory species. Work is required to study how potential impacts of bivalve culture (human activity, presence of structures on the seabed and in the water etc.) influence species in these ecosystems."

4.7.13 Forage Fish Spawning Areas

Direct overlap between shellfish beds and forage fish (excluding herring) spawning habitat is unlikely due to the variation in tidal elevation at which aquaculture and spawning occur. Inside Puget Sound surf smelt spawning is concentrated at a tidal elevation between +7.0 and the MHHW line (WDFW 2008, http://wdfw.wa.gov/fish/forage/smelt.htm#shabitat ; accessed 10/31/2008). Sand lance spawning habitat is generally between +5 ft in tidal elevation and MHHW. Geoduck clams are planted between -3 to approximately +2; oysters are grown at approximately -3 to +3, and Manila clams are planted up to +4. Geoduck kiddie pools used to hold immature geoduck clams prior to harvest are place at approx. +2 tidal to MLLW elevation. (Fisher, *in litt.* 2008b).

Sand lance actively burrow into nearshore sand-gravel bottom sediments during parts of their diurnal and seasonal cycles of activity (Field 1988; Quinn 1999; both cited in Penttila 2007, p. 10). Burrowing may occur mostly at night as a predator-avoidance mechanism. Sand lance may also burrow at or below MLLW in upper, oxygenated stratum of intertidal sediments (Penttila 2007, p. 10). The placement of kiddie pools are the MLLW mark may overlap with burrowing habitat in some areas.

Based on the discussion above, the only aquaculture activities that could affect forage fish spawning areas are upland activities associated with staging, vehicle traffic and the placement on Kiddie pools at the MLLW tidal elevation. Spawning areas could be trampled by vehicles driving over them and by materials being stacked on top of them.

4.7.13.1 Pacific Herring Spawning

Direct overlap between shellfish aquaculture farms and documented herring spawning areas exists. We used spawning data from the Marine Resources Database which includes data collected by the Fish Program, Marine Resources Division of the Washington Department of Fish and Wildlife. These data document the known locations of herring spawning. They are not based on a single year's observation, but cumulative observations over many years. As such, every documented herring spawning area is not used by fish to spawn every year, rather every herring spawning area was used at one time by fish to spawn. Additionally, we used the most recent (2008) spawning density provided by WDFW (Kurt Stick, WDFW, *in litt.* 2008) to evaluate effets to herring spawning as a result of aquaculture activities. As described in the previous sections, through the process of bed clearing and preparation and harvest, eelgrass is removed or reduced. This eelgrass would otherwise have been available to herring for spawning substrate (Figures 4.19 and 4.17). Figure 4.19 shows the direct overlap of farms and spawning habitat.

Table 4.14 presents a compilation by action area of herring spawning areas and spawning density compared to shellfish aquaculture farms. We utilized the information provided to the Corps by the growers to calculate the area (acres) of shellfish farms located within documented herring spawning areas. These calculations are estimates because in many cases there was no specific farm location provided, nor were the acreages provided. ENVIRON diligently located specific farms on the landscape, and attempted to predict the size of the farm. They assigned a symbol for the sizes of each farm. We took this information and, in the cases when a range of acreage was provided, we assumed that the farm was the maximum size indicated. This was only done where there were a few un-quantified farms in the action area. If there were numerous un-quantifiable farms, but a sufficient sample size, we used an average farm size in our calculations. We excluded an analysis for the San Juan Islands in the North Puget Sound action area. This was done because only one shellfish farm (42 acres) was present in a documented herring spawning area.

We used herring spawning intensity information provided by WDFW (Stick, in litt. 2008) (Table 4.10) and the associated tons/acre to predict the total herring spawn in a particular action area. In the cases where there were multiple areas surveyed by WDFW that fell within an action area (e.g., Hood Canal), we used the average for each herring spawn intensity type in our predictions.

Table 4.14 Herring Spawning Biomass Potentially Affected Based by the Overlap of Shellfish Aquaculture Farms and Documented Herring Spawning Habitat

Action Area	Herring Spawning Habitat (acres)	Total Herring Spawn (tons)	Aquaculture Farms in Herring Spawning Areas (acres)	Percent Herring Spawning Areas potentially affected
Willapa Bay	4,696	145	2,570[a]	55
South Puget Sound	354	1,025	67[b]	19
Hood Canal	647	2,962	106[c]	16
Samish Bay	5,346	409	2,265	42
North Puget Sound	800	377	0.5	0.06
Total	**11,843**	**4,918**	**5,008**	

[a] This value is an average since not all the parcel sizes were reported by the growers.
[b] This value is an estimate since not all the parcel sizes were reported by the growers.
[c]: This value is an underestimation because not all parcel sizes were reported by the growers.
There are no herring spawning density data for the San Juan Islands. See Table 4.10 for herring spawning intensity.

Table 4.14 presents the amount of herring spawning on aquaculture farms that could be affected. However, it is not reasonable to assume that all the herring spawn will be lost due to the presence of an aquaculture farm. Herring have been known to spawn on aquaculture equipment, although it is unlikely that they would preferentially spawn on such substrate. Additionally, herring will spawn on other structures and may seek eelgrass or other submerged aquatic vegetation in adjacent areas. Nonetheless, it is reasonable to assume some unquantified amount of the annual herring spawn would be lost due to the removal of eelgrass and other substrate within documented herring spawning areas.

According to the Puget Sound Update (PSAT 2007d, p.52) “Most herring stocks in Puget Sound have declined in the past five years. For some stocks (North Sound and the Straits), this is a continuation of a longer-term decline, while for other stocks (in the central and south Sound) this decline follows a variable trend of stock increases and declines. The force behind this decline is not well understood and may be due to a combination of changing ocean conditions, degraded water quality, nearshore habitat loss, and other factors.”

We focused our analysis on the 12 herring stocks in the six action areas. These stocks include 1) Willapa Bay, 2) Grays Harbor, 3) Squaxin Pass (south Puget Sound action area), 4) Quilcene Bay, Port Gamble, and south Hood Canal (Hood Canal action area), 5) Dungeness Bay, Sequim Bay, Discovery Bay, northwest and interior San Juan Islands (north Puget Sound action area) and 6) Samish Bay. Of the 12 herring stocks in the action areas, WDFW has rated two as healthy, three as moderately healthy, three as depressed, and two as critical (PSAT 2007b). There are not enough data to rate the status of Willapa Bay and Grays Harbor stocks. According to WDFW (PSAT 2007c, p. 62), “Based on limited survey effort, recent spawning biomass for the Willapa Bay herring stock appears to be at a relatively high level.” Indeed, of the twelve stocks we considered, WDFW indicated that the quality of data used to make the stock assessments was “poor” in five cases, “fair to poor” in four cases, and “fair” in one case (PSAT 2007a). We mention this to emphasize that stock status may be only one of several factors that are important for us to consider.

Given the variation in data quality and the uncertainty regarding effects from stressors such as climate change, it would be prudent to be conservative when predicting future trends and stock status from past data. Stock survey data have only been collected since the mid-1970's, and the size of herring populations prior to this time is unknown. Shellfish aquaculture has been ongoing since the late 1800's. Additionally, the growth of the Puget Sound region has been significant over the last century, adding to the number and increasing severity of stressors (e.g., degraded water and sediment quality, habitat loss/degradation) on herring and other fish species. Therefore, biomass data from 1975 to present only represents a snapshot of the health of the populations during a time when perturbations may have already reduced their numbers.

Current and future stressors are expected to affect herring populations as well. Climate change is anticipated to result in sea level rise, increased water temperatures, and decreases in the pH of marine waters. As sea level rises, a greater amount of shoreline will likely be armored to protect public property and reduce threats to public safety (Penttila 2007, p. 18). Current levels of shoreline armoring has interfered with natural erosion of upland material (organic and inorganic debris) onto the beach and into the intertidal area, caused beach scouring, and resulted in changes in population structure of epibenthic and benthic organisms. A decrease in marine water pH is expected to affect marine organisms that have shells (organisms at the base of the food chain), and those species that are temperature sensitive, such as herring. The anticipated future changes in water quality (pH and temperature) along with a loss or degradation of habitat from increased armoring, are expected to add to the current stressors on herring outlined in this Opinion.

Increasing water temperatures will likely affect herring populations directly by influencing survival and growth, and indirectly by changing the predator/prey ratio (US Global Change Research Program 2003, http://www.usgcrp.gov/usgcrp/nacc/education/alaska/ak-edu-4.htm; DFO and DOE 2008, http://www.pac.dfo-mpo.gc.ca/sci/herring/pages/indicator e.htm; both accessed on 1/14/09).

Decreasing marine water pH from basic to acidic will likely affect herring prey. Increasing acidification of marine waters may have significant impacts on marine food-webs. Calcifying species of plankton are expected to suffer serious negative impacts from increased ocean acidification. The negative impacts of increased acidity on plankton may cause negative impacts on many other species which are important food-sources for juvenile salmon, herring, and cod (Ruckelshaus and McClure 2007, p. 55).

Although some herring stocks have been identified as healthy or moderately healthy in the context of long-term shellfish aquaculture in Willapa Bay, Grays Harbor, and the Puget Sound region, the practices allowed under NWP 48 (i.e., the increase in size and number of shellfish beds within a project area or farm) would potentially affect these stocks, particularly in light of existing and potential future stressors.

4.7.14 Effects of the Action on Bull Trout

This section addresses the direct and indirect effects of the proposed action and its interrelated and interdependent activities on bull trout. The Service anticipates that turbidity associated with dredge harvest will measurably affect bull trout due to the size of the area harvested (five acres as a reasonable worse case) and the intensity of such harvest (potentially hundreds of acres per year in any one action area). The Service also expects that long-term, episodic disruption of the benthic community from geoduck harvest, and impacts to eelgrass from bed preparation and some harvest activities. We anticipate these impacts to bull trout prey will indirectly, and measurably, affect bull trout, but available evidence is currently insufficient to establish a likelihood that such impacts will significantly disrupt normal bull trout behavior. Other harvest activities are not expected to result in measurable effects to bull trout, as previously described.

4.7.14.1 Dredge Harvest Activities

The effects on water quality from harvest activities (geoduck and dredge harvest) can have a detrimental impact on salmonids. Suspended sediments can have an adverse effect on migratory and social behavior as well as foraging opportunities (Bisson and Bilby 1982; Sigler et al. 1984; Berg and Northcote 1985). Servizi (1988) observed an increase in sensitive biochemical stress indicators and an increase in gill flaring when salmonids were exposed to high levels of turbidity. Other potential sublethal effects include stress, gill damage, and increased susceptibility to disease. Behavioral responses to elevated turbidity include disruptions to feeding or migration. For other actions that the Corps permits, the Corps requires in-water work windows to avoid or minimize effects to the most vulnerable life stages of fish. However, the proposed action does not require adherence to these timing windows.

The magnitude and duration of dredge harvest can range between 0.5 to 5 acres/day, depending on the density of the oysters. In Grays Harbor and Willapa Bay, the number of acres/year undergoing dredge harvest can range between 200-320 acres and 137 acres, respectively (Jeff Fisher, Environ International Corp., *in litt.* 2008c). Dredge harvest of up to 5 acres will result in a significant turbidity plume, but this activity is conducted in open water (unlike dredging in a river channel) and, as a result, adult and subadult bull trout are expected to be mobile and avoid the plume. Additionally, intertidal and subtidal areas tend to be more turbid in general due to wave and wind action. Therefore, bull trout are likely to be less sensitive to this perturbation in marine than in fresh water.

Dredge harvest may cause bull trout to discontinue foraging or leave the area. The level of turbidity from the dredge harvester can be significant (See Figure 4.22) and bull trout are likely to avoid the plume. It is unlikely, however, that this avoidance behavior will result in a significant disruption of normal behavior patterns, such as foraging or migration, given the duration and extent of turbidity in any single harvest event.

4.7.15 Benthic Community and Eelgrass Impacts

Anadromous bull trout use marine waters as migration corridors to reach seasonal habitats in non-natal watersheds to forage and possibly overwinter (Goetz et al. 2004; Brenkman and

Corbett 2005). In nearshore marine areas of western Washington, bull trout feed on Pacific herring, Pacific sand lance, and surf smelt (WDFW et al. 1997; Goetz et al. 2004). These forage fish species utilize eelgrass beds and rely on benthic macrofauna such as copepods (Figure 14) as prey.

A review of the literature indicates that aquaculture may affect the benthic community. However, the literature is not sufficient to determine how or to what degree these effects are likely to impact the intertidal food web and, potentially, bull trout (Straus et al. 2008, p. 24). A reduction in the diversity and/or biomass of the benthic community suggests the potential for effects, but the effects of a subtle shift in the species composition is less definitive. The somewhat ambiguous science has led Dethier et al. (Dethier et al., *in litt.* 2007, p. 3) to call for more focused study:

> "The flora and fauna of muddy-sand South Sound beaches, while less abundant than those of some other beach types, nonetheless are moderately diverse in lifestyle and position in the food web. Presumably, they interact with the rest of the nearshore ecosystem in a variety of ways, but there has been minimal research about these interactions. Suggested ecological roles include: …small crustaceans living in tubes or on the surface providing key food for salmon and other fishes; and both worm tubes and seaweeds providing locations where herring lay their eggs."

Similarly, Cranford et al. (Department of Fisheries and Oceans 2006, p. 8) states the following:

> "Research is needed to identify methodologies and a standard approach for assessing local and far-field effects on benthic organisms to determine the net effect of shellfish aquaculture on the productivity of benthic habitat."

In an attempt to answer these questions, Washington Sea Grant is funding studies to focus on some of the anticipated effects from shellfish aquaculture. Because research is ongoing and the science is not yet definitive, particularly as it relates to effects from geoduck aquaculture, it is difficult to evaluate the significance of the impacts occurring.

While we don't anticipate that Pacific sand lance and surf smelt will be directly impacted by seeding, grow-out, or harvest of shellfish (upland staging activities notwithstanding), we anticipate that the benthic food web upon which they rely will be disrupted from a variety of actions (see section 4.9.4.6). Additionally, active aquaculture farms are located directly within eelgrass meadows and documented herring spawning habitat, which likely removes, or reduces the quality of this habitat type.

Unlike to benthic invertebrate impacts, more information was available to evaluate potential effects on eelgrass and herring spawning areas. Fortunately, data were available to map 1) shellfish culture areas (although some data were lacking); 2) known eelgrass beds; and 3) documented herring spawning areas. Using GIS, we were able to calculate the area and overlap of shellfish aquaculture farms with these landscape features. Additionally, WDFW provided us with herring spawning density for each action area and associated production in tons/acre, along with the number of herring eggs per ton of herring spawn. Using these data and the amount in acres of overlap between aquaculture farms and these landscape features (eelgrass and herring spawning habitat), we were able to estimate the potential for impacts to eelgrass beds and associated herring spawn from the presence of aquaculture farms (Table 4.14).

We determined that the reduction of herring could lead to a measurable reduction in prey species for bull trout, particularly in Samish Bay. The other action areas (Willapa Bay, South Puget Sound, Hood Canal, and North Puget Sound) do not support populations of bull trout. Within the marine nearshore FMO areas, there is little or no documentation of bull trout in the marine waters of Puget Sound south of the Nisqually River, in Hood Canal, Vashon Island, the west side of Whidbey Island, and the Kitsap Peninsula. It is considered unlikely or extremely rare for bull trout to be in those areas at this time. However, in some areas adjacent to depressed populations, such as Hood Canal, as the depressed core population recovers and increases in abundance, it is likely that those fish will expand their foraging area to include the near-shore marine waters.

It is reasonable to assume that there would be an annual reduction of the herring population in Samish Bay based on a 42 percent overlap between shellfish aquaculture farms and documented herring spawning habitat (Table 4.14). Such a reduction in prey could have a measureable effect on bull trout. As described in the Status of the Species (Section 4.3), bull trout feed on other forage fish species as well. These forage fish species utilize eelgrass beds for a portion of their life history. We calculated the overlap of eelgrass within aquaculture farms in each action area (Table 4.12). The greatest amount of overlap was in Willapa Bay and Samish Bay. Impact to 69 percent of the eelgrass (2,523 acres, Table 4.12) in Samish Bay could have a measurable effect on the available habitat for forage fish. It is highly unlikely that bull trout will be foraging in Willapa Bay during the next 5 years.

We are unable to predict how a reduction in documented herring spawning habitat in other action areas would affect the prey base for bull trout. For instance, we do not know the migration patterns of forage fish such that we could predict how a reduction in South Puget Sound would affect bull trout foraging in North Puget Sound. Therefore, we assume that indirect adverse effects to bull trout due to a reduction in herring spawning are limited to Samish Bay. However, we are unable to establish that these impacts to prey are likely to significantly disrupt bull trout foraging behavior.

In summary, it is anticipated that dredge harvest activity will cause localized reductions in water quality from increased turbidity through the suspension of sediments. We expect short term adverse effects to bull trout associated with the harvest activities primarily because bull trout will avoid the plume or otherwise experience adverse behavioral effects. Based on the apparent overlap between shellfish activities, eelgrass beds, and documented herring spawning habitat, we expect measureable effects to bull trout prey species and ultimately adverse effects to bull trout, primarily in Samish Bay. However, we have not established that there will be a significant disruption to normal behavior patterns of bull trout.

4.7.16 Effects of the Action on Bull Trout Critical Habitat

The activities associated with shellfish aquaculture are expected to result in effects to bull trout critical habitat. Impacts to critical habitat include 1) impacts to the food base through a reduction in eelgrass and herring spawning, and 2) temporary reductions in permanent water quality through elevated sediment levels from dredge harvest, geoduck harvest, bed preparation and the application of carbaryl in Grays Harbor.

Only the PCEs described in paragraphs (i), (vi), (vii), and (viii) of the final rule (70 FR 56212) apply to marine nearshore waters identified as critical habitat. Implementation of the proposed action has the potential to adversely affect two of the four PCEs, depending on the location of the critical habitat and its relation to the location of shellfish aquaculture activities on covered lands. PCEs vii (a*n abundant food base including terrestrial organisms of riparian origin, aquatic macro invertebrates, and forage fish)* and viii (*permanent water of sufficient quantity and quality such that normal reproduction, growth, and survival are not inhibited*) are most likely to be adversely affected by the proposed action.

(vii) *An abundant food base including terrestrial organisms of riparian origin, aquatic macro invertebrates, and forage fish.*

Bull trout critical habitat is present in the Grays Harbor, Hood Canal, Samish Bay, and North Puget Sound action areas. Critical habitat has not been designated in Willapa Bay and South Puget Sound; therefore, none will be affected. In Section 4.9.4.2, we presented the role of eelgrass in the intertidal zone and the importance of eelgrass to the intertidal food web, forage fish, and bull trout. We reviewed the literature and presented the results of an analysis that demonstrates both the loss of eelgrass (Table 4.12) and herring spawning habitat (Table 4.14).

Carbaryl is applied annually in Grays Harbor on approximately 200 acres per year in July and August. The 200 acres is not necessarily contiguous, but is comprised of various farms. Bull trout are present in Grays Harbor during the time of year when spraying is conducted (Section 4.6.3.1.2).

Carbaryl application results in significant mortality of benthic macroinvertebrates and fish (Simenstad and Fresh 1995, p. 62). Immediately after spraying, there is an abundance of dead and dying organisms for bull trout to prey upon. However, after one or two tidal cycles, the area may be relatively devoid of macrionvertebrate prey. This level of mortality could be significant, and depending on the size of the area sprayed, the amount of the chemical applied, and the configuration of the farms (e.g., whether or not they are adjacent to one another), the area that would have reduced prey could be large. Recolonization of an area by epibenthic invertebrates is variable, depends on the species and site, and can take anywhere from 2 to 52 days (Simenstad and Fresh 1995, p. 59). Fish would likely recolonize the area more quickly. Nonetheless, the application of carbaryl results in wide-scale mortality with severity depending on numerous factors, not the least of which is species sensitivity. This activity takes place annually on hundreds of acres in sensitive estuarine habitats.

- Based on the well-documented role of eelgrass in the intertidal food web, the importance of herring as a prey species for bull trout, and annual reduction in prey resulting from carbaryl application, we conclude that adverse effects to PCE vii are likely. We acknowledge that bull trout are opportunistic in their foraging behavior, and therefore consume species other than herring. This does not however negate the adverse effects to this PCE from a reduction in herring and available prey in Grays Harbor.

(viii) *Permanent water of sufficient quantity and quality such that normal reproduction, growth, and survival are not inhibited.*

Short term adverse effects on water quality are anticipated from a number of aquaculture activities (Table 4.11). These activities include harvest (geoduck and dredge), bed preparation (tilling, harrowing, and frosting), and carbaryl application (Figures 4.21, 4.22 and 4.23). These activities result in short term water quality degradation from turbidity and aquatic pesticide use. A conservation measure intended to minimize turbidity from frosting operations only is included in Corps (2008), which should help reduce the short-term effects to this PCE.

The application of carbaryl and its degradation product 1-naphthol is discussed in numerous sections of this opinion (3.2.2, 4.7.3.1, 4.7.3.2 and 4.9.4.12.1). It is clear that the presence of the chemicals in the water and sediment affects the behavior and survival of a variety of species. Although fish are rarely killed immediately, the sublethal effects substantially increase their chances of predation. Water quality is degraded and non-target species (species other than ghost or mud shrimp) experience adverse effects and death as a result. We have established that bull trout are present during the time that carbaryl is applied to Grays Harbor.

Therefore, because of the reduction in water quality from 1) the presence of carbaryl, and 2) the elevated turbidity from harvest and bed preparation, we conclude that adverse effects to this PCE is likely. We do however, anticipate the effects to this PCE will be localized and of short duration.

(USACE 2008)

Figure 4.22 “Frosting” a clam bed

photo by A. LaTier (USFWS)

Figure 4.23 Oyster dredge harvesting

4.7.17 Effects of the Action on Marbled Murrelet

The following section presents the anticipated response of murrelets to specific activities and effects generated by those activities. We discuss the use of boats and human disturbance as shellfish are planted and harvested. We describe the use of helicopters for application of carbaryl in Willapa Bay and Grays Harbor, and the various ways in which it could affect murrelets while nesting, as well as on the water. Finally, we discuss the potential for indirect effects to murrelets through a reduction in prey associated with the overlap of shellfish aquaculture farms, eelgrass beds, and documented herring spawning areas.

Of the activities, effects, and responses we evaluated, three are expected to result in measureable effects to murrelets: 1) disturbance from increased turbidity during dredge harvest, and 2) a potential reduction in prey.

4.7.17.1. Use of Support Boats, Aquaculture Planting and Harvesting Activities

The proposed action will result in increased activity levels due to support boats and human activity associated with planting and harvesting activities. However, all of the action areas likely experience significant boat traffic due to pleasure fishing, pleasure, and commercial boating activities. Although the effects of human disturbance on murrelets at sea are not well documented, murrelets appear to habituate to heavy levels of boat traffic (Strachan et al. 1995). We do not anticipate that boat and other anthropogenic activities associated with planting and harvesting will measurably affect murrelets because the level of these activities is likely to be less than what currently occurs in these two waterbodies. We assume that murrelets using these areas are accustomed to these disturbance levels. Therefore, effects to murrelets due to support boats, planting, and harvesting activities are likely to be insignificant.

4.7.17.2 Increased Turbidity

A description of the magnitude, timing, and duration of dredge harvest and geoduck harvest is presented in the bull trout effects section 4.9.4.10. All life stages of adult and juvenile murrelets may be exposed to harvest activities. The number of murrelets that may be exposed depends on location and time of year.

In general, murrelets will most likely avoid the harvest area and, for most of the year, we don't anticipate this to result in a measurable effect. We assume that dredge harvests occurring outside of forage fish concentration areas and outside of the breeding season will result in insignificant effects to individual murrelets. This is because, at other times and locations, murrelets are not so closely tied to a particular foraging area, and moving to a new foraging area is normal. However, during the nesting season when birds are feeding chicks we expect that this displacement could result in a measurable effect. The following section presents the anticipated effects to murrelets during the breeding season.

Harvest activity and related increases in sediment plumes and turbidity would negatively affect a marbled murrelet's ability to forage, since they rely on sight to catch prey. Because prey would move away or not be visible due to turbidity, murrelets would most likely move to another foraging location. When the harvest area overlaps a foraging area, such disruptions could result in a decreased foraging efficiency and increased energy expenditures[7]. During the nesting season, this could lead to decreased survival rates for both adults and young they are feeding.

In order to avoid predators, trips to and from the nest site are most often made under cover of darkness. This reduces the risk that predators will see nests or adults during arrival and departure. Trips that must be conducted during daylight hours are more perilous to the adults and young by exposing them to the sight of predators. For all breeding murrelets, it may be necessary to fly inland during the day in order to feed a chick, but by requiring an *additional* daytime flight (because they couldn not find an appropriately-sized fish in time to avoid sunrise), they are exposed to additional predation pressure.

Thus, the birds we are most concerned about are those rearing chicks. Dredge harvesting can occur day or night and the two most frequent times of day that food is delivered to the nest (prior to dawn and at dusk) can overlap with dredge harvesting. Therefore, there would be a conflict with boats or harvesters at those times. The remaining times that chick-rearing birds may need to feed young throughout the day are assumed to be few (to none) in number for many pairs. It

[7] During the nesting season, murrelets are expending "extra" energy laying eggs, attending nests, foraging for their chicks in addition to themselves, and flying long distances to and from inland nests. During the molting season, birds can't fly from foraging area to foraging area, and so they are limited to a smaller-than-normal area in which they can forage.

is further assumed that if these birds were to return to their favored foraging areas to forage at mid-day, they would be able to find forage fish at a location very close by.

We have limited information on the scale of dredge harvest, other than what was provided for Willapa Bay and Grays Harbor. Oyster culture is widely conducted in the Puget Sound region as well, and we must assume that as with Willapa Bay and Grays Harbor, hundreds of acres are harvested through the course of a year. We have no information on the duration of dredging, but we assume that it could take at least half a day or night to harvest a five-acre plot depending on the density of oysters.

We assume that dredge harvesting could have a measurable effect on murrelets during the nesting season, specifically when dredge harvest is conducted two hours before dawn and two hours after dusk during the nesting season. However, we cannot establish that this will significantly disrupt or impair normal behaviors.

4.7.17.3 Geoduck Harvest

As described previously, geoduck harvest is conducted during low tide in the intertidal area. It is extremely unlikely that murrelets will be exposed to this activity, and the potential for effects is considered discountable.

4.7.17.4 Reduction in Prey

A detailed discussion regarding the anticipated reduction in prey through overlap of shellfish farms, eelgrass beds, and documented herring spawning habitat is presented in Sections 4.7.3.4.2 and 4.9.4.9. To evaluate the potential effect of the action on eelgrass, forage fish, and ultimately murrelets, we estimated the reduction in eelgrass density in each action area (Table 4.8).

According to our analysis of the overlap between aquaculture farms and documented herring spawning habitat in Willapa Bay, Hood Canal, North Puget Sound and Samish Bay (55, 16, 0.06 and 42 percent, respectively) some level of reduction in herring spawn is expected annually. (Table 4.14). Information is currently insufficient to state that the estimated losses will have insignificant or immeasurable effects on murrelets in these action areas. As described in the Status of the Species (Section 4.4), murrelets feed on other fish species as well, but herring represent the most energetically valuable prey.

Depending on the level, the estimated reduction in herring could result in a measurable effect on murrelets prey in the more widely used action areas of Willapa Bay, Hood Canal, North Puget Sound, and Samish Bay. We are unable to predict how a reduction in documented herring spawning habitat in other action areas would affect the prey base for murrelets. For instance, we do not know the migration patterns of forage fish sufficiently to predict that a reduction in South Puget Sound prey populations would affect murrelets feeding in North Puget Sound. Therefore, we assume the indirect adverse effects to murrelets due to a reduction in herring spawning are most likely to occur in Willapa Bay, Hood Canal, North Puget Sound, and Samish Bay.

Breeding adults exercise more specific foraging strategies when feeding chicks, usually carrying a single, relatively large (relative to body size) energy-rich fish to their chicks (Burkett 1995; Nelson 1997a), primarily around dawn and dusk (Nelson 1997a; Kuletz 2005b). Becker et al. (2007) found murrelet reproductive success in California was strongly correlated with the abundance of mid-trophic level prey (e.g., sand lance, juvenile rockfish) during the breeding and post-breeding seasons. Prey types are not equal in the energy they provide. For example, parents delivering fish other than age-1 herring may have to increase deliveries by up to 4.2 times to deliver the same energy value (Kuletz 2005b).

Nesting murrelets that are returning to their nest at least once per day must balance the energetic costs of foraging trips with the benefits for themselves and their young. Given this, murrelets may prefer to forage in marine areas in close proximity to their nesting habitat. If adequate or appropriate foraging resources (i.e., "enough" prey, and/or prey with the optimum nutritional value for themselves or their young) are unavailable in these areas, murrelets may be forced to forage at greater distances or to abandon their nests (Huff et al. 2006, p. 20). For these reasons, the distribution and abundance of prey suitable for feeding chicks may greatly influence overall foraging behavior during the nesting season, and may affect reproductive success (Becker et al. 2007). Prey availability may also significantly increase the energy demand on adults by influencing both foraging duration and number of trips inland to feed nestlings (Kuletz 2005b).

As previously mentioned, eelgrass provides important habitat for marbled murrelet prey. In general, small schooling fish and large pelagic crustaceans are the main prey items for murrelets. Pacific sand lance, northern anchovy, immature herring, capelin, Pacific sardine, juvenile rockfishes and surf smelt are the most common fish species taken. Squid, euphausiids, mysid shrimp, and large pelagic amphipods are the main invertebrate prey. The majorities of these species relies on eelgrass and are important components of the intertidal food web (Figure 4.16 and 4.17).

The status of herring stocks, in particular, may have important ramifications for murrelets in the marine environment (see Status of the Species section 4.4). As of 2004, only 50 percent of Puget Sound herring stocks were classified as healthy or moderately healthy, with north Puget Sound stocks considered depressed, and the Strait of Juan de Fuca stocks classified as critical (WDFW *in litt.* 2005). Any continued or further reduction in these stocks could adversely affect murrelets, particularly when they are feeding chicks.

Murrelets are able to shift their diet throughout the year and over years in response to prey availability (Becker et al. 2007). However, long-term adjustment to less energetically rich prey resources (such as invertebrates) appears to be partly responsible for poor marbled murrelet reproduction in California (Becker and Beissinger 2006). If a reduction in eelgrass beds results in less habitat and fish prey species for murrelets in Washington, then they may be forced to switch to less energetically rich invertebrate species, with similar consequences as the California birds to reproductive success.

In summary, the predicted reduction in eelgrass habitat is expected to cause a reduction in marbled murrelet forage fish species, including herring. This reduction in prey is expected to adversely affect murrelets for the following reasons: 1) a reduction in herring stocks has been documented in some areas of Puget Sound (PSAT 2007d, p. 52), 2) herring are the most energetically rich prey species that murrelets can consume and feed their chicks, and 3) murrelets forced to switch to a less energetically rich food source may experience reduced overall fitness and reproductive success. However, we are currently unable to determine the magnitude of these adverse effects, and whether such effects will significantly disrupt or impair murrelet behavior.

4.7.18 Interrelated and Interdependent Actions

4.7.18.1 Carbaryl Application

Since 1963, the Washington Department of Ecology has issued National Pollutant Discharge *Elimination* System (NPDES) permits to oyster growers to apply carbaryl to intertidal areas for the purpose of controlling burrowing shrimp (USACE 2008, p. 3). These native shrimp create burrows that destabilize the oyster crop, and cause the oysters to sink. Prior to 1984, the amount of mudflat treated was limited to 300 acres in Willapa Bay and 100 acres in Grays Harbor. In the early 1980s, after shrimp densities increased, the amount of treated area increased to 600 acres in Willapa Bay and 200 acres in Grays Harbor. Although limits are specified in the NPDES permit, these acreages can be exceeded with authorization from Ecology. Recent acreage treated has been less than the permitted maximum. Between 2000 and 2003, the Willapa Bay/Grays Harbor Growers Association applied carbaryl on 542 acres. In 2007, the actual treated commercial acreage was 418.7 acres plus an acre for experimental use in Willapa Bay, and 135.0 acres in Grays Harbor (total treated acreage = 554.7) (Booth and Tufts 2007 as cited in USACE 2008, p. 3).

Carbaryl is applied annually on specific growing areas, although it has been shown to drift to adjacent untreated areas. Carbaryl application is conducted over a period of several days during the lowest tides of the year in July and August. Most applications have occurred in July, based on six application reports submitted to Washington Department of Ecology since 2002. Carbaryl is sprayed annually at a rate of 10 lbs formulated product per acre. This is the equivalent of 8 lbs of active ingredient (a.i.) per acre. Carbaryl and 1-naphthol (the breakdown compound) can be persistent in sediment at 60 and 30 days post treatment, respectively. Areas are sprayed from a height of between10 ft and 20 ft above the oyster beds to reduce drift. Drifting of carbaryl onto unsprayed sites has been shown to occur at concentrations equivalent to sprayed sites (Stonick 1999, p. 6).

4.7.18.1.1 Bull Trout Exposure

As indicated above, carbaryl is applied in both Willapa Bay and Grays Harbor. Bull trout exposure in Willapa Bay is considered highly unlikely, as discussed previously. Bull trout are not expected to be present in this action area; therefore, the remainder of this section will address bull trout exposure and response in Gray Harbor. Bull trout critical habitat will only be exposed to the action in Grays Harbor.

Bull trout have been documented in Grays Harbor and will be exposed to the interrelated action of carbaryl application. Section 4.6.3.1.2 describes bull trout use in, and the conservation role of, this action area. The following sections describe expected (and documented) use of Grays

Harbor by bull trout and address the potential for exposure during periods of elevated water temperatures in the summer.

The review of the available information on bull trout presence and behavior when exposed to elevated water temperatures leads us to conclude that exposure of bull trout to carbaryl is likely. We assume that bull trout will be exposed to the carbaryl upon the incoming tide. We base this conclusion on the fact that 1) bull trout have been documented in Grays Harbor through July 14, and, 2) they can tolerate elevated temperatures up to 20 °C to 24 °C for at least short periods of time.

4.7.18.1.2 Bull Trout and Bull Trout Critical Habitat Response Analysis

Carbaryl is a broad spectrum pesticide most often used to control invertebrates. Carbaryl causes reversible cholinesterase inhibitition that blocks neurotransmission by inhibiting the enzyme acetylcholinesterase. Acetycholine is vital for the transmission of nerve impulses. Cholinesterase breaks apart the neurotransmitter acetylcholine after the impulse has been transmitted. For normal nerve-to-nerve communication to occur, the excess acetylcholine must be dissolved following the transmission of a nerve impulse. This is the normal function of cholinesterase. If actetylcholine is not broken down, the nerve impulse keeps firing, debilitating the organism.

As an example, an electrical signal or nerve impulse is conducted by acetylcholine across the junction between the nerve and the muscle (the synapse) stimulating the muscle to move. Normally, after the appropriate response is completed, cholinesterase is released, which breaks down the acetylcholine, ending the stimulation of the muscle (i.e., stopping the movement). The enzyme acetylcholine accomplishes this by chemically breaking the compound into other compounds and removing them from the nerve junction. If cholinesterase is unable to break down or remove acetylcholine, the muscle will continue to move uncontrollably (Extoxnet 1993; http://extoxnet.orst.edu/tibs/cholines.htm).

Carbaryl is acutely toxic to invertebrates, and sublethally toxic to fish. Although it may not kill fish outright, it affects their behavior via neurological effects, rendering them subject to predation. The major transformation products identified in fate studies are 1-naphthol and carbon dioxide. 1-naphthol is at least as toxic, if not more toxic, to fish than carbrayl, although little toxicity data are available because it is a degradate and not the active ingredient in carbaryl. Toxicity information on 1-napthol is relatively lacking for ecological receptors. Baker, the makers of Sevin^tm^ , report the aquatic toxicity for 1-napthol in fish (LC_{50}/96-hour) is between 1 and 10 mg/L (J.T. Baker MSDS N0840 as cited in Environ 2008, p. 34).

The effects on bull trout through direct exposure and consumption of contaminated prey are evaluated further in the following sections. The 96-hr LC[8] $_{50}$ toxicity values ranged in concentrations of 0.25 mg/L to 20 mg/L for technical grade carbaryl. Atlantic salmon (*Salmo salar*) represent the most sensitive species tested, with a mean LC_{50} value of 1.28 mg/L. The

[8] LC50 is the concentration that results in mortality for 50 percent of the test population

hydrolysis degradation product of carbaryl, 1-naphthol, also ranged in acute toxicity, based on median lethal concentrations, from 0.75 mg/L to 1.6 mg/L (EPA 2003 as cited in Environ 2008, p. 29).

In order to predict effects to fish, ENVIRON (2008) used the maximum exposure concentration measured in Willapa Bay on the incoming tide after application. For screening purposes, the maximum concentration detected by Major et al. (2005 as cited in Environ 2008, p. 41) of 11.3 µg/L following the first tide was used as the acute exposure concentration.

We've included toxicity information for salmonids compiled by ENVIRON 2007 for comparison to the maximum surface water concentration tested in Willapa Bay (11.3 µg/L). We've only included the data for salmonids in order to reduce uncertainty associated with interspecies sensitivity. We have also only considered data representative of a no-effect level, consistent with the level of protection that should be afforded listed species.

Table 4.15 Laboratory toxicity results for salmonids exposed to carbaryl no-effect levels.

Species	Toxicity Index	Concentration (ppb)	Static Lab Bioassay
Salmo gairdneri	No effect	4340 µg/l	96 hr [b]
Salmo trutta	No effect	1950 µg/l	96 hr [b]
Oncorhynchus kisutch	No effect	764 µg/l	96 hr [b]

[b] Macek and McAllister 1970, as cited in ENVIRON (2007, p. 25)

Comparing the maximum surface water concentration to the lowest no-effect level yields a risk quotient of 0.014[9]. The level of concern (LOC) identified by the EPA for risk to endangered species using a no-observable-adverse-effect concentration is 1.0. Bull trout are in the family *Salmonidae,* as are the test species listed in Table 4.15. Therefore, we would expect a similar toxicological sensitivity to contaminants.

The data to conduct a similar analysis for 1-naphthol is significantly more limited. There are no requirements to monitor 1-naphthol under the NPDES for the application of carbaryl. Therefore, we have no surface water exposure concentrations with which to calculate a risk quotient. Toxicity data are similarly lacking, with one data point available from EPA (2003 as cited in Environ 2008, p. 24) for Atlantic salmon (*Salmo salar*). This LC_{50} concentrations ranged from 0.75 µg/L to 1.6 µg/L. If we assumed that the surface water concentration of 1-naphthol is equivalent to the surface water concentration of carbaryl (11.3 mg/L), and we calculate the risk quotient using an acute value (750 µg/l), we obtain a risk quotient of 0.015. The LOC identified by the EPA for risk to endangered species using an acute toxicity endpoint is 0.05. This LOC is lower than the LOC for a chronic endpoint to be more protective given the endpoint tested (lethality). The risk quotient we have calculated (0.015) is still approximately three times lower than the LOC of 0.05.

Additionally, as mentioned above, bull trout are more active at twilight, dawn, and dusk, reducing the likelihood that they will be directly exposed to the highest carbaryl concentrations[10].

[9] RQ = 11.3/764
[10] First incoming tide after early morning spray event

Therefore, while we assume that bull trout will be exposed to carbaryl in Grays Harbor, we conclude that the exposure concentrations will not result in measurable effects to bull trout.

A secondary indirect exposure pathway exists through dietary consumption. Bull trout are opportunistic in their foraging behavior; therefore, we assume that they will consume dead and dying invertebrates and fish. Although carbaryl does not bioaccumulate, the moribund individuals have some body burden of the chemical. If bull trout were to consume these individuals, they would also be consuming the chemical. We are unable to predict the amount of carbaryl a bull trout would receive, nor what physiological effect it would have on the fish. Therefore, we cannot conclude that the potential effect is insignificant. However, we cannot establish that the potential effect is likely to significantly disrupt normal behavior.

4.7.18.1.3 Murrelet Exposure

Carbaryl Application

Marbled murrelets are known to forage in Willapa Bay and Grays Harbor. However, there is a low likelihood that marbled murrelets will be in these project areas during herbicide application. Activity patterns and foraging locations are influenced by biological and physical processes that concentrate prey, such as weather, climate, time of day, season, light intensity, up-wellings, tidal rips, narrow passages between islands, shallow banks, and kelp (*Nereocystis* spp.) beds (Strong et al. 1995; Ainley et al. 1995; Burger 1995; Speckman 1996). In contrast, the project area is comprised of shallow mudflats and sand flats that dewater during low tide.

Murrelets typically forage in shallow waters between 20 m to 80 m (65.6 ft to 262.4 ft) in depth, but have been observed in waters less than 1 m (3.28 ft) and more than 100 m (328 ft) (Strachan et al. 1995, p. 223). In Alaska, most murrelets were found feeding at depths of 18 to 45 m (59 ft to 147.6 ft) (Sanger 1987b in Strachan et al. 1995, p. 251). In California, murrelets were found to forage generally in waters 20 m to 30 m in depth (65.6 ft to 98.4 ft) (Strachan unpubl. data in Strachan et al. 1995, p. 251). We do not expect that murrelets will consume dead and dying invertebrates. Rather we expect they are more likely feeding in deeper water at the inlets to Willapa Bay and Grays Harbor and would not be exposed to carbaryl.

Helicopter Use

The proposed action will result in the application of carbaryl, and the use of helicopters in proximity to suitable marbled murrelet nesting habitat during the marbled murrelet nesting season (April 1 to September 15), primarily adjacent to Long Island in Willapa Bay. Other areas of suitable marbled murrelet nesting habitat in or near Willapa Bay or Grays Harbor are outside of potential disturbance areas from this activity. Additionally, murrelets likely occur year-round within Willapa Bay and Grays Harbor, primarily loafing and feeding. The stressors that need to be considered related to helicopters include sound, visual image (predator), collision, and rotor wash.

The following analysis was conducted to evaluate the potential effects of carbaryl spraying notably sound disturbance to murrlets from helicopters during the nesting season.

Several types of helicopters may be used as part of the proposed action, including a Bell 47 G3 B2, Bell 206 Jet Ranger, Aero Falcon OH58A+, and Aero Falcon OH58C (Dan Foster, Farm and Forest Helicopter Service, pers. comm. 2008). Helicopters are initially transported from Chehalis by truck to the staging area. Helicopters are also transported by truck between Grays Harbor and Willapa Bay. Staging areas for the helicopters are shown in Figure 4.22.

Up to two helicopters may be used to apply pesticides. Helicopter flights occur primarily in the morning, during low tide and when winds are less than 10 miles per hour. However, some flights have occurred in the afternoon. Up to 10 acres may be treated per flight. Flights are of short duration, and spraying is completed within one to two hours (Jeff Fisher, Environ International Corp., *in litt.* 2008a) each day. It is estimated that spraying of all sites may take up to 7 days during the 2 month time period.

Increased Sound Pressure

The Western Washington Fish and Wildlife Office has previously evaluated the effects of noise-related disturbance in the terrestrial environment and determined that murrelets could be adversely affected by sounds higher than 92 dBA (USFWS 2007).

The sound levels generated by most of the helicopters that may be used as part of the proposed action was not available as sound level information was not required by Federal Aviation Administration. Sound levels were only available for the Bell 206 Jet Ranger. However, estimated information was available for the Bell 47. Although no information was available for either of the Aero Falcon helicopters, they are considered to be similar to the sound pressures produced by a Bell 206 (Victor Simmons, Arrow Falcon Exporters, Inc., pers. comm. December 3, 2008). The sound pressures anticipated ae presented in table 4.16.

Table 4.6 Anticipated sound pressures from helicopters (John Brieger, Bell Helicopter Textron, Inc., pers. comm. December 12, 2008).

Helicopter Model	Flyover Sound Pressure	Takeoff Sound Pressure	Landing Sound Pressure
Bell 47	78.9 dBA[1]	79.1 dBA	Not available
Bell 206 B3 Jet Ranger[2]	74.8 dBA @ 100 knots @ 492 ft altitude	79 dBA @ 50 knots @ approximately 450 ft altitude	83.1 dBA @ 50 knots (average) at 394 ft altitude

[1] Values converted from Effective Perceived Noise Level dB (Rene Bergeron, Bell Helicopter, pers. comm. December 5, 2008) to dBA peak using a factor of -10.5 (Brieger, pers. comm. 2008).
[2] Peak sound pressure levels are based on the estimates of Model 206B3, the highest peak value provided, for Bell Jet Ranger 206.

Helicopters may fly over murrelets as they are foraging or loafing in marine waters. We anticipate that most of the flights will occur over mud flats, rather than open water, as the helicopter pilot has stated that the shortest flight path is likely to be used when spraying (Foster, pers. comm. 2008), reducing the potential for murrelets to be exposed to high sound pressures while foraging and loafing. However, if flights occur over open water when murrelets are present, they may be exposed to sound pressure levels greater than 92 dBA.

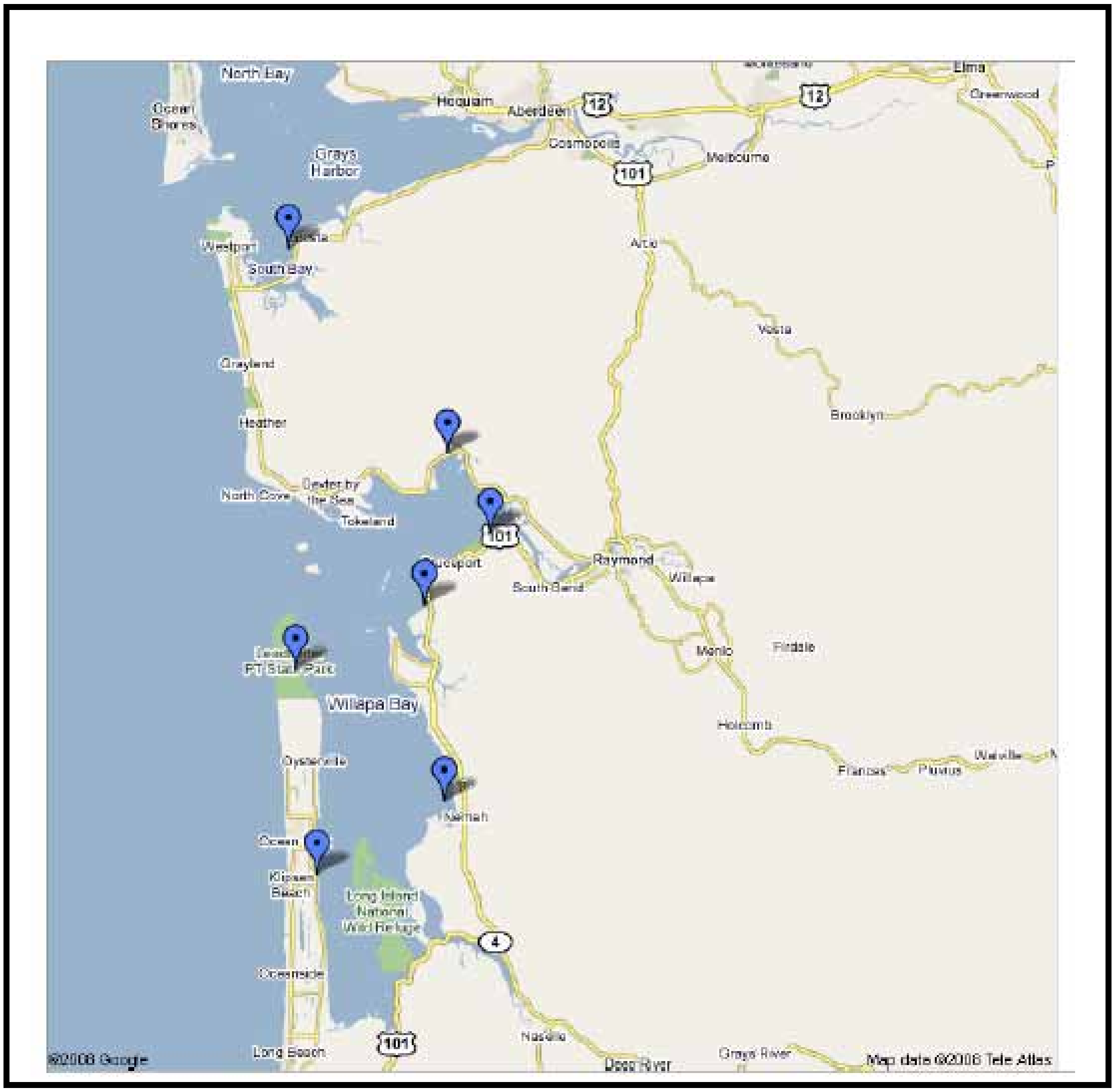

Figure 4.24 Grays Harbor and Willapa Bay helicopter landing sites (Jeff Fisher, Environ International Corp., pers. comm. 2008).

Behavioral Responses to Stressors

The behavioral response of animals to human disturbance has been documented to include 1) abandonment of nest and foraging sites (Henson and Grant 1991; Gill et al. 1996; Fowler 1999), 2) increased activity levels, 3) premature deaths or reduced reproductive success when energy expenditures exceed energy budgets (Daan et al. 1996; Giese 1996; Mullner et al. 2004), and 4) higher predation rates when higher risk foraging or migratory strategies are adopted (Frid and Dill 2002).

No known studies or data are available that evaluate the behavioral response of murrelets (or other alcids) to noise in the marine environment. Behaviors that we believe would indicate disturbance of murrelets in the marine environment include aborted feeding attempts, multiple delayed feeding attempts within a single day or across multiple days, multiple interrupted resting periods, and precluded access to suitable foraging habitat. These impacts could result in measurable effects to murrelets depending on the frequency and duration of the disturbance.

Sound Pressure

Exposure to elevated sound pressure from helicopter use may cause murrelets to avoid suitable foraging and loafing habitat in Grays Harbor and Willapa Bay. The proposed flights are limited in duration (no more than 2 hours a day for up to 7 days) and limited in area within these waterbodies. Therefore, other than temporary disturbance or displacement, is it unlikely the helicopter activities will measurably alter marbled murrelet access to suitable foraging and loafing habitat within Grays Harbor and Willapa Bay.

Sound pressures may exceed 92 dBA during spraying application. However, flights would need to be approximately 8 ft above water to generate sound pressures of this value (Table 4.17). The helicopter pilot has indicated that flights between spray sites may be 50 ft or higher above the water (Foster, pers. comm. 2008). Therefore, it is unlikely that foraging and loafing murrelets will be exposed to sound pressure levels that exceed 92 dBA. Therefore, the effects of the proposed use of helicopters on murrelet foraging and loafing behavior are anticipated to be insignificant.

Table 4.17. Anticipated sound pressure from helicopter flyovers

dBA_{peak}	**Altitude (ft)**
74.8	492
77.8	246
80.8	123
83.8	62
86.8	31
89.8	15
92.8	8

Additionally, the sound levels generated by the helicopters that may be used as part of the proposed action are unlikely to reach levels that may result in measurable affects to nesting murrelets. The maximum sound pressure reported was 74.8 dBA at 492 ft for the Bell Jet Ranger 206 B3. Helicopters will be greater than 492 ft from suitable murrelet nesting habitat during operation. Therefore, effects of sound pressure on nesting murrelets associated with helicopter use are likely to be insignificant.

Visual Image

Primary marbled murrelet predators are other bird species (e.g., peregrines); therefore, murrelets are somewhat adapted to threats from above. We assume that murrelets will perceive the approaching helicopter as a threat and will respond as they would to any potential aerial predator, by diving and/or heightening their awareness. This behavior will be of short duration due to the limited duration of flights (no more than two hours) over several days. This disturbance is unlikely to measurably affect murrelets and their ability to forage. Therefore, effects of visual disturbance to murrelets associated with helicopter use are likely to be insignificant.

Collision

The use of helicopters is weather-dependant; therefore, we expect murrelets in flight will be able to see the helicopter and avoid collisions. Murrelets will flush off the water if a perceived threat comes from a great enough distance to allow them to take flight (Agness et al. 2008). However, we assume any marbled murrelet that flushes is likely to fly away from the perceived threat (helicopter), thus avoiding the likelihood of collision. Given the extremely low likelihood that murrelets will collide with a helicopter, the risk of collision is expected to be discountable.

Rotor Wash

Rotor wash directly over or close to a nest site can cause murrelets to be blown from their nest. The helicopters used as part of the proposed project will not be operated over or within 0.25 mile of suitable marbled murrelet nesting habitat on Long Island (Foster, pers. comm. 2008). Additionally, there is much less downwash associated with the passing of a helicopter versus hovering. With a Bell Jet Ranger at a distance of at least 50 ft above the tree canopy, and a speed of greater than 25 knots, the canopy would be outside of the downwash zone (Karen White and F. White, U.S. Army, pers. comm. April 12, 1994). Therefore, marbled murrelet suitable nesting habitat is likely to be outside the zone where rotor wash may affect nesting individuals. In addition, helicopters are unlikely to hover over waterbodies where murrelets may be foraging or loafing. For these reasons, we anticipate that the effects to murrelets due to rotor wash are likely to discountable.

4.7.18.1.4 Murrelet Response

Pesticide applications within Willapa Bay have not occurred within a 0.25 mile of the southwestern shore of Long Island (Figure 4.25). Aquaculture beds in this area are either not in use or are cultured entirely by natural set and development and harvested occasionally. It is unlikely that these areas will be treated with carbaryl, especially by helicopter, during the duration of the NWP 48 (2012) (Steven R. Booth, Willapa Bay/Grays Harbor Growers Association, in litt. 2008).

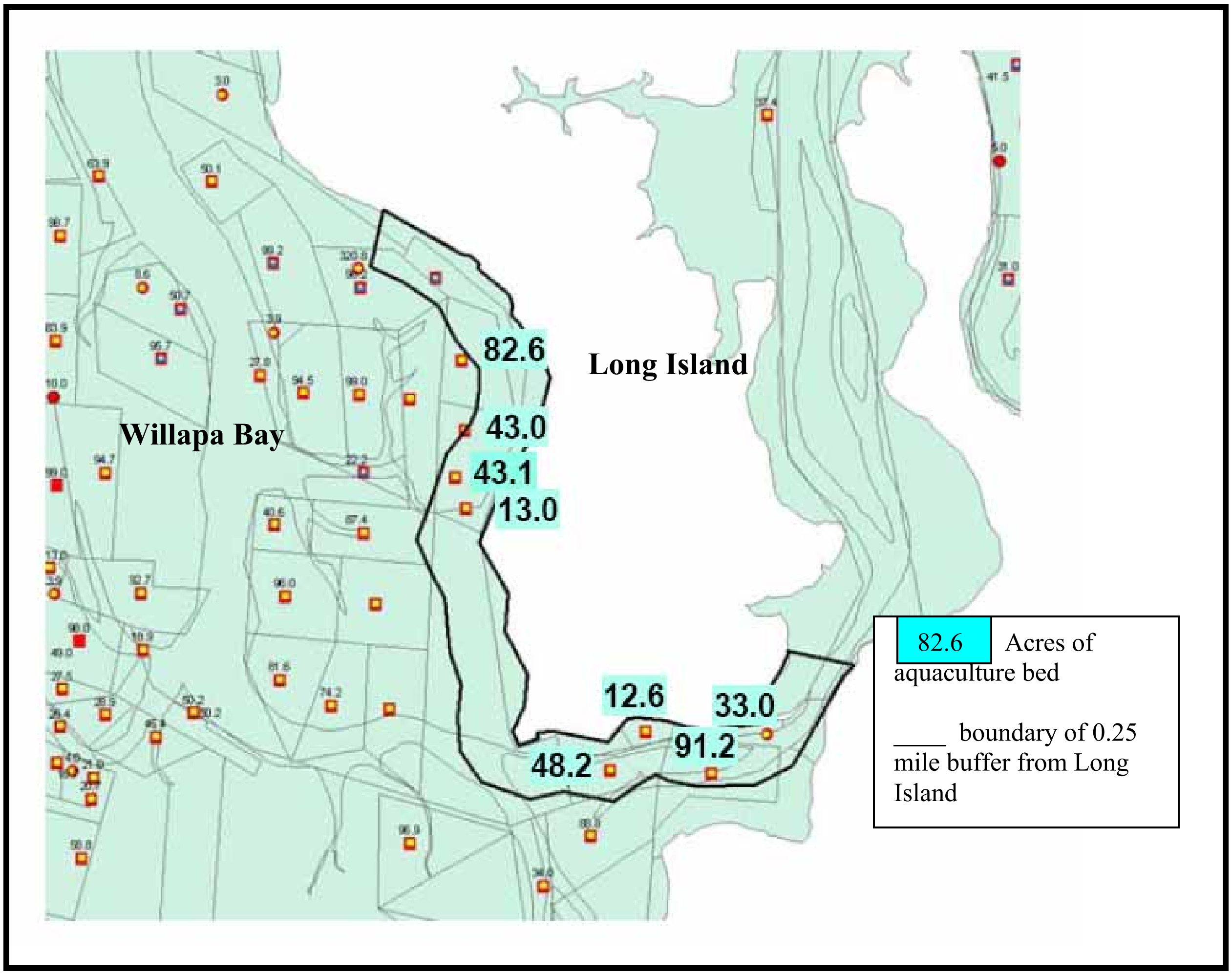

Figure 4.25 South western shore of Long Island with shellfish aquaculture beds and buffer

5.0 CUMULATIVE EFFECTS (BULL TROUT, BULL TROUT CRITICAL HABITAT AND MURRELET)

Cumulative effects include the effects of future State, tribal, local or private actions that are reasonably certain to occur in the action area considered in this Biological Opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the Act.

There are ongoing activities within and adjacent to the action area, including boat traffic, dredging, and, in some cases, adjacent Tribal geoduck harvest that will continue and may increase in the future. Urban development will increase in the future and will result in increased stormwater and wastewater discharges and degraded water quality.

Bull trout and their prey species are likely to be negatively impacted by these activities. Exposure of bull trout and their prey to degraded water quality is most likely during the late fall, winter, and early spring when rain events occur. The response to these exposures will depend on the amount and concentration of contaminants discharged, which is dependent upon many factors (e.g., existence of stormwater BMPs, maintenance of the stormwater BMPs, time between rain events), and is therefore likely to be more severe in urbanized areas.

Bull trout critical habitat is also likely to be negatively impacted by these activities. Urban development will result in increased stormwater and wastewater discharges and degraded water quality. This will result in adverse effects to PCE 7 (An abundant food base including terrestrial organisms of riparian origin, aquatic macro invertebrates, and forage fish) and PCE 8 (Permanent water of sufficient quantity and quality such that normal reproduction, growth, and survival are not inhibited).

Marbled murrelets and their prey species are likely to be negatively impacted by these activities. Direct exposure of marbled murrelets and their prey to degraded water quality is most likely during the late fall, winter, and early spring when rain events occur. The response to these exposures will depend on the amount and concentration of contaminants discharged, which is dependent upon many factors (e.g., existence of stormwater BMPs, maintenance of the stormwater BMPs, time between rain events), and is therefore likely to be more severe in urbanized areas. Continued negative effects to prey abundance is of particular concern. Disruption of foraging from high levels of boat traffic may also have adverse effects.

6.0 CONCLUSION

6.1 Bull Trout

After reviewing the current status of bull trout, the environmental baseline for the action area, the effects of the proposed action and the cumulative effects, it is the Service's Biological Opinion that NWP 48, as proposed, is not likely to jeopardize the continued existence of the bull trout.

This determination is based on the following rationale:

- The marine waters of the action areas are considered essential for maintaining the anadromous life form of bull trout in the Coastal/Puget Sound IRU.
- Adverse effects to bull trout from sediment and reductions in prey are anticipated. However, information was insufficient to determine whether the magnitude of these effects were likely to result in a disruption of normal behaviors leading to injury or mortality. The disruption of migratory corridors and water quality impacts associated with sediment are expected to be localized and short term, and affected areas are expected to continue to support bull trout.
- Potential adverse effects to 9 of the 14 bull trout core areas within the Coastal/Puget Sound IRU are anticipated. Effects to core areas are likely to be variable, with the most significant effects to the most robust core populations, the lower Skagit and upper Skagit. In addition, only the anadromous component of all core populations will be affected.

- Therefore, we do not anticipate a measurable reduction in numbers, reproduction, or distribution of bull trout within the IRU or the coterminous range of the species.

6.2 Bull Trout Critical Habitat

After reviewing the current status of bull trout, the environmental baseline for the action area, the effects of the proposed NWP 48 and the cumulative effects, it is the Service's Biological Opinion that the NWP 48, as proposed, is not likely to adversely modify bull trout critical habitat. It is the Service's Biological Opinion that the action, as proposed, will not destroy or adversely modify designated bull trout critical habitat. This determination is based on the following:

- Critical habitat was designated in marine waters in the action area to address the FMO needs of bull trout. PCEs include adequate water temperatures, migratory corridors with no barriers, an abundant food base, and permanent water of sufficient quantity and quality.
- The action area is in critical habitat from two Critical Habitat Units (CHU), the Olympic Peninsula and Puget Sound CHUs. These CHUs provide for subadult and adult migration, forage and refugia. These units are important to maintaining the overall distribution and genetic diversity of bull trout.
- Critical habitat in Samish Bay is located in the Puget Sound CHU, North Puget Sound is located in the Puget Sound and Olympic Peninsula CHU, and Hood Canal and Grays Harbor are in the Olympic Peninsula CHU. South Puget Sound and Willapa Bay are not in critical habitat.
- The proposed action will have adverse effects to critical habitat, specifically to PCE vii (an abundant food base) and PCE viii (Permanent surface water quality).
- Adverse effects to PCE viii associated with sediment and carbaryl are expected to be localized and of short duration, and dispersed throughout the critical habitat units. PCE viii in affected areas will continue to support bull trout.
- Adverse effects to PCE vii will be significant. However, the importance of effects to abundant food as a PCE is related to the needs of bull trout in the marine environment. Given the availability for bull trout of marine food resources, we did not establish that the reduction in food resources will be significant to individuals. These effects are likely to be significantly less in the Olympic Peninsula CHU than Puget Sound CHU and dispersed throughout these units.
- The direct and indirect effects of the proposed action (permanent and temporary) will not preclude bull trout from foraging, migrating or overwintering within the action area. Effects to habitat connectivity will be insignificant at the scale of the CHU area.

- Within the action area, designated bull trout critical habitat will remain functional. The anticipated direct and indirect effects of the action, combined with the effects of interrelated and interdependent actions, and the cumulative effects associated with future State, tribal, local, and private actions will not prevent the PCEs of critical habitat from being functionally maintained at the scale of the action area. Critical habitat within the action area will continue to serve the intended conservation role for the species at the scale of the core area, interim recovery unit, and coterminous range.

6.3 Marbled Murrelet

After reviewing the current status of murrelet, the environmental baseline for the action area, the effects of the proposed NWP 48 and the cumulative effects, it is the Service's Biological Opinion that the NWP 48, as proposed, is not likely to jeopardize the continued existence of the murrelet.

This determination is based on the following rationale:

- Murrelets from Conservation Zones 1 and 2 are present in the action area. However, adverse effects are not anticipated in Conservation Zone 2. The murrelet population in Conservation Zone 1 is relatively large, with an estimated population of 7,000 (4,100 – 10,400). However, the poor breeding success inferred from juvenile ratios determined through at-sea monitoring in Conservation Zone 1 and an adult survival estimate of 0.83 to 0.93, led investigators to conclude the murrelet population trend is negative (Ralph et al. 1995b; Cam et al. 2003; McShane et al. 2004b).
- Protecting the quality of the marine waters and reducing adult and juvenile mortality in the marine environment in the action area is considered essential for maintaining the murrelet in Conservations Zone 1 and 2.
- Adverse effects to murrelets from reductions in prey are anticipated. However, information was insufficient to determine whether the magnitude of these effects would create a likelihood of injury through a significant disruption of normal behaviors.
- Disruption of foraging associated with sediment is expected to be localized and short term, and affected areas will continue to support foraging by marbled murrelets. Furthermore, these effects will be temporally and geographically dispersed throughout the Conservation Zone. Information was also insufficient to determine whether the magnitude of these effects would create a likelihood of injury through a significant disruption of normal behaviors.
- We do not anticipate a measurable reduction in numbers, reproduction, or distribution of murrelets within either Conservation Zone 1 or the species' listed range. Therefore, anticipated direct and indirect effects of the action, combined with the effects of interrelated/interdependent actions and cumulative effects, will not appreciably reduce the likelihood of both survival and recovery of the marbled murrelet.

7.0 INCIDENTAL TAKE STATEMENT

Section 9 of the Act and Federal regulation pursuant to section 4(d) of the Act prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is defined by the FWS as an act which actually kills or injures wildlife. Such act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavior patterns, including breeding, feeding, or sheltering (50 CFR 17.3). Harass is defined by the FWS as an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering (50 CFR 17.3). Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the Act provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

7.1 Amount or Extent of Take

The Service does not anticipate the proposed action will incidentally take any marbled murrelets or bull trout.

8.0 REASONABLE AND PRUDENT MEASURES

The Service does not anticipate the proposed action will incidentally take any marbled murrelets or bull trout. Therefore, no reasonable and prudent measures are required.

The Service is to be notified within three working days upon locating a dead, injured or sick endangered or threatened species specimen. Initial notification must be made to the nearest U.S. Fish and Wildlife Service Law Enforcement Office. Notification must include the date, time, precise location of the injured animal or carcass, and any other pertinent information. Care should be taken in handling sick or injured specimens to preserve biological materials in the best possible state for later analysis of cause of death, if that occurs. In conjunction with the care of sick or injured endangered or threatened species or preservation of biological materials from a dead animal, the finder has the responsibility to ensure that evidence associated with the specimen is not unnecessarily disturbed. Contact the U.S. Fish and Wildlife Service Law Enforcement Office at (425) 883-8122, or the Service's Washington Fish and Wildlife Office at (360) 753-9440.

9.0 CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the Act directs Federal agencies to utilize their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

Given the potential effects from the overlap between eelgrass, documented herring spawning grounds and shellfish aquaculture in Willapa Bay, Grays Harbor, Samish Bay, and North Puget Sound, we have developed conservation recommendations that are consistent with those outlined in the PCSGA Environmental Codes of Practice. Therefore, we believe the conservation measures we have developed are reasonable.

Our intent in requesting the implementation of these conservation recommendations is twofold 1) reduce impacts from aquaculture practices on eelgrass and herring spawning habitat, and 2) create a regulatory framework for implementation of these recommendations.

Currently, there is no formal regulatory framework for these guidelines, but their intent is to, among other things, aid growers in developing their own individual farm plans. The guidelines are broken into sections covering an overview of operations and specific species and culture methods.

Section II of the Environmental Codes of Practice (Shellfish Aquaculture: Interaction in the Marine Environment) presents effects of shellfish aquaculture. Germane to the effects analyzed in this Opinion is a discussion on submerged aquatic vegetation (PCSGA 2002; p. 20). Both the beneficial effects and areas of concern are described in this section. Growers are directed to determine if seagrass existed prior to planting oysters. According to the guidelines:

> "Where this is the case, and threatened or endangered species are present, growers must include mitigation efforts in their farm management plans. This might include setting aside areas where submerged aquatic vegetation (SAV) is growing and taking care to avoid disturbing these beds during periods when these common areas are being utilized as habitat for important prey species such as herring spawn.
>
> Protection of eelgrass beds is of particular concern in several regions along the West Coast, where stringent regulations are in place to assure no disruption or net loss. Growers must be familiar with the laws that govern operation in eelgrass beds in their particular region and assure their farm practices comply with applicable regulations and permit requirements[5]."

Although these guidelines have been in place for almost seven years, we have no information on the extent to which they are followed or how farm management plans address conservation or mitigation of lost eelgrass. We know of no enforcement or oversight implemented by PCSGA or other entity to ensure that mitigation (although required) is included in farm management plans. Therefore, we request that the conservation recommendations in the following table be implemented by the Corps.

Table 4.16 Proposed Conservation Recommendations Designed to Reduce Effects of Shellfish Aquaculture Activities on Listed Resources Evaluated in the NWP 48 Endangered Species Act Section 7 Consultation

	Conservation Objective	Corps General Conditions (GC)	Specific Service Recommendation (if preceded by a number, the number indicates priority)
1)	*Reduce impacts to herring spawning and spawning habitat, as herring are an energy rich prey important for both bull trout and marbled murrelets.* We are focusing on herring as opposed to all forage fish because surf smelt and sand lance spawning are not expected to be significantly impacted from most activities. As stated in the draft Biological Opinion"…we don't anticipate that Pacific sand lance and surf smelt will be directly impacted by seeding, grow-out, or harvest of shellfish (upland staging activities notwithstanding)." Upland staging areas are not expected to cause significant effects.	GC 3: "Activities in spawning areas during spawning seasons must be avoided to the maximum extent practicable."	By January 1, 2010, condition the permits to avoid impacts during the herring fish spawning seasons, as defined in WAC 220-110-271 for the tidal reference areas identified in WAC 220-110-240. Protect areas most important for prey production. Those are Samish Bay, North Puget Sound, Hood Canal and Willapa Bay for murrelets, and Samish Bay and North Puget Sound for bull trout; South Puget Sound and Grays Harbor are excluded. The following activities conducted on shellfish farms located within or directly adjacent to documented herring spawning areas in specified action areas should be prohibited during time periods indicated in Table 4.19) Mechanical dredge harvest, 2) raking, 3) harrowing, 4) tilling or other bed preparation activities, and 5) frosting or applying oyster shell on beds. All other activities, including hand harvest, can occur. In lieu of discontinuing the activities, a shellfish grower could elect to have a herring spawning survey conducted on their property. The purpose of the survey would be to verify that herring spawn was, or was not, present in the area where work would be conducted. The survey must be conducted according to the WDFW herring survey protocol by a qualified company representative that has received training by WDFW (Maryann Baird will be sending language). The intertidal survey should be conducted within 3 days of the proposed harvest, during a tidal stage that is low enough to enable the determination of whether herring had spawned (generally, less than or equal to +2 MLLW). A brief, one-page letter report should be submitted to the Corps summarizing the results of the survey within one day of completion of the survey. If herring spawn is detected, the shellfish grower must refrain from conducting any of the aforementioned activities until the end of the specified time period identified for their location (Table 4.19). If herring spawn is not detected, then adherence to a timing window is not necessary.

	Conservation Objective	Corps General Conditions (GC)	Specific Service Recommendation (if preceded by a number, the number indicates priority)
2)	*Reduce potential impacts to eelgrass and other SAV habitats that provide important ecological functions within the marine environment, particularly in regards to supporting important forage for bull trout and marbled murrelets.* Note: This objective is consistent with the objective stated in WAC 173-26-221(2)(iii)(A)[11].	None, other than requiring a PCN for dredge harvest, tilling, or harrowing in areas inhabited by SAV. The Corps does not specifically define SAV, but refers to the definition of vegetated shallows[12].	1) Prohibit bed harrowing and tilling or any other bed preparation methods that impact or disrupt eelgrass[13] and vegetated shallows during the aquatic vegetation growing season (March through September). 2) Do not locate geoduck tube culture in eelgrass and vegetated shallows. 3) Design and locate intertidal long line and stake culture to avoid shading of eelgrass and other vegetated shallows. 4) Prohibit beach gravel enhancement in eelgrass and vegetated shallows during the growing season (March through September). 5) Locate and design existing aquaculture racks to avoid erosion, shading of, and sediment deposition on eelgrass and vegetated shallows. 6) Do not locate floating raft culture over eelgrass and vegetated shallows. 7) Do not locate new aquaculture racks in eelgrass and vegetated shallows. 8) Avoid trampling eelgrass and whenever possible use one footpath to access shellfish beds.

[11] WAC 173-26-221(2)(iii)(A) states that "Critical saltwater habitats include all kelp beds, eelgrass beds, spawning and holding areas for forage fish, such as herring, smelt and sandlance; subsistence, commercial and recreational shellfish beds; mudflats, intertidal habitats with vascular plants, and areas with which priority species have a primary association. Critical saltwater habitats require a higher level of protection due to the important ecological functions they provide. Ecological functions of marine shorelands can affect the viability of critical saltwater habitats. Therefore, effective protection and restoration of critical saltwater habitats should integrate management of shorelands as well as submerged areas".

[12] *Vegetated shallows:* Vegetated shallows are special aquatic sites under the Clean Water Act 404(b)(1) Guidelines, as defined in the final rule for Reissuance of Nationwide Permits (FR Vol. 72, No.47). Vegetated shallows are areas that are permanently inundated and under normal circumstances have rooted aquatic vegetation, such as seagrasses in marine and estuarine systems and a variety of vascular rooted plants in freshwater systems.

[13] Eelgrass bed as defined by the Washington State Department of Natural Resources.

Conservation Objective		Corps General Conditions (GC)	Specific Service Recommendation (if preceded by a number, the number indicates priority)
3)	*Maximize conservation of bull trout and marbled murrelets by minimizing the need for a PCN through implementation of the conservation recommendations listed above via permit verification letters*. Incorporation of these conservation recommendations should reduce overall the number of PCNs submitted to the Corps. It would ensure that fewer growers would be 1) required to submit a PCN, 2) subject to obtaining individual permits, and 3) potentially subject to subsequent consultations.	None.	Ensure that a systematic approach is available for use by a District Engineer to identify activities requiring a PCN and determining the potential for adverse environmental effects. The development of a set of specific criteria will minimize inconsistency and subjectivity inherent in decision-making. These criteria should guide evaluation of the most commonly reported impacts, such as effects on eelgrass and other SAV, herring spawning areas, benthic species, and sensitive habitats (such as small enclosed bays dominated by a high density of shellfish farms).

Table 4.17 Prohibited work time in the documented herring spawning areas in the action area

Action Area	TRA	Herring Stock	Prohibited Work Times	
			Begin	**End**
Willapa Bay[14]	17	Willapa Bay	Feb. 17	Mar. 14
Hood Canal	12/13	South Hood Canal	Jan 15	Mar. 1
		Quilcene Bay	Feb 15	Apr. 1
		Port Gamble	Feb 7	Mar. 21
Samish Bay	9	Samish Bay	Feb 7	Mar. 21
North Puget Sound	8/10	San Juan Island	Feb 21	Apr. 7
		Discovery Bay	Feb 21	Apr. 7
		Dungeness Bay	Jan. 21	Mar. 7

These time periods bracket the mean peak herring spawning period in each action area. The peak spawning period may vary by up to two weeks in a given year[15]. Therefore, the mean peak spawning period is bracketed by two weeks to reflect this annual variation in peak spawning periods.

[14] Stick et al. (2005) did not present a mean peak spawning period for Willapa Bay, therefore the prohibited work time window was taken directly from the WAC.
[15] Kurt Stick, Washington Department of Fish and Wildlife, LaConner, Washington. E-mail to Andrea LaTier, Fish and Wildlife Biologist, U.S. Fish and Wildlife Service, Lacey, Washington on January 6, 2009. Subject: Mean two-week spawning period

In addition to the recommendations listed abover we request that the following be implemented in Willapa Bay and Grays Harbor during carbaryl application.

Carbaryl Spraying

- Monitor for 1-naphthol in surface water after carbaryl spraying.
- Conduct bird surveys during carbaryl spraying to observe bird behavior after consumption of compromised prey.

In order for the Service to be kept informed of actions minimizing or avoiding adverse effects or benefitting listed species or their habitats, the Service requests notification of the implementation of any conservation recommendations.

10.0 REINITIATION NOTICE

This concludes formal consultation on the action(s) outlined in the (request/reinitiation request). As provided in 50 CFR 402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease pending reinitiation.

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