United States Department of the Interior

FISH AND WILDLIFE SERVICE

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

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In Reply Refer To:
13410-2009-F-0020
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Dan Hayes
Assistant Chief of Staff for Environment and Safety
Department of the Navy
Navy Region Northwest
1103 Hunley Road
Silverdale, Washington 98315-11030

Dear Mr. Hayes:

This document transmits the U.S. Fish and Wildlife Service's (Service) biological opinion (BO) on the proposed United States Navy's (Navy) Explosive Ordnance Disposal (EOD) Training located near Whidbey Island in Island County, Washington. We evaluated effects on bull trout (*Salvelinus confluentus*) and marbled murrelet (*Brachyramphus marmoratus*) (murrelet) in accordance with section 7 of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.).

This BO is based on information provided in the December 2000 Biological Assessment, the August 3, 2005 addendum to the Biological Assessment, a field demonstration, and numerous meetings, phone calls, emails, and letters on the project. A complete record of this consultation is on file at the Service's Western Washington Fish and Wildlife Office in Lacey, Washington.

The Navy initially determined that the EOD training operation was "not likely to adversely affect" the bull trout and the murrelet. We did not concur with these effect determinations. Based on our discussions, the NAVY requested formal consultation for bull trout and murrelet.

The Navy also made a "no effect" determination for bull trout critical habitat. There is no requirement for Service concurrence on "no effect" determinations. Your determinations that the project will have no effect on these species and critical habitat rest with the action agency.

If you have any comments or questions regarding this BO, please contact Deanna Lynch at (360) 753-9545 or Jim Muck at (206) 526-4740.

Sincerely,

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

Endangered Species Act - Section 7 Formal Consultation

Biological Opinion

United States Navy Explosive Ordnance Disposal Training Operations, Puget Sound; Whidbey Island, Island County, Washington.

Agency:

US Navy
Navy Region Northwest
Silverdale, Washington

Consultation Conducted By:

U.S. Fish and Wildlife Service
Western Washington Fish and Wildlife Office

Ken Berg, Manager
Western Washington Fish and Wildlife Office

11/7/08
Date

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CONSULTATION HISTORY

On January 8, 2001, the United States Navy (Navy) sent the Fish and Wildlife Service (Service) a letter requesting informal consultation for the Navy's Explosive Ordnance Detonation (EOD) Training Operation on bull trout and marbled murrelets (murrelet). By letter on April 18, 2002, the Service did not concur with the Navy's "may effect, but is not likely to adversely affect" determination for Coastal-Puget Sound bull trout. This letter also identified possible options to eliminate or reduce negative impacts of the EOD training to listed species. The Navy identified potential mitigation measures in a letter to the Service dated July 5, 2002. Through numerous communications and meetings, the Service requested additional information needed to initiate consultation. On March 2, 2004, the Service received the necessary information required to initiate formal consultation.

A chronological list of significant communications related to the consultation history is provided below:

- January 8, 2001 - The Navy requested informal consultation with the Service for a "may effect, but is not likely to adversely affect" determination for bull trout and murrelets.

- October 29, 2001 - The Navy conducted a field demonstration at the Crescent Harbor training site. Some of the agencies present included the Service, National Marine Fisheries Service, Washington Department of Fish and Wildlife (WDFW), Swinomish Tribe, and the Skagit System Cooperative. During the field demonstration, the Service requested additional information on impacts of underwater explosions to fish.

- December 18, 2001 - The Navy sent an addendum of the Biological Assessment (BA) to the Service providing additional information on effects of EOD training on Dungeness crab (*Cancer magister*), fish, and marine mammals.

- April 18, 2002 - The Service sent a letter to the Navy stating we did not concur with effects determination for bull trout. This letter also identified possible options to eliminate or reduce negative impacts of the EOD training to listed species.

- July 5, 2002 - The Navy identified potential mitigation measures in a letter to the Service.

- Between April 2002 and March 2004 the Navy and the Service developed a monitoring plan for bull trout.

- March 2, 2004 - The Service received the necessary information required to initiate formal consultation.

- March 30, 2004 - The Service sent a letter to the Navy initiating consultation.

- Between March 2004 and September 2007, the Navy and the Service defined an accurate project description through meetings and numerous correspondences.

- November 1, 2005 - The Navy sent an email to the Service transmitting the effects of the EOD underwater detonations on bull trout critical habitat. The Navy made a "No Effect" determination for bull trout critical habitat.

- October 24, 2007 - The Navy and the Service met to discuss potential impacts to murrelets and measures to minimize impacts.

- Between September 2007 and October 2008, the Service and the Navy developed a pre-detonation murrelet survey protocol and negotiated changes to the project description to reduce impacts.

- October 9, 2008 - The Navy sent an email to the Service withdrawing the detonations in Port Townsend Bay and Bangor from the proposed action, restricting the detonations at Crescent Harbor to 2.5 lbs and providing a monthly schedule of the training exercise to be conducted through December 2009.

- October 16, 2008 - The Navy requested formal consultation on murrelets.

BIOLOGICAL OPINION

Approach to the Jeopardy Analysis

To conduct a jeopardy analysis, we evaluate the following for bull trout and murrelets: (1) the *Status of the Species*, which evaluates the rangewide condition, the factors responsible for that condition, and their survival and recovery needs; (2) the *Environmental Baseline*, which evaluates the condition in the action area, the factors responsible for that condition, and the conservation role of the action area; (3) the *Effects of the Action*, which determines the direct and indirect impacts of the proposed Federal action and any interrelated or interdependent actions; and (4) the *Cumulative Effects*, which evaluates the effects of future, non-Federal activities in the action area.

DESCRIPTION OF THE PROPOSED ACTION

For the purposes of this consultation, the proposed action is the ongoing Navy's EOD Training Operations in Washington State's Puget Sound. The duration of this consultation will be from the date of signature of this Biological Opinion (BO) through December 31, 2009. The purpose of the training is for personnel to meet and maintain requirements for basic proficiency in combat and non-combat EOD Mine Countermeasures readiness. The training consists of using explosive charges to destroy or disable inert mines that are either underwater or floating on the surface.

The Navy originally proposed to conduct their EOD training in four areas. These locations are associated with the Navy installations in Puget Sound at Crescent Harbor, Holmes Harbor, Port Townsend Bay, and Bangor in northern Hood Canal. However, the Navy has determined that through December 31, 2009, EOD training will only occur at Crescent Harbor. Therefore, this consultation is specific to the training at Crescent Harbor. The Crescent Harbor training area is on the east side of Whidbey Island, next to the Naval Air Station (NAS) Whidbey Island Seaplane Base.

General Training Procedures

In general, each underwater training exercise entails placing an inert mine, locating the mine with hand-held sonar, placing a charge near the mine, attaching of detonation equipment, detonation of the charge, retrieval of debris, and in-water inspection of the detonation site. In some of the exercises, a disabled mine is raised and moved ashore for dismantling and inspection. After the detonation, the divers retrieve debris, which consists mainly of pieces of the mine (the explosive is consumed in the explosion).

Prior to any detonation, two Navy workboats will patrol the training range within a specific radius of the detonation site in order to determine the presence of mariners (water users), marine mammals, and birds. The radius of the survey for all training exercises will be 1,640 ft (ft) [500 meters (m)]. If any mariners, marine mammals, or birds are observed within this range, the training exercise will either be cancelled for the day or delayed until the vicinity has been cleared.

An inert mine is placed by the training unit operating from a small, outboard powered boat, generally 16 to 22 ft (4.9 to 6.7 m) long. Two divers locate the mine using hand-held sonar with a range of approximately 360 ft (109.7 m). The location of the mine is then marked with a small buoy. The boat then proceeds to a nearby beach on Navy property to pick up the explosive charge from a land-based team that assembled the explosive. This transfer site is chosen to be away from pedestrian and vehicle traffic and the magazine area. In Crescent Harbor, it is located near Polnell Point on the east shore of the harbor. The boat then proceeds back to the location of the mine for placement and detonation of the explosive.

Training events may occur throughout the year and are not dependent upon weather; therefore, the training events may occur under all possible weather and sea-state conditions.

The explosives used in the training are either C-4 or A-3. C-4 (MIL-C-45010A) is a combination of 91 percent Royal Demolition Explosive (Hexahydro-1,3,5-trinitro-1,3,5-triazine) and 9 percent polyisobutylene. A-3 (MIL-C-440B) is composed of 91 percent Royal Demolition Explosive and 9 percent wax.

Underwater Detonations

Prior to placement and detonation of the explosive, the mine is lowered to the seafloor. Placing the mine and explosive on the seafloor minimizes the explosive impacts into the water column. The two divers place the charge immediately adjacent to the mine. The charge has an attached detonation cord, of which the free end, called the primary loop, is attached to one of two small floats on the surface. The second small float contains the initiator which consists of two blasting caps that are attached to the primary loop on the first float (the initiator, blasting caps, and detonation cord are done in duplicate to minimize false firings).

All detonations will be initiated manually. With the manual procedure, a diver pulls two pins at the initiator. In this case, the initiator includes a length of slow-burning fuse, (called the time train) that delays the detonation by approximately eight to ten minutes to allow time for the divers to board a boat and move to a safe distance from the detonation site. With this manual procedure, the detonation cannot be interrupted once it has been initiated.

After the detonation, boats return to the detonation site. All surface debris, consisting mainly of floats and attached equipment, is retrieved. The divers retrieve some debris from the seafloor, which consists mainly of pieces of the mine. In cases where the mine is only intentionally disabled, not destroyed, the mine is taken ashore for dismantling and inspection. The training mine is inert and does not contain any explosive material.

Underwater detonations at Crescent Harbor through December, 2009, will be limited to 2.5 pound (lb) [1.1 1-kilograms (kg)] charges of C-4. The 2.5-lb (1.1-kg) explosive is for training purposes simply to demonstrate capability to set the charge, detonate the explosive, and destroy the inert mine. Detonations will occur between 1,100 ft (330 m) and 7,200 ft (2,200 m) from the nearest shoreline at a depth of 40 to 100 ft (12.2 to 30.5 m) on sandy or muddy bottoms. Through December, 2009, 6 underwater detonations may occur at Crescent Harbor (Table 1).

Surface or Floating Mine Detonations

Two swimmers attach a 2.5-lb (1.1-kg) charge to a mine simulated by a clean metal 55-gallon drum (with 1 to 2 sand bags placed inside for ballast) free floating at the surface. The explosive is placed on top of the 55-gallon drum so that the explosive is entirely out of the water. The explosive has a short length of detonation cord attached, called the primary loop. A small float that contains the initiator, which consists of two blasting caps, is attached to the primary loop of the explosive (as with the underwater detonations, the initiator and blasting caps are done in duplicate to minimize false firings). The swimmers initiate the detonation manually by pulling two pins on the initiator. The initiator has a slow-burning fuse that delays the detonation by approximately 10 minutes to allow time for the swimmers to board the insertion craft. This process is the same as with the underwater detonations.

The swimmers may be inserted via helicopter or small boat. About 50 percent of the floating mine training insertions are completed with a helicopter and the other 50 percent by boat. Helicopter involvement is fair-weather dependent. Boat insertion would be similar to the method described above. The helicopter (a MH-60 Sierra with a 54-inch total blade length) takes off from Ault Field located on NAS Whidbey Island, flying at an elevation of about 500 ft (152.4 m) and approaches Crescent Harbor from the north and flies around the harbor going about 70-80 knots looking for a float mark that identifies the simulated mine. The helicopter slows to less than (<) 1 knot and hovers about 10 to 20 ft (3.0 to 6.1 m) above the water for insertion of the swimmers. The helicopter then flies to the survival area (NW shoreline of the Seaplane Base) were it waits for the charge to be set. The swimmers are extracted by helicopter on approximately 25 percent of these training exercises and by boat the other 75 percent of the time. Through December, 2009, 4 surface detonations may occur at Crescent Harbor (Table 1).

Table 1 Schedule of surface and underwater detonations at Crescent Harbor through December, 2009.

Date	Number of Events	Type of Detonation	Maximum Size of Charge
October 2008	1	Surface	2.5 lbs
November 2008	1	Underwater	2.5 lbs
December 2008	0		
January 2009	0		
February 2009	3	Underwater	2.5 lbs
March 2009	0		
April 2009	2	Surface	2.5 lbs
May 2009	0		
June 2009	1	Surface	2.5 lbs
July 2009	2	Underwater	2.5 lbs
August 2009	0		
September 2009	0		
October 2009	0		
November 2009	0		
December 2009	0		
Total	10		

Conservation Measures

The conservation measures described here and in the consultation initiation package are considered part of the proposed action and are intended to reduce or avoid adverse effects on listed species and their habitats. The Service regards these conservation measures as integral components of the proposed action and expects that all proposed project activities will be completed consistent with these measures. We have completed our effects analysis accordingly.

- Pre-explosion surveys (via boat) will be conducted in accordance with the Protocol Monitoring for Sea Birds for EOD Training Exercises (Appendix A). The radius of the survey range will be no less than 1,625 ft (500 m). The explosive will be detonated only when the sea birds are not observed in the survey area.
- A monitoring plan will be implemented to provide estimates of fish mortalities related to EOD training (Appendix B). Reports will be submitted annually to the Service.

Action Areas

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.

The basis for defining the aquatic portion of the action area was the distance at which underwater sound associated with the underwater detonations either intersects with a land mass or where it attenuates to background levels. In Crescent Harbor, the action area was defined by the distance where the sound intersects with a land mass. In the action area, the distance at which the underwater sound intersects with a land mass is less than the distance at which it would otherwise attenuate to background level.

The terrestrial portion of the action area is defined by the property lines of NAS Whidbey Island Seaplane Base. Polnell Point is also included in the terrestrial portion of the action area as this is the transfer location for the divers. The terrestrial portion is where operations of helicopters for the insertion and extraction of the divers would occur.

The Crescent Harbor action area is bounded on the west by Whidbey Island and the east by Camano Island (Figure 1). The southern end is a line drawn between East Point, located just east of Holmes Harbor, north to Lowell Point on Camano Island. The northern extent is a line drawn due west from the South Fork of the Skagit River to Strawberry Point on Whidbey Island and the surrounding shoreline. Specific waters include Penn Cove, Crescent Harbor, Oak Harbor, the southern end of Skagit Bay, and the northern portion of Saratoga Passage. Saratoga Passage is bounded by Whidbey Island on the west and Camano Island on the east. The Crescent Harbor action area is located in Island County. The action area is approximately 239 km^2.

Crescent Harbor is an arc-shaped embayment located between Forbes Point and Polnell Point on Whidbey Island, at the north end of Saratoga Passage. The bathymetry of this southward-facing embayment is characterized by a gently sloping bottom along the west and east sides of the harbor which reaches its deepest point in a central valley. Water depths range to a depth of approximately -120 ft Mean lower low-water (MLLW) within the central valley of the embayment (NOAA 1989). At this point, water depths rapidly increase to the deeper waters of Saratoga Passage. The shallow subtidal areas near Forbes Point and Polnell Point consist of rock and boulders. Nearshore intertidal areas (less than -9.8 ft MLLW) are composed of gently sloping sandy beaches or mud flats. Seawalls are located on the west side of Crescent Harbor to protect structures built for the Seaplane Base at NAS Whidbey Island. The NAS Whidbey Island, near Crescent Harbor's test site intertidal area, is characterized by gentle to moderate slopes and is composed of sand beaches and mud flats (EA Engineering, Science, and Technology 1996).

South of Crescent Harbor, within Saratoga Passage, water depths drop off more rapidly from the shore, and water depth increases toward the south end of the Crescent Harbor action area, reaching depths of approximately -420 ft MLLW.

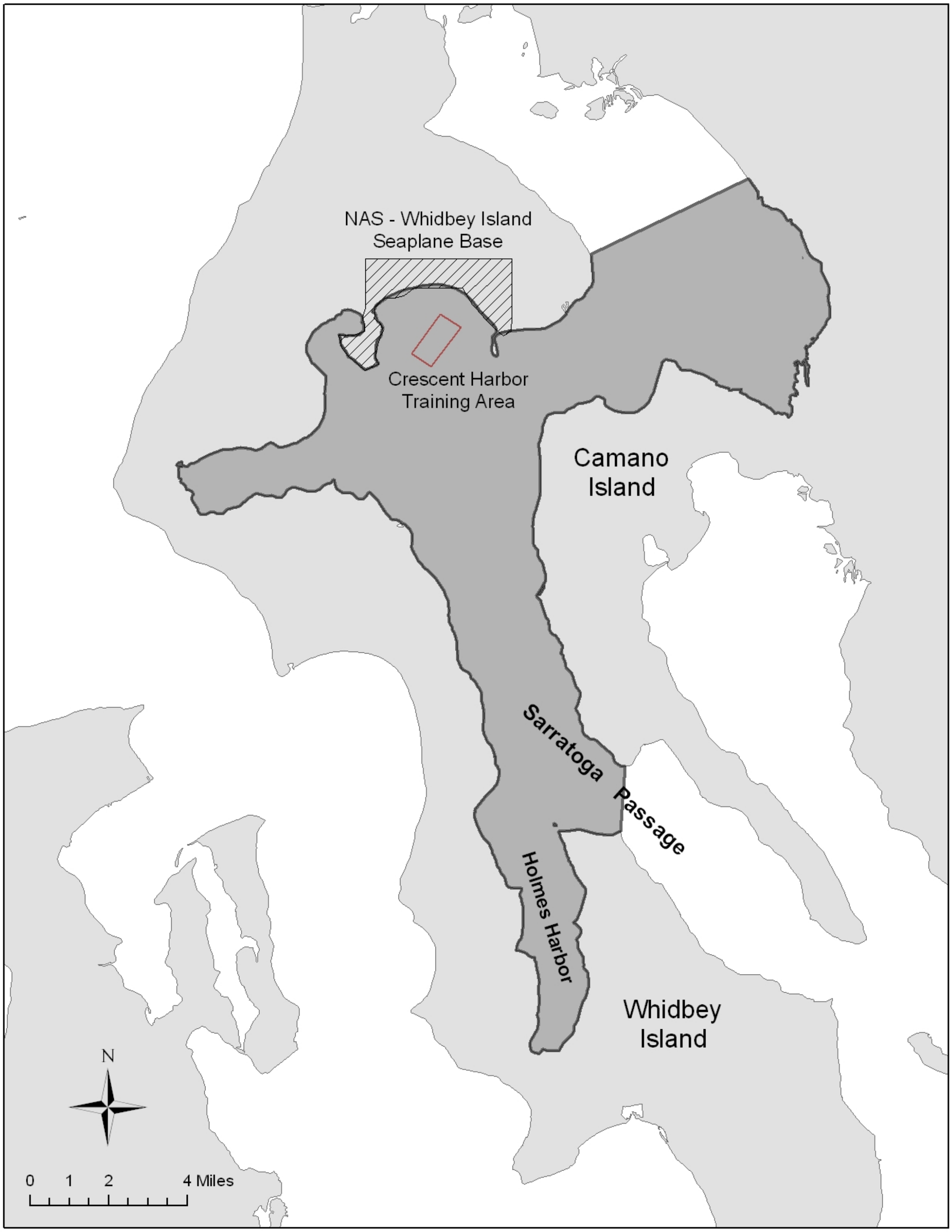

Figure 1 Location of the Crescent Harbor Action Area.

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 (Cavender 1978; Bond 1992; Brewin and Brewin 1997; Leary and Allendorf 1997).

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. 2007; Rieman et al. 2007). 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 2002; 2004a; 2004b). 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 2002; 2004a; 2004b).

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 2002; 2004a; 2004b) 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. 2003).

Central to the survival and recovery of bull trout is the maintenance of viable core areas (USFWS 2002; 2004a; 2004b). 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 2002; 2004a; 2004b).

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 2004b). The draft bull trout recovery plan (USFWS 2004b) 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 2004b).

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 2002). Bull trout populations in this interim recovery unit face a high risk of extirpation (USFWS 2002). The draft Klamath River bull trout recovery plan (USFWS 2002) 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 2002).

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 (Quigley and Arbelbide 1997). 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.*, 1995). The draft Columbia River bull trout recovery plan (USFWS 2002) 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 2005).

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 2004a). 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 2004a) 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 2002). 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 2002). 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 2002). The draft St. Mary-Belly bull trout recovery plan (USFWS 2002) 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 1993). 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 1989). 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 1989), or saltwater (anadromous form) to rear as subadults and to live as adults (Cavender 1978; 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 1989). The largest verified bull trout is a 32-pound specimen caught in Lake Pend Oreille, Idaho, in 1949 (Simpson and Wallace 1982).

Habitat

Bull trout have more specific habitat requirements than most other salmonids (Rieman and McIntyre 1993). 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; Goetz 1989; Hoelscher and Bjornn 1989; Sedell and Everest 1991; Howell and Buchanan 1992; Pratt 1992; Rieman and McIntyre 1993; 1995; Rich, Jr. 1996; Watson and Hillman 1997). Watson and Hillman (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 1993), bull trout should not be expected to simultaneously occupy all available habitats (Rieman et al.

1997).
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 1993; Rieman et al. 1997; Mike Gilpin *in litt.*, 1997). Migrations facilitate gene flow among local populations when individuals from different local populations interbreed or stray to nonnatal 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 1993; Spruell et al. 1999). 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 1993).

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 1993; Baxter et al. 1997; Rieman et al. 1997). 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 1989; Buchanan and Gregory 1997). In Granite Creek, Idaho, Bonneau and Scarnecchia (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 1993; 1995; Rieman et al. 1997; Buchanan and Gregory 1997). 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; Goetz 1989; Hoelscher and Bjornn 1989; 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

1993). 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 (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 1989; 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 1992).

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 (WDOE 2002) 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 Zweep1996 *cited in* (Stewart et al. 2007)). 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 1993; 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 1993).

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 1989; 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*), 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.

Changes in Status of the Columbia River Interim Recovery Unit

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.

Changes in Status of the Klamath River Interim Recovery Unit

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.

STATUS OF THE SPECIES: 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]; (Beissinger and Nur 1997 in USFWS 2004). 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: 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 and NMFS 1998) and clarified for recovery units through Memorandum (USFWS 2006), 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. 1995), 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. 2004).

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 2). 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 1997), 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 1997). 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 1997).

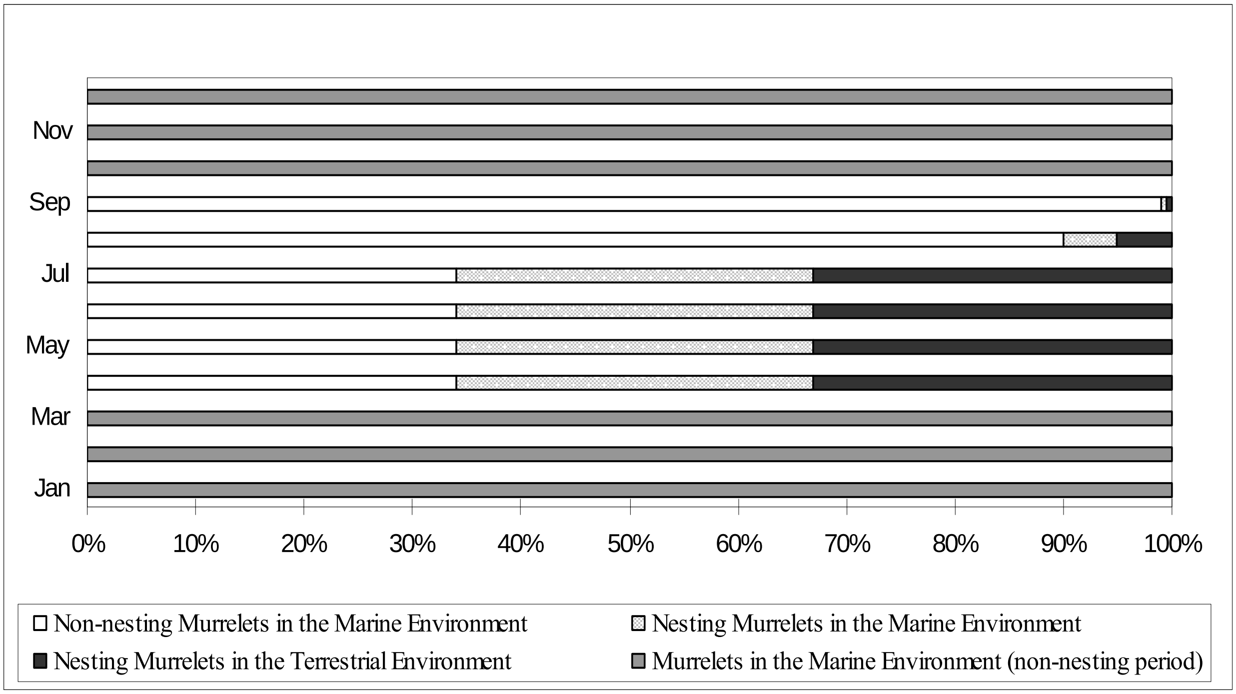

Figure 2 The seasonal changes in the relative proportion of breeding and non-breeding murrelets in the marine and terrestrial environments[1] within Washington State (Conservation Zones 1 and 2)

Vocalization

Murrelets are known to vocalize between 480 Hertz and 4.9 kilohertz and have at least 5 distinct call types (Suzanne Sanborn, pers. comm. 2005). Murrelets tend to be more vocal at sea compared to other alcids (Nelson 1997). 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 1997; 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 1997). 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 1997). Observations of courtship occurring in the winter suggest that pair bonds are maintained throughout the year (Speckman 1996; Nelson 1997). Courtship involves bill posturing,

[1] 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.

swimming together, synchronous diving, vocalizations, and chasing in flights just above the surface of the water. Copulation occurs both inland (in the trees) and at sea (Nelson 1997).

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. (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 1997). 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 1997). A complete pre-basic molt occurs from mid-July through December (Carter and Stein 1995; Nelson 1997). During the pre-basic molt, murrelets lose all flight feathers somewhat synchronously and are flightless for up to two months (Nelson 1997). 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. (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. (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 1986; Gaston and Jones 1998; Henkel et al. 2003; Kuletz 2005). Murrelets typically forage in pairs, but have been observed to forage alone or in groups of three or more (Carter and Sealy 1990; Strachan et al. 1995; Speckman et al. 2003). Strachan et al. (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 1990) and resurfacing together on most dives. Strachan et al. (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 1990; 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 1997). 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 1997).

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 (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 (Jodice and Collopy 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 1997). 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 1997). During the winter there may be a general shift from exposed outer coasts into more protected waters (Nelson 1997), 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. 2004).

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 1986); 57 FR 45328 [October 1, 1992]). In general, small schooling fish and large pelagic crustaceans are the main prey items. Pacific sand lance *(Ammodytes hexapterus)*, northern anchovy *(Engraulis mordax),* immature Pacific herring *(Clupea harengus)*, 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 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 1997), primarily around dawn and dusk (Nelson 1997; Kuletz 2005). 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 (Hobson 1990). Becker et al. (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 2005). 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 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. 2006:20). 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 2005).

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. 2004). California sea lions (*Zalophus californianus*), northern sea lions (*Eumetopias jubatus*), and large fish may occasionally prey on murrelets (Burger 2002).

Murrelets in the Terrestrial Environment

Murrelets are dependent upon old-growth forests, or forests with an older tree component, for nesting habitat (Ralph et al. 1995; Hamer and Nelson 1995; McShane et al. 2004). Sites occupied by murrelets tend to have a higher proportion of mature forest age-classes than do unoccupied sites (Raphael et al. 1995). 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. 1995); 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. (Ralph et al. 1995) 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 1997) which may indicate adults are defending nesting sites and/or stands (Ralph et al. 1995). 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. 2004). 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. 1995).

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. 1995). Therefore, unoccupied stands will not necessarily indicate that habitat is not limiting or that these stands are not murrelet habitat (Ralph et al. 1995) 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. 2004). 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. (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. 1995). 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. 1995). 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 1997). 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 1997; 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. (Ralph et al. 1995) 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. 1995).

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. 2004)) 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. 2004), 24 mi in Desolation Sound, British Columbia, Canada (Hull et al. 2001), and 48 mi in southeast Alaska. In California, Hebert and Golightly (Hebert and Golightly 2003) 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 (Burger 2002). 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. 1995). 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. 2004).

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 (CI)) was in 2004 and the lowest total population estimate (17,400 +/- 4,600 birds at the 95 percent CI) 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 CI) (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. 2004), 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. 2004). Two other more complex, unpublished models (Akcakaya 1997 and Swartzman et al. 1997 in McShane et al. 2004) evaluate the effect of nest habitat loss on murrelets in Conservation Zone 4 (McShane et al. 2004). McShane et al. (McShane et al. 2004) 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. 2004). Table 2 lists rangewide murrelet demographic parameter values from four studies all using Leslie Matrix models.

Table 2 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 %

*in (USFWS 1997b)

Regardless of model preference, the overall results of modeling efforts are in agreement, indicating murrelet abundance is declining (McShane et al. 2004:6-27). 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. 2004) 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 1 under McShane et al. (McShane et al. 2004) 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. 2004), 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 (CIs 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 CIs 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. 2004).

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. 2004). 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 CIs) 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. (McShane et al. 2004) 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. (McShane et al. 2004) 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 3).

Table 3 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 3 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 3. 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 (Raphael et al. 2006). 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. (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. (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 4). 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. (Raphael et al. 2006) used the Biomapper Ecological Niche-Factor Analysis model developed by Hirzel et al. (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. (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. (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). 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 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. (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. (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. (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).

Raphael et al. (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.

<u>Conservation Zone 1</u>

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. 1995; USFWS 1997b; McShane et al. 2004). 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 (WDFW 2005). 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 2005). There is currently only one commercial herring fishery which operates primarily in south and central Puget Sound (WDFW 2005) 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, but these populations appear to have relatively high levels of abundance (WDFW 2005). 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 (Bargmann 1998). 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. 2004). 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 affect 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. 2004).

Since the murrelet was listed, the amount of oil tanker and shipping traffic has continued to increase (USFWS 1997b; Burger 2002). 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 2003b). 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. 2004). Fishing effort has also decreased since the 1980s because of lower catches, fewer fishing vessels, and greater restrictions (McShane et al. 2004), 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. 2004).

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. 2004). 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. 2004).

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 1997). 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 1997). 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 1981; 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 2005). 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 (Entranco and Hamer Environmental 2005). 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 1981). 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 (Ross et al. 2001) 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. 2004). 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. 2004). 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. 2004). Raphael et al. (Raphael et al. 2006) recently completed a change analysis for 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. (Healey et al. 2003). Raphael et al. (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. (Raphael et al. 2006) are dependant upon the habitat model used (Table 3) 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. 2004). 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 (Ralph et al. 1995; Nelson and Hamer 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 (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 Stellar'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 1997; 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. 2004). 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. 2004). For example, Nelson and Hamer (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. 2004). 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.

<u>Other Threats</u>

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. 2004).

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. 2004).

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. 2004). 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. 2004). 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. 2004). 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. 2004).

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. 2004). 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 (USFWS 2003a). 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. 2001), extremely small population sizes (Zones 5 and 6), and alarmingly low reproductive rates (Zone 6) (Peery et al. 2002). 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. 1995). 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 1995) (Mineral Tree Farm HCP); Plum Creek Timber Company (Plum Creek Timber Company, L.P. 1996; 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 (USFWS 2001; Tacoma Public Utilities 2001) (Green River HCP) and City of Seattle (USFWS 2000a; City of Seattle 2001) (Cedar River HCP), and the Washington Department of Natural Resources (WDNR 1997; USFWS 1997a). 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 (WFPB 2005), 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.

ENVIRONMENTAL BASELINE

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.

Puget Sound

The proposed action directly and indirectly affects a major portion of northern Puget Sound basin including Saratoga Passage and Skagit Bay. To adequately describe the current baseline, it is necessary to discuss the past and current conditions as well as the on-going activities on a Puget Sound basin-wide basis. The Puget Sound Action Team recently completed a comprehensive report of the conditions of Puget Sound referred to as the "2007 Puget Sound Update" (PSAT 2007). 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, and are being used to establish the environmental baseline for this consultation.

<u>Physical Environment and Habitat</u>

Puget Sound is a large inland fjord carved by glaciers, fed by over 10,000 rivers and streams that flow into Puget Sound from the encircling Cascade and Olympic mountain ranges. Puget Sound is deep, with 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 and contribute nearly 85 percent of the fresh water that enters Puget Sound. 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 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 included include:

- The Pacific Ocean off the west coast of the U.S. experienced two unusual conditions in 2005 - a winter-like colder state that persisted through mid-July, followed by ocean warming that resembled a large El Niño event. The biological impacts of these alternating atypical ocean conditions in 2005 were significant. Zooplankton stocks were reduced by one half, salmon returns weakened, and sea bird deaths were extraordinarily high among common murre, cormorant, and Cassins' auklet populations. Several subtropical species, such as albacore tuna (*Thunnus alalunga*) and Humboldt squid (*Dosidicus gigas*), became common in the offshore shelf waters.

- During the 20th century, the global average air temperature rose by approximately 1.1 degrees ºF (0.6 degrees °C). In Puget Sound, the average temperature doubled the global average, increasing by 2.3 degrees ºF (1.3 degrees ºC) during the same period.

- Average global sea surface temperature has increased by 1.7 degrees ºF (0.9 degrees ºC) since 1921.

- Hood Canal, Budd Inlet, Penn Cove, Saratoga Passage, and Possession Sound are locations of highest concern, based on Ecology's 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, 7 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. Comparing oxygen data from 1930 -1960s with data from 1990 - 2006, shows that in recent years, the area of low dissolved oxygen is getting larger and spreading northwards. Periods of hypoxia are persisting longer through the year.

- Approximately 82 percent of tidal wetlands in Puget Sound have been lost to development.

<u>Biological Resources</u>

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.

Significant changes in the biological communities of Puget Sound have occurred in the past 30 years, including declines in forage fish, salmonids, bottomfish, marine birds, and orcas (*Orcinus orca*). These changes have resulted in restricted and closed fisheries, petitions to list species under State programs and the Endangered Species Act (Act), and development of recovery and management plans for several species. Coordinated efforts by PSAMP and other monitoring and research programs have been 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.

Many 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.

A recent study (Brown and Gaydos 2007) identified 46 marine species of concern in the Puget Sound—3 invertebrates, 22 fishes, 1 reptile, 11 birds, and 9 mammals. In status reviews conducted for the 14 species listed as threatened or endangered by Washington State or the Federal government, contaminants, habitat loss, and over-harvest were the most frequent causes cited for species declines.

Key findings included:

- Nearly 60 percent of groundfish stocks in Puget Sound are in good condition. Those in decline include middle-trophic level predators such as rockfishes, spiny dogfish (*Squalus acanthias*), Pacific cod (*Gadus macrocephalus*), and Pacific hake (*Merluccius productus*).

- Spawning potential for copper (*Sebastes caurinus*) and quillback rockfish (*S. maliger*) 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 have increased.

- The total Pacific herring (*Clupea pallasi*) 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 since a high of 12,000 tons in 1976, a low of only 800 tons in 2000, followed by a gradual increase to 2,200 tons in 2006.

- 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.

- Surf scoters (*Melanitta perspicillata*), white-winged scoters (*M. fusca*), and black scoters (*M. perspicillata*) have collectively declined by approximately 57 percent between 1978 and 1999. This decline has continued from 1999 through 2005 in nearly all of the subregions of Puget Sound. The decrease in scoters represents the largest decline in biomass of marine birds over the last 25 years in Puget Sound.

- Loons and grebes that over-winter in Puget Sound have declined by nearly 75 percent over the past 10 years. It is unknown whether this reflects declines in the overall populations or whether birds are over-wintering outside of Puget Sound.

- Native eelgrass (*Zostera marina*) has declined in Hood Canal for four consecutive years since 2001. The San Juan Archipelago has experienced declines in eelgrass in small embayments. In eleven embayments approximately 83 acres of eelgrass were lost between 1995 and 2004.

- Sea lions have become more abundant in Washington waters. The California sea lion (*Zalophus californianus*) populations have increased by about 5 percent annually, with a current population of 4,000 - 5,000 animals. Steller sea lions (*Eumetopias jubatus*) are also increasing in population, by about 10 percent annually. Surveys conducted in 2005 of Steller sea lions during peak abundances in fall and winter recorded 1,000 - 1,500 sea lions along Washington's outer coast. This species also regularly inhabits North Puget Sound.

- Harbor seals (*Phoca vitulina*) have been steadily increasing in population since the early 1970s, with current populations consisting of 16,000 seals along the outer Washington Coast and 14,000 in the inland waters of Puget Sound.

- The pinto abalone (*Haliotis kamtschatkana*), 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.

- Restoration of the Olympia oyster (*Ostreola conchaphila*), a native shellfish species, has been successful in expanding the oyster's historic range in Puget Sound.

- Results from monitoring marine reserves in Puget Sound have shown that, within a decade, lingcod (*Ophiodon elongates*) have become abundant and, as top predators, 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 percentage of these were probably introduced via ship ballast.

<u>Toxic Contamination</u>

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 within the system, and the trapping of toxics means that biota are subject to increased exposure. 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 (*Oncorhynchus tshawytscha*) 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 Pacific herring, one of Puget Sound's keystone forage fish species. These fish live almost all of their lives in pelagic waters, so one might suspect they would be among the least contaminated of fish species. However, PSAMP scientists have shown high body burdens of PCBs in this species from the central and Southern basins of Puget Sound—comparable to herring from northern Europe's severely contaminated Baltic Sea.

The toxic contaminants that harm or threaten the health of the Puget Sound ecosystem 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 included:

- Approximately one 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 Chinook from Alaska, British Columbia, and Oregon.

- Flame retardants, or 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 in English sole (*Parophrys vetulus*) 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, polycyclic aromatic hydrocarbons (PAHs) 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 (*Cancer magister*), PAH exposure was six times higher in urban areas than in non-urban areas. In comparison to non-urban areas, English sole had three to four times the PAH exposure in 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 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 (*O. kitsutch*) returning to urban streams in the Puget Sound region between 2002 and 2005, suggesting that contaminants from stormwater are posing a threat to the spawning success of salmon in urban streams.

<u>Nutrients and Pathogens</u>

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. As a general rule, phosphorus tends to be the limiting nutrient in freshwater systems, and nitrogen tends to be the limiting nutrient in marine systems. This means that increased loadings of these nutrients can have significant effects on the character and condition of these respective systems.

Human activities have had a profound effect on the cycling of nutrients worldwide and nutrient pollution in the 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.

Monitoring of nutrients is critical for assessing and understanding both short- and long-term changes in water quality and their effects on the Puget Sound marine ecosystem. Increased nutrient loading can dramatically change the structure and function of freshwater and marine ecosystems by altering biogeochemical cycles and producing cascading effects throughout the ecosystem and food web, such as prolonged algae blooms, depressed oxygen levels, fish kills and losses of aquatic vegetation. Eutrophication, as these nutrient-driven changes are known, is one the most important challenges facing Puget Sound 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 onsite sewage systems and municipal sewage treatment plants, stormwater runoff, and boat waste. Pathogen pollution causes a range of environmental, human health, and economic impacts that include the contamination of shellfish beds, recreational waters and beaches, drinking water supplies, and other water-related resources.

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 better understand the nature and scope of the problems and to inform management plans and efforts to prevent and control the pollution sources.

Key findings included:

Fresh Water

- In Ecology's 2004 Water Quality Assessment, 58 freshwater sites were identified with dissolved oxygen problems in Puget Sound because of excessive nutrients (phosphorus and nitrogen) in the streams. Nutrients sources include drainage from agricultural, forestry, and residential activities and other sources.

- Twenty-five of 38 freshwater stations scored "Good" according to the total nitrogen Water Quality Index. Ten stations scored "Fair." Three stations (in Hood Canal and on the Deschutes River near Olympia) scored "Poor."

- In 2005, freshwater stations were nearly equally divided between "Good" and "Fair" for phosphorus and were stable in water years 2000 through 2005.

- The Water Quality Index for fecal coliform rated "Good" at 28 of 38 freshwater streams for fecal pollution. The remainders were "Fair". Fecal conditions appear to be stable since 2000.

Marine Waters

- Hood Canal, Budd Inlet, Penn Cove, Saratoga Passage, and Possession Sound are locations of highest concern, based on Ecology's index of water quality for Puget Sound.

- Stations in Hood Canal, Penn Cove, Possession Sound, and Saratoga Passage had very high sensitivity to eutrophication, suggesting 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.

- 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, over 12,500 acres of shellfish growing areas were upgraded and 5,000 acres were downgraded, for a net increase of 8,500 acres. As a result of Kitsap County's Pollution Identification and Correction Program, parts of four shellfish harvest areas have been cleaned up and reopened for harvest; Burley Lagoon, Cedar Cove (part of Port Gamble), Illahee State Park, and Dyes Inlet.

- 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 Sound beaches typically have the highest measured bacterial pollution, most notably in Dyes and Sinclair Inlets.

- 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 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 Bay, Holmes Harbor, and Penn Cove). Several shellfish species were affected. All four areas were closed to shellfish harvest.

Crescent Harbor Action Area

The Crescent Harbor action area is highly influenced by the Skagit River that enters Puget Sound at Skagit Bay. The Skagit River has created a delta and the shallow waters in and around Skagit Bay. Sediment type in the action area is mostly sand. Sand represents 61.4 to 65.5 percent of the sediment type in the intertidal area of Skagit Bay. Deeper areas have a mixture of mud and sand (Stout et al. 2001).

Waters within the action area become stratified during the summer, with surface waters ranging between 10 to 13 degrees ºC in the summer and 7 to 10 degrees ºC in the winter (Stout et al. 2001). Dissolved oxygen concentrations are highest in the surface waters (up to 15 mg/L) and lowest levels tend to be at the greatest depths during the fall (3.5 to 4.0 mg/L).

There are a variety of habitats found throughout the Crescent Harbor action area, including shallow subtidal bay with mud substrates; mud flats and open mixed-coarse beaches such as Oak Harbor; areas containing open rocky shores such as along the Polnell Point peninsula and Maylor Point; and areas in which riprap armoring or bulkheads along the NAS shoreline in Crescent and Oak Harbors. Extensive tidelands occur throughout much of the Crescent Harbor action area (e.g. Oak Harbor, Penn Cove, and parts of Crescent Harbor); however, tidelands in some areas have been modified by dredging, armoring, and the construction of piers, docks, and boat ramps.

Saltmarsh habitat is present in a number of locations within this action area, with the most extensive tracts located in Oak and Crescent Harbors. The marshes, intertidal shallows, and eelgrass beds provide important habitat for waterfowl, raptors, migratory birds, and a variety of marine invertebrates and fishes, including salmonid species. Some areas provide important spawning habitat for forage fish species such as Pacific herring, Pacific sand lance, and surf smelt. In general, habitat quality is good in much of the Crescent Harbor action area, although natural habitats have been modified in others (e.g. NAS shoreline within Oak and Crescent Harbors), rendering these areas less suitable for juvenile salmonids.

Most of the action area is surrounded by rural areas with low, human population densities. Agriculture is the predominant land use surround the action area. The NAS Whidbey Island comprises the entire shoreline of Crescent Harbor itself. NAS Whidbey Island has approximately 10.1 miles of shoreline. Parts of the shoreline have been modified with seawalls, rock and concrete-rubble riprap, and bulkheads. High bank bluffs provide natural habitat and sediment to Crescent Harbor beaches.

The Navy keeps non-military boats from entering the general area when a training event is occurring. Otherwise, the training area is open to the public. Private and commercial boat traffic activity is common in Crescent Harbor with vessels transiting the area to and from several directions.

Military EOD diving operations are the primary diving activity that takes place in Crescent Harbor. EOD conducts diving operations for a number of purposes, including proficiency training with the diving systems, location of underwater objects, maintaining personnel qualifications, and practicing emergency procedures, in addition to the underwater detonation activities.

Status of the Species in the Action Area

Bull Trout

The action area is within the Coastal-Puget Sound Interim Recovery Unit (IRU). Bull trout from three core areas in watersheds that drain into marine waters near the action area are most likely to utilize the action area. Core areas represent the closest approximation of a biologically functioning unit for bull trout (FWS 2004). 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 the IRU. Bull trout from the following core areas are expected to be present in the action area: Lower Skagit, Stillaguamish, and the Snohomish/Skykomish Rivers. Unique to the Coastal-Puget Sound 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.

Anadromous juvenile, subadult, and adult bull trout utilize marine waters of the action area for foraging, migration, and overwintering. 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. *in litt.* 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. 2007; U.S. Geologic Survey, *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 two recent acoustic telemetry projects, the greatest bull trout densities were at depths greater than 2.0 to 2.5 meters, up to depths as great as 25 m. (Goetz et al. 2004; U.S. Geologic Survey *in litt.* 2008). 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 ~10m to >3 km within 100-400m of the shoreline (U.S. Geologic Survey, *in litt.* 2008). Aquatic vegetation and substrate common to bull trout marine habitat include eelgrass, green algae, sand, mud, and mixed fine substrates. Forage fish (Surf smelt, Pacific herring and Pacific sand lance) occurrence is also correlated with these habitat features. Bull trout prey on surf smelt, Pacific herring, Pacific sand lance, and other small schooling fish (Kraemer 1994).

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 in the action area simultaneously (Brenkman et al. 2007; Brenkman and Corbett 2005; Goetz et al. 2004; Goetz et al. 2007; Goetz et al. *in litt.* 2007). It is expected that bull trout from the Stillaguamish, Snohomish/Skykomish, and Lower Skagit Rivers are likely to be present in the action area. Therefore, 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.

Lower Skagit Core Area

The Lower Skagit core area comprises the Skagit basin downstream of Seattle City Light's Diablo Dam, including the mainstem Skagit River and the Cascade, Sauk, Suiattle, White Chuck, and Baker River including the lake systems (Baker Lake and Lake Shannon) upstream of upper and lower Baker Dams.

Bull trout, which occur throughout the Lower Skagit core area, include fluvial, adfluvial, resident, and anadromous life history forms. Resident life history forms, found in several locations in the core area, often occur with migratory life history forms. Adfluvial bull trout occur in Baker, Shannon, and Gorge Lakes. Fluvial bull trout forage and overwinter in the larger pools of the upper portion of the mainstem Skagit River and, to a lesser degree, in the Sauk River (WDFW et al. 1997; Kraemer 2003).

Many bull trout extensively use the lower estuary and nearshore marine areas for extended rearing and subadult and adult foraging. Key spawning and early rearing habitat, found in the upper portion of much of the basin, is generally on federally protected lands, including North Cascades National Park, North Cascades Recreation Area, Glacier Peak Wilderness, and Henry M. Jackson Wilderness Area.

The status of the bull trout core area population is based on four key elements necessary for long-term viability: 1) number and distribution of local populations, 2) adult abundance, 3) productivity, and 4) connectivity (USFWS 2004).

Number and Distribution of Local Populations

Nineteen local populations were identified in the draft recovery plan (USFWS 2004): 1) Bacon Creek, 2) Baker Lake, 3) Buck Creek, 4) Cascade River, 5) Downey Creek, 6) Forks of Sauk River, 7) Goodell Creek, 8) Illabot Creek, 9) Lime Creek, 10) Lower White Chuck River, 11) Milk Creek, 12) Newhalem Creek, 13) South Fork Cascade River, 14) Straight Creek, 15) Sulphur Creek, 16) Tenas Creek, 17) Upper South Fork Sauk River, 18) Upper Suiattle River, and 19) Upper White Chuck River. Although initially identified as potential local populations in the draft recovery plan (USFWS 2004), Stetattle Creek and Sulphur Creek (Lake Shannon), each now meets the definition of local population based on subsequent observations of juvenile bull trout and prespawn migratory adult bull trout (Jim Shannon, *in litt*., 2004; R2 Resource Consultants and Puget Sound Energy 2005). With 21 local populations, the bull trout in the Lower Skagit core area is at diminished risk of extirpation and adverse effects from random naturally- occurring events (see "Life History").

Adult Abundance

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). Consequently, the bull trout population in this core area is not considered at risk from genetic drift.

The majority of local populations in the core area include 100 adults or more; therefore, they are at a diminished risk of extirpation. However, some local populations probably have fewer than 100 adults and may be at risk from inbreeding depression. There is some risk of extirpation of the following local populations due to their lower numbers of adults; however, other factors, such as stable or increasing population trends may reduce this risk. Fewer than 100 migratory adults and a limited number of resident fish use the Forks of the Sauk River; however, the migratory component appears abundant and is increasing (Kraemer 2003). Fewer than 100 adults probably occur in Tenas Creek, but this local population is presumed to be increasing. The Straight Creek local population includes fewer than 100 migratory adults and an unknown number of resident fish (Kraemer 2001), but the migratory component appears stable. The Lime Creek local population probably has fewer than 100 migratory adults, but resident and migratory components are considered abundant. The South Fork Cascade River local population probably has fewer than 100 migratory adults(Kraemer 2001); however, resident and migratory components are considered stable. Based on recent observations, the Sulphur Creek local population in the Lake Shannon system also has fewer than 100 adults(R2 Resource Consultants and Puget Sound Energy 2006). Prior to 2004, Goodell Creek supported more than 100 adult spawners. In October 2003, a large landslide in Goodell Creek blocked access to the majority of spawning habitat for migratory bull trout in the Goodell Creek local population. Adult counts of migratory bull trout in 2004 and 2005 have been fewer than 100 individuals (Downen 2006) in this local population. In the Baker Lake local population, annual peak counts of 85 adults have been recorded between 2001 and 2005 (R2 Resource Consultants and Puget Sound Energy 2006). Since the most upstream accessible habitat was not surveyed in these efforts, and bull trout typically spawn as far upstream as they can within a stream system, this would suggest that on average there may be at least 100 adults in this local population. Total adult abundances in Newhalem and Stettatle Creek local populations are unknown.

Productivity

Long-term redd counts in the index areas of the Lower Skagit core area generally indicate stable to increasing population trends(USFWS 2004). Therefore, this core area is not considered at risk of extirpation at this time. Recent declines in redd counts may indicate a potential change to this long-term trend (Downen 2006). Redd counts conducted by WDFW between 2002 and 2005 show a significant downward trend in Bacon, Goodell, and Illabot Creeks, and the Sauk River. However, Downey Creek had a significant increase in the reported redd counts between these years. The reason for these changes is unknown.

Connectivity

The presence of migratory bull trout in most of the local populations indicates the bull trout in the Lower Skagit core area has a diminished risk of extirpation from habitat isolation and fragmentation. However, the lack of connectivity of the Baker Lake and Sulphur Creek local populations in the Baker River system and Stetattle Creek local population in the Gorge Lake system with other local populations in the core area is a concern with respect to long-term persistence, life history expression, and refounding. In addition, there is currently only partial connectivity within the Baker Lake system, with no upstream passage for adults within Lake Shannon at upper Baker Dam.

Changes in Environmental Conditions and Population Status

Since the bull trout listing, Federal actions occurring in the Lower Skagit core area have caused harm to, or harassment of, bull trout. These actions include statewide Federal restoration programs that include riparian restoration, replacement of fish passage barriers, and fish habitat improvement projects; federally funded transportation projects involving repair and protection of roads and bridges; and section 10(a)(1)(B) permits for Habitat Conservation Plans addressing forest management practices. Capture and handling, and indirect mortality, during implementation of section 6 and section 10(a)(1)(A) permits have negatively directly affected bull trout in the Lower Skagit core area.

The number of non-Federal actions occurring in the Lower Skagit core area since the bull trout listing is unknown. Activities conducted on a regular basis, such as emergency flood control, development, and infrastructure maintenance, affect riparian and instream habitat and probably have negatively affected bull trout and parts of their forage base.

<u>Threats</u>

Threats to bull trout in the Lower Skagit core area include:

- Gorge and Baker Dams restrict connectivity of the Stetattle Creek, Baker Lake, and Sulphur Creek (Lake Shannon) local populations with the majority of other local populations in the core area due to impaired fish passage.

- Operations of the Lower Baker Dam occasionally have significantly affected water quantity in the lower Baker and Skagit Rivers.

- Agricultural practices, residential development, and the transportation network, with related stream channel and bank modifications, have caused the loss and degradation of foraging, migration, and overwintering habitats in mainstem reaches of the major forks and in a number of the tributaries.

- Estuarine nearshore foraging habitats have been, and continue to be, negatively affected by agricultural practices and development activities.

Stillaguamish Core Area

The Stillaguamish core area comprises the Stillaguamish River basin, including the North Fork and South Fork Stillaguamish Rivers and their tributaries. Major tributaries to the North Fork Stillaguamish River include the Boulder River and Deer, Little Deer, and Higgins Creeks. Canyon Creek, the only major tributary to the South Fork Stillaguamish River, has minor tributaries including Millardy, Deer, Coal, Palmer, Perry, and Beaver Creeks.

Bull trout occur throughout the Stillaguamish River basin and, in the Stillaguamish core area, primarily include anadromous and fluvial life-history forms (USFWS 2004). There are no known populations in the North Fork Stillaguamish River above the barrier to migration at river mile 37.5 (Kraemer 1999). No resident populations have been found above any of the natural migratory barriers on Deer or Higgins Creeks. No exclusively resident populations have been identified in this core area, but the South Fork Stillaguamish River population has a strong resident component coexisting with migratory forms.

The South Fork Stillaguamish River upstream of Granite Falls has supported anadromous bull trout since the construction of a fishway in the 1950s. Previously the falls were impassable to anadromous fish. Anecdotal information from fish surveys in the 1920s and 1930s, however, suggest that native char likely were present above Granite Falls prior to construction of the fishway (WDFW 1998).

Spawning habitat is generally limited in the Stillaguamish core area, and apparently, only the upper reaches provide adequate spawning conditions. Bull trout spawn in the upper reaches of the accessible portions of the upper North Fork Stillaguamish River and its tributaries, including Deer and Higgins Creeks. There have been no extensive juvenile sampling or evaluation of spawning success in the North Fork Stillaguamish River. Bull trout in the Upper Deer Creek local population spawn in Higgins Creek, and spawning also may occur in upper Little Deer Creek. Bull trout spawn in the Boulder River below the impassible falls at river mile 3. Although unconfirmed, spawning and rearing probably occur in the Squire Creek system, which is similar in size to Boulder River and also influenced by snowmelt. Boulder River may be identified as an additional local population when more distribution information is available.

Spawning areas in the South Fork Stillaguamish River and its tributaries include Canyon Creek and upper South Fork Stillaguamish. Bull trout are known to spawn and rear in Palmer, Perry, and Buck Creeks and the upper South Fork mainstem above Palmer Creek. Recent spawning surveys identified a major spawning area above the Palmer Creek confluence. Between 50 and 100 bull trout spawn in this reach. Electrofishing surveys also documented high densities of juveniles (Downen 2003). Spawning and early rearing habitat in the South Fork Stillaguamish River is considered to be in fair condition. Although bull trout spawn in the upper South Fork Stillaguamish River and other tributaries, available habitat is partially limited by gradient and competition with coho salmon. Upstream movement of bull trout from the lower river depends on proper functioning of the fish ladder at Granite Falls. Migratory and resident fish coexist on the spawning grounds.

Bull trout in the Canyon Creek local population use the upper South Fork Stillaguamish River for spawning and rearing. Although there have been isolated and incidental observations of spawning by migratory-size bull trout, electrofishing surveys have been unable to locate any juvenile or resident bull trout from this population. Despite repeated survey efforts, very few bull trout have been located in this population because of the difficulty in locating individuals.

The status of the bull trout core area population is based on four key elements necessary for long-term viability: 1) number and distribution of local populations, 2) adult abundance, 3) productivity, and 4) connectivity (USFWS 2004).

Number and Distribution of Local Populations

Four local populations have been identified in the Stillaguamish core area: 1) Upper Deer Creek, 2) North Fork Stillaguamish River, 3) South Fork Stillaguamish, and 4) Canyon Creek. The scarcity and spatial isolation of available spawning habitat limits the number of local populations in the Stillaguamish core area. With only four local populations, bull trout in this core area are considered to be at increased risk of extirpation and adverse effects from random naturally occurring events.

Adult Abundance

The bull trout population in the Stillaguamish River basin is estimated at fewer than 1,000 adults. In the North Fork Stillaguamish River, as many as 100 adult bull trout have been observed holding near the mouth of the Boulder River. Surveys documented nearly 300 adult char between river miles 21 and 25 during fall 2001; fewer than 100 adults were counted in the remaining sample years between 1996 and 2003 (Pess 2003). Other limited snorkel surveys had similar results (Mark R. Downen, pers. comm. 2003). These staging adult bull trout are assumed to spawn somewhere in the North Fork Stillaguamish River. Adult abundance in the Upper Deer Creek and Canyon Creek local populations is considered low. The Boulder River population probably has fewer than 100 adults. Approximately 50 to 100 adults are present in the South Fork Stillaguamish River, based on conservative estimates from spawning and electrofishing surveys (Downen 2003). Although accurate counts are unavailable, current estimates of adult abundance suggest that Upper Deer Creek and Canyon Creek local populations have fewer than 100 adults and are considered at risk of inbreeding depression.

Connectivity

Primary foraging, migration, and overwintering areas in the Stillaguamish River basin include the mainstems of the North Fork and South Fork Stillaguamish Rivers and the Stillaguamish River to the estuary. Foraging sub-adults and adults may be found in nearly all reaches of the basin below migratory barriers to the basin. Rearing individuals may use nearly all accessible reaches in higher elevation and coldwater portions of the basin. Anadromous forms in the Stillaguamish core area are presumed to use nearshore marine areas in Skagit Bay, Port Susan, and Possession Sound, but may also use areas even farther from their natal basin.

All native char habitat within the Stillaguamish River Basin generally has good connectivity. However, because the local populations are somewhat isolated from one another, maintaining connectivity among them will be critical to support life-history diversity, refounding, and genetic exchange.

Changes in Environmental Conditions and Population Status

Since the bull trout listing, Federal actions occurring in the Stillaguamish core area have caused harm to or harassment of bull trout. These actions include statewide Federal restoration programs that include riparian restoration, restoration of fish passage at barriers, and habitat-improvement projects. In addition, federally funded transportation projects involving repair and protection of roads and bridges have been completed. Finally, section 10(a)(1)(B) permits have been issued for Habitat Conservation Plans that address bull trout in this core area.

The number of non-Federal actions occurring in the Stillaguamish core area since the bull trout listing is unknown. However, activities conducted on a regular basis, such as emergency flood control, development, and infrastructure maintenance, affect riparian and instream habitat and probably negatively affect bull trout.

Threats

Threats to bull trout in the Stillaguamish core area include:

- Channel widening and a significant reduction in primary pool abundance have seriously degraded habitat conditions in the North Fork and lower South Fork Stillaguamish Rivers.

- Spawning habitats in Deer and Canyon Creeks have been extremely degraded.

- Past logging and logging-related activities, such as roads, have degraded habitat in the Stillaguamish River basin. The loss of riparian cover, slope failures, stream sedimentation, increased stream temperatures, flooding, and loss of large woody debris have adversely affected bull trout in Deer Creek and in the South Fork Stillaguamish River (WDFW 1997; USFWS 2004). Deer and Higgins Creeks currently violate State water-quality standards for temperature.

- Agricultural and residential development have contributed to poor water quality in the lower Stillaguamish River basin. Excessive siltation caused by mud and clay slides on the North Fork Stillaguamish River near Hazel, Washington, and on the South Fork above Robe, contribute to poor water quality (Williams et al. 1975).

- Other limiting factors in the North Fork Stillaguamish River include loss of deep holding pools for adults and low summer flows (USFWS 2004).

- Low flows and high temperatures during the summer affect holding habitat for anadromous migrants in the mainstem Stillaguamish River, especially in the lower river sloughs that have slow-moving water without significant riparian cover (WDFW 1997).

Snohomish-Skykomish Core Area

The Snohomish-Skykomish core area comprises the Snohomish, Skykomish, and Snoqualmie Rivers and their tributaries. Bull trout occur throughout the Snohomish River system downstream of barriers to anadromous fish. Bull trout are not known to occur upstream of Snoqualmie Falls, upstream of Spada Lake on the Sultan River, in the upper forks of the Tolt River, above Deer Falls on the North Fork Skykomish River, or above Alpine Falls on the Tye River.

Fluvial, resident, and anadromous life history forms of bull trout occur in the Snohomish River/Skykomish core area. A large portion of the migratory segment of this population is anadromous. There are no lake systems within the basin that support an adfluvial population. However, anadromous and fluvial forms occasionally forage in a number of lowland lakes connected to the mainstem rivers.

The mainstems of the Snohomish, Skykomish, North Skykomish, and South Fork Skykomish Rivers provide important foraging, migrating, and overwintering habitat for subadult and adult bull trout. The amount of key spawning and early rearing habitat is more limited, in comparison with many other core areas, because of the topography of the basin. Rearing bull trout occur throughout most of the accessible reaches of the basin and extensively use the lower estuary, nearshore marine areas, and Puget Sound for extended rearing.

The status of the bull trout core area population is based on four key elements necessary for long-term viability: 1) number and distribution of local populations, 2) adult abundance, 3) productivity, and 4) connectivity (USFWS 2004).

Number and Distribution of Local Populations

Four local populations have been identified: (1) North Fork Skykomish River (including Goblin and West Cady Creeks), (2) Troublesome Creek (resident form only), (3) Salmon Creek, and (4) South Fork Skykomish River. With only four local populations, bull trout in this core area are considered at increased risk of extirpation and adverse effects from random naturally occurring events (see "Life History").

Adult Abundance

The Snohomish-Skykomish core area probably supports between 500 and 1,000 adults. However, this core area remains at risk of genetic drift. Most of the spawners in the core area occur in the North Fork Skykomish local population. Redd counts within the North Fork Skykomish local population peaked at over 530 in 2002 (USFWS 2004), but have recently declined to just over 240 in 2005 and 2006 (WDFW 2007). This is one of two local populations in the core area (the other is South Fork Skykomish River) that support more than 100 adults, which minimizes the deleterious effects of inbreeding. The Troublesome Creek population is mainly a resident population with few migratory fish. Although adult abundance is unknown in this local population, it is probably stable due to intact habitat conditions. The Salmon Creek local population likely has fewer than 100 adults. Although spawning and early rearing habitat in the Salmon Creek area is in good to excellent condition, this local population is at risk of inbreeding depression because of the low number of adults. Monitoring of the South Fork Skykomish local population indicates increasing numbers of adult migrants. This local population recently exceeded 100 adults and is not considered at risk of inbreeding depression (C. Jackson, Washington Department of Fish and Wildlife, pers. comm. 2004). Fishing is allowed in this system.

Productivity

Long-term redd counts for the North Fork Skykomish local population indicate increasing population trends. Productivity of the Troublesome Creek and Salmon Creek local populations is unknown but presumed stable, as the available spawning and early rearing habitats are considered to be in good to excellent condition. In the South Fork Skykomish local population, new spawning and rearing areas are being colonized, resulting in increasing numbers of spawners. Sampling of the North Fork and South Fork Skykomish local population areas indicates the overall productivity of bull trout in the Snohomish-Skykomish core area is increasing.

Connectivity

Migratory bull trout occur in three of the four local populations in the Snohomish-Skykomish core area (North Fork Skykomish, Salmon Creek, and South Fork Skykomish). The lack of connectivity with the Troublesome Creek local population is a natural condition. The connectivity between the other three local populations diminishes the risk of extirpation of the bull trout in the core area from habitat isolation and fragmentation.

Changes in Environmental Conditions and Population Status

Since the bull trout listing, Federal actions occurring in the Snohomish-Skykomish core area have caused harm to, or harassment of, bull trout. These actions include statewide Federal restoration programs that include riparian restoration, replacement of fish passage barriers, and fish habitat improvement projects; federally funded transportation projects involving repair and protection of roads and bridges; and section 10(a)(1)(B) permits for Habitat Conservation Plans addressing forest management practices. Capture and handling during implementation of section 6 and section 10(a)(1)(A) permits have directly affected bull trout in the Snohomish-Skykomish core area.

The number of non-Federal actions occurring in the Snohomish-Skykomish core area since the bull trout listing is unknown. However, activities conducted on a regular basis, such as emergency flood control, development, and infrastructure maintenance, affect riparian and instream habitat and probably negatively affect bull trout.

Threats

Threats to bull trout in the Snohomish-Skykomish core area include:

- Past timber harvest and harvest-related activities, such as roads, have degraded habitat conditions in the upper watershed.

- Agricultural and livestock practices, including blocking fish passage, altering stream morphology, and degrading water quality in the lower watershed (FMO habitat), have significantly affected the floodplain and bull trout habitat.

- Illegal harvest or incidental hooking mortality may occur at several campgrounds where recreational fishing is allowed by the Washington Department of Fish and Wildlife.

- Water quality has been degraded by municipal and industrial effluent discharges and development.

- Nearshore foraging habitat has been, and continues to be, affected by development activities.

Use of the Action Area

Within the Crescent Harbor action area, twenty bull trout were caught using beach seines in Penn Cove and Utsalady Bay from June 1974 to July 1975 (Goetz et al. 2004). Only three were measured; lengths were 457 mm (18 in.), 483 mm (19 in.), and 508 mm (20 in.). Seining was conducted on 16 different dates, and bull trout were caught on 9 of these days. Maximum number of bull trout caught in one day was three.

Two bull trout were captured during intertidal beach seining activities at the outlet of the tidegate located in Crescent Harbor (Beamer, *in litt*. 2003). These bull trout were 505 mm (19.8 in) and 610 mm (24.0 in.) in length, caught on May 10, 2002. In a similar study at the same location, two bull trout were caught during beach seining around the same time. One bull trout was sampled on April 2, 2002, but no length measurement was taken, and a second bull trout measuring 450 mm (17.7 in) was caught on April 29, 2002 (Heatwole, *in litt*. 2003). These samples confirm that bull trout are utilizing the habitats available in the Crescent Harbor action area.
Given the proximity of the mouth of the Skagit River and the size of the bull trout population in the Lower Skagit Core area, we expect that the majority of bull trout in the action area would be from the Lower Skagit Core area. Although the marine waters adjacent to the mouths of the Stillaguamish and the Snohomish Rivers are farther from the action area and the bull trout populations are smaller, because of their migratory behavior, bull trout from these rivers may use the Crescent Harbor action area.

Murrelet

Conservation Needs of the Murrelet in the Action Area

The Murrelet Recovery Plan (USDI 1997) outlines the conservation strategy for the murrelet. Of the primary recovery plan recommendations, the following are most pertinent to the needs of murrelets within the action area: (1) protect the quality of the marine environment and (2) reduce adult and juvenile mortality in the marine environment.

The proposed action is located within Conservation Zone 1 (Puget Sound) and includes marine habitat. The recovery plan has identified all water of Puget Sound as essential for murrelet foraging and loafing.

Nesting Habitat

Most of the activities associated with this project will occur in the marine environment, except for the on-shore transfer sites and the helicopter departure point and flight path. Suitable nesting habitat does not occur in the action area.

Marine Habitat

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

Likelihood of Murrelet Presence in the Action Area

Murrelets are found most commonly in the nearshore waters of the San Juan Islands, Rosario Strait, the Strait of Juan de Fuca, Admiralty Inlet, and Hood Canal. They are more sparsely distributed elsewhere in Conservation Zone 1, with smaller numbers observed at various seasons as far south as the Nisqually Reach and Budd Inlet, as well as in Possession Sound, Skagit Bay, Bellingham Bay, and along the eastern shores of Georgia Strait.

During the breeding season, murrelets tend to forage in well-defined areas along the coast in relatively shallow marine waters (Strachan et al. 1995). Murrelets forage at all times of the day and in some cases at night (Strachan et al. 1995).

During the pre-basic molt flightless murrelets must select foraging sites that provide adequate prey resources within swimming distance (Carter and Stein 1995). During the non-breeding season, murrelets typically disperse and are found farther from shore (Strachan et al. 1995).

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 (Strait) 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, although numbers declined in the western portion of the Strait (USDI 2001). Surveys in the near shore waters of the San Juan Islands conducted by the Forest Service and collaborators (Ralph et al. 1995, Evans 1999) 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 recovered near Orcas Island in September, and then recovered in Desolation Sound the following year (Beauchamp et al. 1999).

Murrelet presence in the action area is documented by several sources. The most accurate information comes from the consistent sampling method used to estimate population size and trends under the Northwest Forest Plan Murrelet Effectiveness Monitoring Plan (NWFPEM) (Raphael et al. 2007). For the purposes of the NWFPEM, Conservation Zone 1 is subdivided into three strata and each stratum is divided into “Primary Sampling Units” (PSUs). Each PSU 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.

The Crescent Harbor action area occurs within strata 2 and 3 in Conservation Zone 1. The density estimate for stratum 3 varied from 0.29 to 2.07 murrelets per km^2 between 2000 and 2007 (Table 5).

Table 5 Murrelet population estimates and densities in Conservation Zone 1, based on NWFPEM (summer at-sea boat surveys)

Year	Stratum	Density (birds/km^2)	Source
2000	1	3.36	Huff et al. 2006
	2	1.11	
	3	1.00	
2001	1	4.51	
	2	1.76	
	3	2.07	
2002	1	7.19	
	2	1.86	
	3	0.97	
2003	1	6.64	Lance 2004
	2	1.44	
	3	0.79	
2004	1	3.83	Falxa et al. 2008
	2	1.52	
	3	0.29	
2005	1	2.50	
	2	2.43	
	3	2.02	
2006	1	2.76	
	2	1.42	
	3	1.28	
2007	1	3.45	
	2	1.22	
	3	1.8	

Additional data on murrelet abundance and distribution come from multiple sources that employ a variety of survey methods to answer various research questions. A comprehensive August survey of the inland waters of Washington estimated post-fledging juvenile:adult ratios (Stein and Nysewander 1999). Merizon et al. (1997) focused on murrelet numbers and distributions in areas where fall tribal fisheries take place. The Puget Sound Ambient Monitoring Program (PSAMP) undertaken by the Washington Department of Fish and Wildlife estimated murrelet densities as a by-product of their summer boat (1992-1999) and winter aerial (1993-2005) sampling of seabird populations.

Observations by Stein and Nysewander (1999) indicate a murrelet density of 0.5 murrelets per square-kilometer (km^2) between Forbes Point and Polnell Point. Merizon et al. (1997) found the east shore of Whidbey Island, from Polnell Point through Oak Harbor and Penn Cove, and south to Holmes Harbor was utilized by few murrelets in the late summer/early fall. However, on the last survey in mid-November 1996, 23 murrelets were observed, primarily in Holmes Harbor. Similar results were seen in surveys conducted in 1995 (Merizon et al. 1997).

Along the eastern side of Saratoga Passage, Stein and Nysewander (1999) observed murrelet densities between 0.0 and 10.8 murrelets per km^2, with the highest densities between Onamac Point and Elger Bay. Observations by Merizon et al. (1997) found similar results, with murrelets concentrated between Utsalady Point to Lowell. Merizon et al. (1997) found that over 80 percent of the murrelets in this area were within 500 m of shore.

PSAMP winter aerial surveys between 1993 and 2005 estimated densities of 0 to 5.5 murrelets per km^2, with the highest densities in Penn Cove (WDFW 2005 - PSAMP maps). PSAMP summer aerial surveys between 1992 and 1999 estimated densities between 0 - 5 murrelets per km^2 in Crescent Harbor (WDFW 1992-1999 data).

The total number of murrelets counted in Penn Cove, mid and southern Saratoga Passage, and Holmes Harbor under the NWFPEM ranged from 0 to 24 and the highest numbers were counted between 100 and 500 meters from shore (Raphael and Bloxton, unpub. data 2004). Raphael and Bloxton's surveys detected 0 - 1.22 murrelets per km.

Conservation Zone 1 stratum 2 PSU 25 (NWFPEM) occurs within the action area. Within this PSU, density estimates ranged from 0.0 to 0.35 murrelets per km^2 between 2000 and 2007, with an average of 0.17 murrelets per km^2 (Falxa unpub. data 2008). There are no stratum 3 PSUs in the action area.

Overall, it appears that murrelets likely occur year-round in the Crescent Harbor action area and the number of murrelets likely increases in late fall/early winter and begins to decline in late winter/early spring.

<u>Estimation of murrelet density within the action area</u>

As noted above, a variety of sources provide murrelet density estimates for the action area. However, none of the surveys were conducted with equivalent protocols or with the same rigor. Neither do most of the surveys provide density information for spring or fall time-frames.

The NWFPEM surveys provide recent and consistent murrelet density estimates that are applicable for the months of May through July. These density estimates have been extended to April and August because these months are also part of the breeding season and the murrelet densities should not vary greatly from the estimates derived during the middle of the breeding season. Density estimates calculated for a larger area (e.g. a stratum or Conservation Zone) are more accurate and less variable than a density derived at a smaller scale. However, the estimated densities in the PSU differ greatly from a density estimated for the stratum. In the case of the Crescent Harbor action area, the highest density estimates between 2000 and 2007 for strata 2 and 3 were 2.43 and 2.07 murrelets per km^2, respectively. In contrast, during the same time frame the highest density estimated for the PSU within the action area was 0.35 murrelets per km^2. Therefore, in order to use the estimate that best represents the summertime murrelet density in the action area, we used the PSU density data.

The PSAMP aerial seabird survey data are the only consistent source for winter density information. While these surveys are not specific to murrelets and likely underestimate murrelet presence because they were designed to detect larger seabirds that occur in large flocks, they represent the best data available. Therefore, the December and January density estimates in the action area are derived from the PSAMP data. These density estimates were used for November and February as well, because we do not expect murrelets to be making significant location changes between November and February.

Because density estimates were not available for all months of the year, an "equal density change between study estimates" was used to interpolate density estimates for March, September, and October. This interpolation reflects the at-sea survey data, which indicates there is immigration into Puget Sound during the fall and emigration out in the spring by birds from the outer Washington coast (Conservation Zone 2) and from Canada. See Appendix C for specific density estimates used in our analysis.

Forage Fish

The status of forage fish is described here because of their importance to bull trout and murrelet. 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 (PSATeam 2007, Penttila 2007). They feed mainly on zooplankton and phytoplankton and reside in the upper levels of the water column and nearshore areas (PSATeam 2007). The three most common forage fish species are Pacific herring, surf smelt, and sand lance. These three fish and their critical spawning habitats, 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 spawning habitat during the year. Some species tend to use the same beaches annually. All three species use the adjacent nearshore habitats as nursery grounds (Penttila 2007). Three other, less important, species: northern anchovy (*Engraulis mordax*), 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).

Pacific Herring

WDFW recognizes 19 different stocks of Pacific herring in Puget Sound, based on the timing and location of spawning activity (PSAT 2007, Stick 2005). 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 Pacific 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 the continental shelf off the mouth of the Strait of Juan de Fuca in the summer months (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 non-spawning times of year (Penttila 2007).

For period of 2003-04 only 50 percent of all Puget Sound herring stocks are 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; whereas north Puget Sound's combined stocks have declined from healthy in 1994 to depressed since 1998 and the Strait of Juan de Fuca's status has been consistently classified as critical since 1994. The spawning biomass for all Puget Sound stocks combined, in general, can be considered healthy.

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 eel grass, algae, hard substrates, and occasionally polychaete tube mates. 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) (Pentilla 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 (2-4 years), herring migrate back to the spawning grounds. Most spawning occurs between mid-January and March.

Pacific herring are visual sight feeders that feed on plankton macro-zooplankton, primarily arthropods that may be found anywhere from "bank to bank" across the width of Puget Sound. Pacific herring can generally be found in a scattering layer mixed with their prey and predators at 30-40 fathoms depth (180-240 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 Pacific herring, most commonly juveniles, may occur in midwater or surface water depths. Juvenile herring rearing along shoreline may occur in quite shallow depths (a few feet), even in the daytime.

<u>Surf smelt</u>

Surf smelt are common, year-round residents in the nearshore areas of Puget Sound. They appear to be relatively short-lived fish with most spawning populations comprised of one- and two-year old fish. Spawning occurs at high tides on mixed-sand and gravel substrates in the upper tidal zone generally higher than plus seven feet in tidal elevation. Smelt eggs incubate for two to six weeks (WDFW 2000). They are a visual sight feeder feeding on plankton macro-zooplankton, primarily arthropods and are closely associated with 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, like there is for Pacific herring. Their home ranges are unknown and there has been no assessment of stock status.

Surf smelt spawn year-round in a number of areas 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).

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-February spawning season. Pacific sand lance use the same stretches of beach as surf smelt, at same time of year (Bargmann 1998). Sand lance spawning is confined to the upper tidal zone, generally higher than plus five feet in tidal elevation. The incubation period for sand lance eggs is about 30 days (WDFW 2000). Pacific sand lance are visual sight feeders on plankton macro-zooplankton, primarily arthropods. During spring and summer months, these fish are considered epibenthic, schooling pelagically during the day in order 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 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, like there is for Pacific herring. Their home ranges are unknown and there has been no assessment of stock status.

Forage Fish in Crescent Harbor Action Area

A variety of habitats are found throughout the Crescent Harbor action area. These include shallow subtidal muddy bay habitat; mud flats and open mixed-coarse beaches such as Oak Harbor; open rocky shores along the Polnell Point peninsula and Maylor Point; and areas in which riprap armoring or bulkheads have been placed such as along the NAS shoreline in Crescent and Oak Harbors. Extensive tidelands occur throughout much of the Crescent Harbor action area (e.g. Oak Harbor, Penn Cove, and parts of Crescent Harbor); however, tidelands in some areas have been modified by dredging, armoring, and the construction of piers, docks, and boat ramps.

Saltmarsh habitat is present in a number of locations within this action area; the most extensive area is located in Oak and Crescent Harbors. Some areas provide important spawning habitat for forage fish species such as Pacific herring, Pacific sand lance, and surf smelt. In general, habitat quality is good in much of the Crescent Harbor Action Area, although natural habitats have been modified in others (e.g. NAS shoreline within Oak and Crescent Harbors), rendering these areas less suitable for juvenile salmonids.

Forage fish that occur within this action area include surf smelt, Pacific herring, Pacific sand lance, surf smelt, and anchovy. Surf smelt, Pacific herring, and sand lance spawn in various locations within this action area. It is unknown whether anchovy spawn within the area.

- *Pacific herring*: nearest stocks are Skagit Bay and Holmes Harbor herring stocks.
  - Skagit Bay – Documented spawning is outside of the action area along most of northern and west shorelines of Skagit Bay, almost to mouth of Crescent Harbor, prespawner holding area in passage just outside of Crescent Harbor (see Figure 3, Stick 2005). The entire prespawn holding area is in the Crescent Harbor action area. Acoustic/trawl surveys have observed large prespawner and juvenile herring concentrations in the north end of Saratoga Passage (just outside of Crescent Harbor). Spawning occurs from February to mid-April. Spawning biomass is used to estimate overall abundance. From 2000 to 2004, the mean spawning biomass was 1,852 tons (Table 6) The 2004 stock summary indicates recent trend is "stable" and status is "healthy," but data quality is poor (Stick 2005).
  - Holmes Harbor – The Holmes Harbor herring stock's spawning grounds are all entirely within the Crescent Harbor action area (Figure 3, Stick 2005). Documented spawning occurs throughout the harbor. No prespawner holding area has been documented. Spawning occurs from February to April with most spawning activity from mid-March to early April. Mean spawning biomass for 2000 to 2004 was 496 tons (Table 6). The 2004 stock summary indicates recent trend is "increasing" and status is "healthy," but data quality is poor (Stick 2005).

Table 6 Yearly and mean spawning biomass (tons) of Pacific herring for the Skagit Bay and Holmes Harbor stocks (Stick 2005).

Year	Skagit Bay	Holmes Harbor
2000	646	281
2001	2170	275
2002	2215	573
2003	2983	678
2004	1245	673
Mean	1852	496

- *Surf smelt*: Surf smelt spawn along the west shores of Oak Harbor and in Penn Cove (Figure 4). Spawning along the south shore of Penn Cove extends into the west shore of Saratoga Passage. Spawning also occurs on the west shoreline of Holmes Harbor and along the west and north shores of Camano Island.
- *Sand lance:* Sand lance spawn in the same general locations as surf smelt, but the spawning grounds are much smaller (Figure 5). Sand lance spawn in a larger area on both the east and west side of Holmes Harbor. A small spawning area is located in Crescent Harbor.

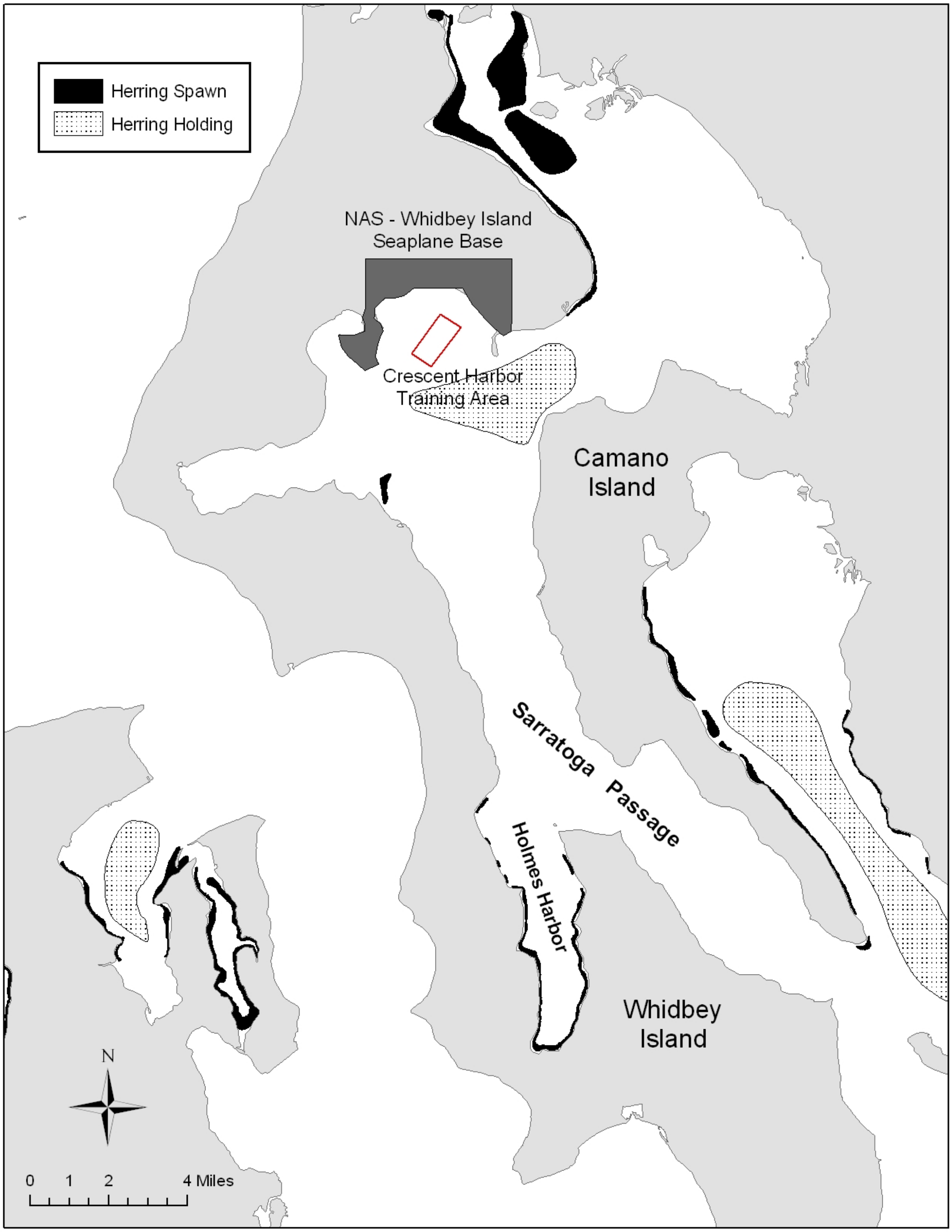

Figure 3 Spawning and prespawn holding areas for the Skagit Bay herring stock (Stick 2005).

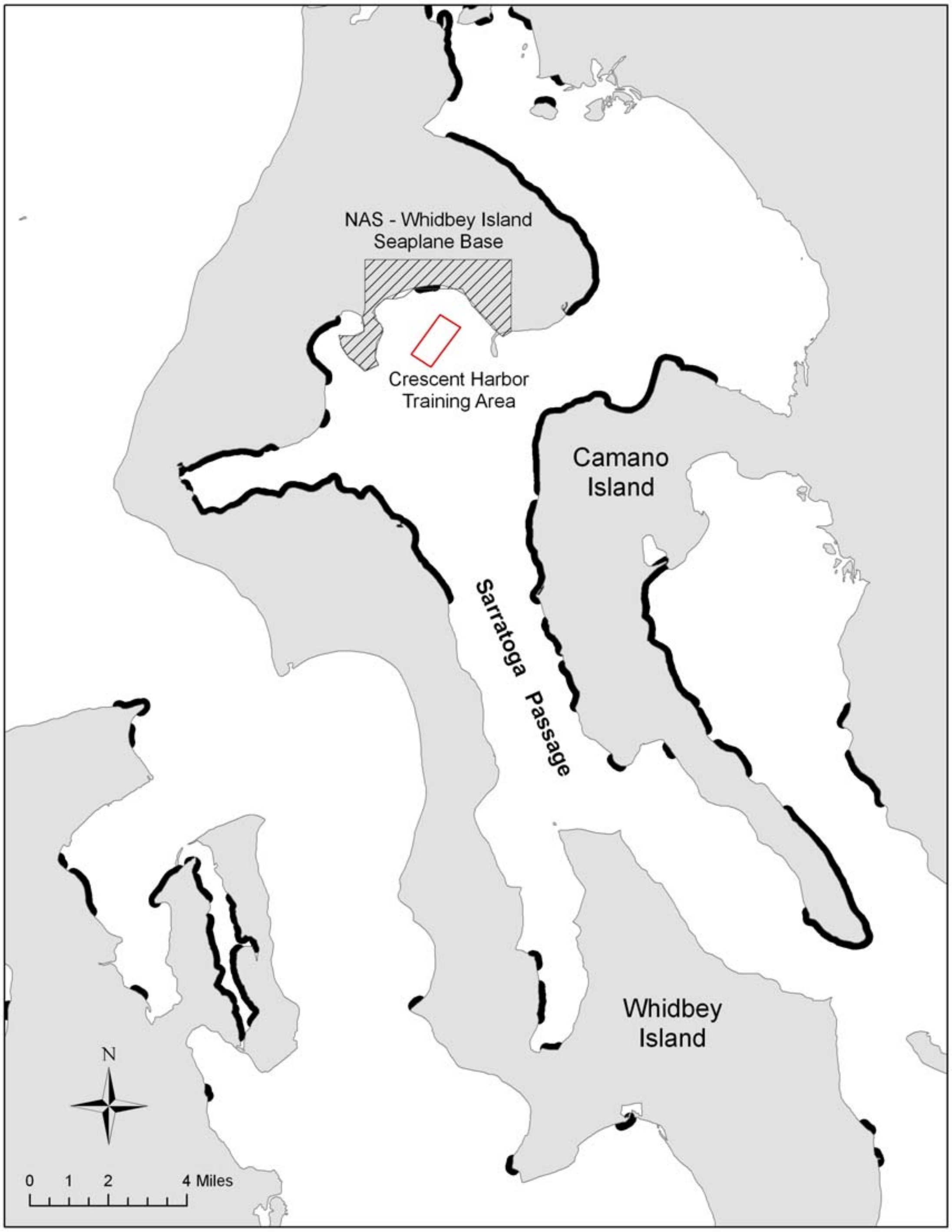

Figure 4 Documented surf smelt spawning locations for the Crescent Harbor action area (Bargmann 1998).

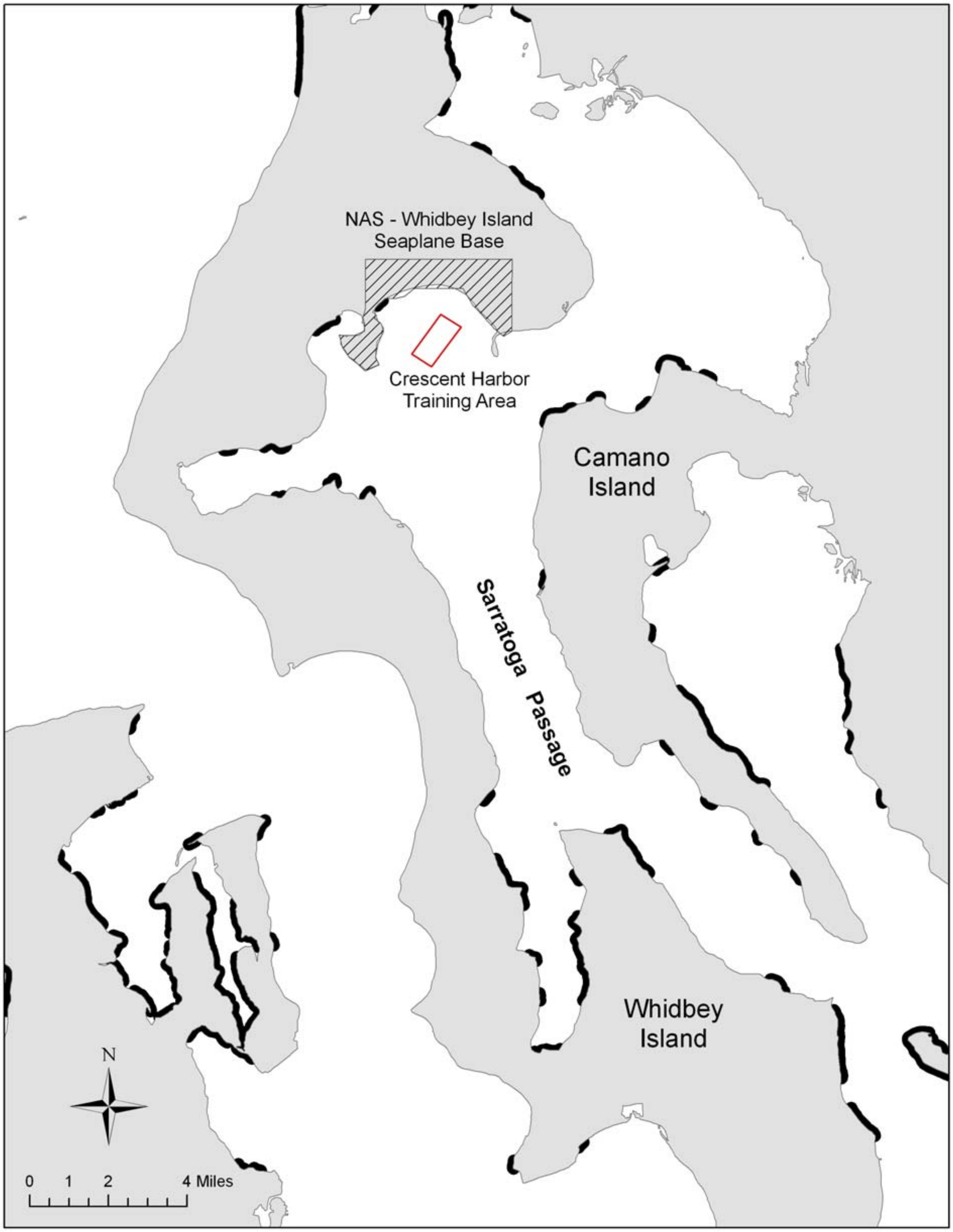

Figure 5 Documented sand lance spawning locations in the Crescent Harbor action area (Bargmann 1998).

EFFECTS OF THE ACTION

This section addresses the direct and indirect effects of the proposed action. 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 § 402.02).

Direct effects are the immediate effects of the project on the species or its habitat. Direct effects result from the proposed action and include the effects of interrelated and interdependent actions. The primary direct effects of the proposed project derive from the nature, extent, and duration of the activities and exposure of bull trout or murrelets to these activities. Indirect effects are those effects that are caused by or will result from the proposed action and are later in time, but are still reasonably certain to occur.

To provide a clear analysis of effects for bull trout and murrelets from the Navy EOD activities, we first discuss potential water quality impacts that could affect both species. Then a brief review of acoustic concepts and terminology is presented that provides the definitions used in the effect analyses for bull trout and murrelets. This is followed by separate analyses for bull trout and murrelets that address the direct and indirect effects anticipated to result from the Navy EOD activities. It should be noted that, because of the data available which are specific to fish, the methodologies used in this BO to evaluate effects to bull trout and murrelets differ.

Water Quality Effects

The explosives used during the training include C-4 (MIL-C-45010A) and/or A-3 (MIL-C-440B) which are both composed of 91.0 percent RDX (Hexahydro-1,3,5-trinitro-1,3,5-triazine). Almost all of these compounds are consumed in the detonations. While exposure to RDX is moderately toxic to salmonids, using rainbow trout as a surrogate (Sappington et al. 2001), the amount of RDX left after detonation is very small. Given the dilution, duration, and exposure, the impact of RDX to bull trout and murrelets is likely negligible. Effects are therefore insignificant.

Upon underwater detonation, the major explosive byproducts of RDX, in order of percentage by weight, includes nitrogen (37 percent), carbon dioxide (24.9 percent), carbon monoxide (18.4 percent), and water (16.4 percent) (Navy 2008). Other byproducts include ammonia (0.9 percent), hydrogen (0.3 percent), propane (0.2 percent), methane (0.2 percent), hydrogen cyanide (<0.1 percent), methyl alcohol (<0.1 percent), formaldehyde (<0.1 percent), and other compounds (<0.1 percent). Contamination of water, sediments, or prey from these residual chemicals released during explosive detonation will be insignificant. Other products resulting from secondary reactions are not expected to result in adverse water contamination effects for one of two reasons: (1) other products are harmless; or (2) are produced in such small amounts relative to their toxicity that the product would dilute or dissipate to non-toxic levels very quickly. Potential exceptions are ammonia and hydrogen cyanide. These residual compounds will be produced at levels above Washington State Water Quality Standard (WQS) for marine acute levels until dilution occurs. Table 1 in the August 3, 2005 BA Addendum (Effects of EOD

Underwater Detonations on Southern Resident Killer Whales) presents information on the volume of water needed to achieve dilution to WQS safe levels for 5 and 20 lb charges. Extrapolating this data and calculating for 2.5 lb charges, the amount of ammonia and hydrogen cyanide produced is 11.5 g and 0.05 g, respectively. The water volumes needed to meet WQS levels are 49 liters for ammonia and 17,778 liters for hydrogen cyanide. The 17,778-liter volume can be expressed as a cube approximately 8.5 ft (2.6 m) per side. Tidal exchange, infrequent explosion occurrence, dispersive force of the explosion and movement of explosive sites within the training areas will reduce the potential for toxic accumulation in sediments.

Bull trout or murrelets which would be potentially exposed to toxic concentrations of compounds would be so close to that blast that they would killed by the detonation of the explosive. Dilution would rapidly occur, and effects to bull trout and murrelets outside of the mortality zone would be insignificant.

A Brief Review of Acoustic Concepts and Terminology

A number of technical acoustic descriptors are used throughout this section. The following is a list of terms and a brief explanation of each.

- Amplitude - measurement of the acoustic energy of sound vibrations. Sound amplitude is measured on a logarithmic scale in units called decibels.
- Decibel (dB) - a numerical expression of the relative loudness of a sound.
- Frequency - the rate of oscillation or vibration of sound measured in cycles per second, or hertz (Hz). Ultrasonic frequencies are those that are too high to be heard by humans (greater than 20,000 Hz); and infrasonic sounds are too low to be heard (less than 20 Hz).
- Impulse - The measure of the total energy content of the pressure wave. Positive impulse is the integral of pressure over time measured from the arrival of the leading edge of the pressure wave until the pressure becomes negative.
- Reference Pressure - The reference scale for underwater sound is 1 micro-pascal (μPa) and is expressed as “dB re: 1 μPa”. This is in contrast to the reference pressure for in-air sound of 20 μPa, which is based on a human hearing threshold. The difference in the two values accounts for the difference in the density of the media (water vs. air).
- Sound - vibrations in air, water, etc, that stimulate the auditory nerves and produce the sensation of hearing. The perception of a sound depends on two physical characteristics - amplitude and frequency, both of which can be measured.
- Sound Exposure Levels (SEL) - the time-integrated, sound-pressure-squared level. SEL is the level of sound accumulated, both positive and negative pressure, during a given event.
- Sound Pressure Levels (SPL) - sound pressure that is expressed in dB. In this document, underwater sound pressure levels are referred to in units of dB re: 1 μPa and are denoted as dB.

- Peak pressure (peak) - the highest level or amplitude or greatest absolute sound pressure level during the time of observation. Sound pressure levels expressed as peak are used in discussing injury or mortality to aquatic species.
- Root mean square (rms) - is root square of the energy divided by the duration. Sound pressure levels expressed as rms are commonly used in discussing behavioral effects. Behavioral effects often result from auditory cues and may be better expressed through averaged units than by peak pressures.

- Transmission loss (TL) - the loss of sound energy as sound passes through a medium such as water. Several factors are involved in TL including the spreading of the sound over a wider area (spreading loss), losses to friction (absorption), scattering and reflections from objects in the sound's path, and interference with one or more reflections of the sound off of surfaces (in the case of underwater sound, these surfaces are the substrate and air-water interface).

Effects to Bull Trout

Stressors

All EOD training activities were evaluated during this consultation to determine potential effects to bull trout. Negative effects may occur during the training exercises from the underwater blasts, the floating mine detonations, and the surface support activities. Bull trout may be affected by stressors such as a) elevated underwater pressure levels; b) increased activity levels from support boats, divers, and helicopters; and c) reduced forage availability.

Exposure

Bull trout from three core areas are likely to be present in the Crescent Harbor action area. The number of bull trout in the action area from each core area will vary depending on the abundance of population in the core area and the proximity of the core area to the action area. It is assumed that more bull trout from the Lower Skagit River core area will be utilizing the Crescent Harbor action area because the Skagit River has a high population of bull trout and it flows directly into the action area.

Bull trout utilize the marine waters year-round. However, the numbers of bull trout and the life history stage found in the marine waters will vary with the seasons. Juveniles and sub-adults will be found in marine waters throughout the year. Adults will enter the marine waters and the action area in December and January after spawning in the upper watersheds. In summer (July and August), adult bull trout will leave the marine waters and migrate upstream to spawn. Bull trout that have been caught within the action area have all been adults caught in shallow water from April through July. Bull trout may utilize deep water as they migrate from one forage area to another. Juveniles and sub-adults may also migrate to lower reaches of larger river systems to forage during the winter. Therefore, their numbers will be lower from August through January.

Bull trout exposure to the effects of the EOD training will increase in late winter through the summer as more bull trout, especially the adults, will be in the marine environment. Exposure will also be greater during detonations that occur in shallower water as the impact area will include the shallow nearshore habitat which bull trout will most likely utilize.

Analysis of the probable bull trout responses to Navy EOD Activities

For many of the activities, bull trout are either extremely unlikely to be exposed to the impacts, or the effects are not likely to be measurable. These activities include effects from all power boat/helicopter operations, placing the mine, insertion and extraction of divers, locating the mines by hand-held sonar, placing of explosives and detonation equipment on the mine, retrieval of debris after the detonations, and seafloor impacts resulting from the detonations.

Powerboat/helicopter operations

The powerboat operation includes, in general, bringing personal and equipment (explosive, detonation equipment, etc.) from shore to the detonation site, insertion and extraction of divers, and pre-detonation surveying for mammals and birds. Effects to bull trout from exposure to the impacts of the powerboat and helicopter activities are not expected to be measurable. Noise and vibration from the powerboat and helicopter activities may be detectable to fish in the water. However, noise impacts are not expected to reach levels that cause injury to bull trout. Bull trout may have a short-term, startled reaction from the powerboat or helicopter activities, but should resume normal activities within a few minutes after the disturbance. Due to the short duration of the activities and noise levels below levels expected to pose a risk of injury, the potential effects of this exposure are considered insignificant.

In-water diver activities

In-water diver activities include placing the mine, locating the mines by hand-held sonar, placing of explosives and detonation equipment, and retrieval of debris. These activities will have minimal impacts to bull trout. Divers swimming through the water may produce an alarm response to any bull trout encountered while in the water. Any noise produced during placement of explosives and detonation equipment will be minor and will not result in levels that would cause injury to bull trout. Due to the short duration of the activities and noise levels below levels expected to pose a risk of injury, the potential effects of this exposure are considered insignificant.

Seafloor impacts

Prior to underwater detonations, the mines are placed on the seafloor to minimize detonation impacts in the water column. Detonations of the mine on the seafloor result in seafloor habitat alterations and mortality of some invertebrate and benthic fish species. However, these impacts will have minimal effects to bull trout. Bull trout are shallow-water oriented, and migrating over deeper water primarily to reach foraging areas or natal streams. Because bull trout do not utilize deep water habitats, the potential effects of seafloor impacts or habitat alterations are considered insignificant.

Behavioral Responses

Behavioral impacts result from continuous exposure to underwater sound or pressure waves over a period of time. The period of time in which behavioral impacts occur varies with the activity being conducted. Continuous exposure to underwater sound may result in behavioral changes to bull trout feeding, migration and habitat use. The Navy EOD training will conduct 10 detonations through December 2009 (Table 1). In three months, February, April, and July, 2009, more then one detonation will occur. It is unknown whether these detonations will occur in one day or over multiple days. Even if these multiple events occur on the same day, the detonations are not one right after another. The detonations would occur at least an hour or more apart as new explosives and detonation equipment are installed. The likelihood of any bull trout being exposed to more than one detonation is small because the size of the impact zone is small compared to the entire area available to them. Bull trout are likely to be moving in search of food, which means they will likely be moving through the impact zone and have moved on in less than a day or two. Therefore, the Service does not expect the detonations to cause any observable adverse change in bull trout behavior because of the EOD training detonations. The assumption is that with only one exposure to a pressure wave, there will not be any lasting effect on behavior for those bull trout that are not killed or injured. This is consistent with the idea that a single incident will elicit a startle response, but if the incident does not reoccur, there will not be any change in behavior.

<u>Activities that could result in lethal or sublethal injuries</u>

Detonations

Both underwater and surface detonations have the potential to generate sound levels that result in physical injury to bull trout. However, the differences between the two types of detonations will be described below. We describe potential effects, thresholds for these potential effects, quantify the areas where these effects may occur, and finally quantify to the extent possible, the number of bull trout exposed to these effects.

<u>Effects of underwater detonations</u>

The EOD training detonation has negative effects to bull trout from the pressure wave that results from the detonations. Underwater explosions can affect fishes in two basic ways: their behavior could be altered in a manner that reduces their survival or they can be physically injured and killed (Nedwell and Edwards 2002, Nedwell et al, 2003). An underwater detonation produces a pressure wave that radiates quickly from the detonation site. The strength of this wave depends on the type and amount of explosive, the location of the detonation in the water column (near the bottom versus near the surface), distance from the detonation site (the strength of the pressure wave dissipates with distance), and the location of the fish in the water column. The typical pressure wave from an explosion consists of an instantaneous increase to the peak pressure, followed by a slower (but still very rapid) logarithmic decrease to ambient pressure (SAIC 2000). The pressure wave can be displayed as a waveform that describes the pressure-time history, where time is measured in seconds, while pressure is measured in micropascals (μPa).

The principal mechanism by which pressure waves from blasts cause physical injuries to organisms is through oscillations in body tissues. Most blast injuries in marine animals involve damage to air- or gas-containing organs (Yelverton 1981). For example, fish with swim bladders (including salmonids) are vulnerable to the effects of explosives, while fish without swim bladders (flatfish, sharks, and rays) and invertebrates are much more resistant (Yelverton 1981, Young 1991). During exposure to shock waves, the swim bladder oscillates and may rupture, in turn causing hemorrhages in nearby organs. Fish that have thick-walled swim bladders that are close to the body wall and away from the kidneys are more resistant to blast injury than are fish with thin-walled swim bladders that touch the kidneys.

Several authors have described methods for calculating the theoretical kill or injury zones around underwater explosions (e.g., Gaspin et al. 1975; O'Keefe and Young 1984; Young 1991). However, a more common metric to use for a single acoustic event that accounts for both the negative and positive pressure wave is sound exposure level (SEL) (Hastings and Popper 2005). The SEL is the time-integrated sound pressure-squared, and is expressed in dB referenced to 1 micropascal-squared*second (1μPa2*sec)[2].

The best experimental data available on the effects of underwater detonations is found in a report by Yelverton et al. (1975). However, this study provided thresholds for injury, based on the mass (weight) of the experimental fish, as the impulse of the detonation (the time-integrated sound pressure). Hastings and Popper (2005) used the data provided in Yelverton et al. (1975) to calculate the SEL where no injury was expected. The thresholds for injury used in this BO are based on the values in Hastings and Popper (2005), but due to the uncertainties associated with the calculations, the thresholds were reduced by 10 dB to add a margin of safety. Because the threshold for injury varies with the mass of the fish, the following thresholds for SEL were used: 187 db for juveniles (1.2 oz or 35 gms) and 188 db for adults (2.2 lbs or 1,000 gms). The kill or injury zones are based on the distance from the detonation where these thresholds are expected to be met.

The zone around the detonation where the thresholds for SEL are expected to be exceeded were calculated using the equations provided in Richardson et al. (1995). The calculations of Richardson et al. (1995) are based on trinitrotoluene, which has a lower energy than the C-4 explosives used by the Navy. The C-4 weights were multiplied by 1.1 to give equivalent trinitrotoluene charge weights.

The equations of Richardson et al (1995) give the pressure waveform at a given distance for a given charge weight, and this waveform was used to calculate the SEL. An iterative process was used in which the distance from the charge was varied in the equation until the thresholds for injury were met. This distance is the radius of an assumed circular kill or injury zone. The area calculated would describe the area where bull trout will be killed or injured. For a 2.5 lbs charge, the radius for the kill or injury zone is 486 ft (148 m).

The effects of the detonations diminish with distance. The number of injured or killed individuals is related to the number of detonations and the season of the year when the

[2] Throughout this BO, SEL is referenced to 1 μPa^2-sec.

detonations occur. Adult bull trout are most vulnerable from December through August when they are out of their natal streams and foraging in the marine environment. Juveniles and sub-adult bull trout enter the marine waters at the same time as adults but can be found in the marine environment year-round. Some juveniles and sub-adults may migrate to the lower estuarine, freshwater reaches of larger river systems to feed during the winter. Little is known about bull trout movement and use of the marine environment, but based on bull trout movement studied by Goetz (2004), bull trout use the shallow nearshore habitat for foraging and migration. However, because bull trout have been captured around Whidbey Island (i.e., Crescent Harbor and Penn Cove), they must migrate over deeper water at some time to get to these areas.

The calculated kill or injury zone for the 2.5 lbs detonations (486 ft) was combined with the Service's assumptions of when bull trout will be in the action area to estimate the expected numbers of bull trout killed or injured.

There are two distinct types of training, subsurface and surface. Subsurface detonations generally impact a spherically shaped underwater area, constrained by the substrate and air/water interface. Surface detonations propagate vertically into the water column. Both types of detonations are conducted at least 3,000 ft from the shoreline. Given the difference in the physics of the two types of detonations, they will be treated separately.

As described above, the equations of Richardson et al (1995) were used to calculate the distance for an underwater detonation that would kill or injure a bull trout. The calculated kill and injury area (radius) from a 2.5 lb charge is 486 ft. Surface area for the kill and injury area for each detonation is 741,655 ft^2. The total volume of the cylinder for the kill and injury area based on 95 ft depth of each detonation is 70,457,225 cubic ft.

The Navy will be conducting six underwater detonations through December, 2009. One detonation will occur in November, 2008, three in February, and two in July, 2009 (Table 1). The detonations in February and July will occur during the time when the highest numbers of bull trout are found in the marine environment. Most bull trout, particularly adults, return to freshwater in July and August. However, juveniles and sub-adults may remain in the marine environment year-round but in fewer numbers as some may migrate to the lower reaches of large river systems during the winter. It is unknown at what depth the detonations will occur. Depths within the project area where detonations occur range from 30 to 100 ft. Monitoring data for detonations show that depth of charges range from 35 to 90 ft. Bull trout are shoreline oriented and detonations that affect shallow waters will impact more bull trout.

To estimate the number of bull trout that may be killed during underwater detonations, we assumed a high risk of bull trout mortality, or that one bull trout would be in the kill and injury zone, during the months in which all life history stages of bull trout may be in the marine waters (November through August). We assumed a low risk of bull trout mortality, or no bull trout would be present in the kill and injury zone, during the months when only juveniles and sub-adults may be in the marine waters (August through December). At this time adults are absent from marine waters, and some juveniles and sub-adults migrate to lower river systems to forage during the winter.

The number of underwater detonations that the Navy will conduct, the month in which the detonations will occur, the risk factors associated with each detonation, and the shoreline orientation of bull trout while in the marine environment were considered in estimating bull trout mortality. We estimated that five bull trout (one/detonation) would be killed or injured from the five underwater detonations during the months through December 2009 in which all life history stages of bull trout may be found in marine waters.

Effects of surface detonations

Surface detonations will transmit about 30 dB to 40 dB less energy into the water than subsurface detonations of similar a size (2.5 lbs of C-4). In addition, the energy, at least the vast majority, will propagate vertically into the water column with about thirteen degrees of dispersion (C. Greene, Greeneridge Sciences, pers. comm. 2006). Assuming a circle three ft in diameter (the approximate area occupied by a 55 gallon drum on its side), this would be the area that would transmit energy into the water column. Assuming the 13 degree energy dispersion as the energy propagates vertically into the water column, the area impacted by the downward energy pulse would be a circle measuring 46.8 ft in diameter at a depth of 95 ft. Another assumption is that any bull trout in the impact volume will be killed or injured (independent of the actual amount of energy in the area of impact). Again, assuming a worst case, the impact area was considered to be a cylinder 46.8 ft in diameter from 95 ft deep to the surface. This results in an impact area of 1,719 ft^2 at the surface, or 163,305 cubic ft for the cylindrical impact volume. This is considerably smaller than the subsurface detonation impact area. The area impacted by each detonation is 1,719 ft^2 or approximately 0.02 percent of the area impacted by an underwater detonation.

The Navy will be conducting four surface detonations through December, 2009. One detonation will occur in October, 2008, two in April, and one in June, 2009 (Table 1). Using the same analysis as described above for the underwater detonations, but because of the much smaller impact area for a surface detonation, we believe the likelihood of bull trout being present in the area where injury or mortality would occur is discountable.

Effects to Bull Trout – Forage Fish Impacts

Forage fish which are prey for bull trout are being impacted by the Navy EOD training detonations. A substantial number of forage fish are being killed, based on the surface data the Navy collects during each training exercise. In Puget Sound, forage fish are the primary food source for bull trout and murrelets.

Surface counts of fish collected by the Navy after training exercises held at Crescent Harbor indicate the underwater detonations primarily result in mortality to Pacific herring and surf smelt (Table 7). Other species identified include shiner surf perch (271 total over all 46 detonations), Pacific tomcod (29 total), blackeye goby (1 total), and northern anchovy (7 total).

Table 7 shows the variability in the data based on the month that detonations occur. Five 10-pound charge detonations occurred in June and September, 2002, but they had very low surface count mortalities of herring and surf smelt. The five-pound charges had few surface mortalities in January, April, and June of 2003, but high numbers of mortality in July, 2003, and June, 2004. Underwater detonations of 2.5 lbs charges had highest mortalities in the months of May, July, August, and September. Surface detonations had fewer fish mortalities than underwater detonations using 2.5-pound charges. Most surface detonations occurred on the same day, or within one day, as the underwater detonations.

Table 7 Monitoring data of the number of fish floating on the surface after EOD detonations in Crescent Harbor. Date of detonations, explosive size, type of detonation (surface or underwater), and depth of detonation are also provided.

Date	**Time**	**Herring**	**Surf Smelt**	**Total**	**Comments**
10 pound charges					
06/12/02	1230	50	0	50	Suspended 10 feet from bottom
06/26/02	1030	0	0	0	None
09/19/02	1100	100	0	100	Suspended 10 feet from bottom – 2 shots
09/24/02	1300	0	75	75	None
09/26/02	1730	0	5	5	None
Average		30	16	46	
5 pound charges					
01/28/03	1350	120	0	120	Depth 90 feet
04/15/03	1320	2	214	216	Depth 70 feet
06/04/03	1240	0	222	222	None
07/15/03	1116	1862	79	1941	Depth 45 feet, suspended 10 feet from bottom
06/03/04	1245	3760	3077	6837	Depth 40-45 feet
Average		1149	718	1867	
2.5 pound charges – underwater					
01/13/05#	1344	84	84	168	Depth 40 feet, on bottom
04/08/05	1110	18	351	369	Depth 40 feet, on bottom
04/29/05	1158	5	227	233	Depth 40 feet, on bottom
05/11/05	1038	39	0	39	Depth 35 feet, on bottom
05/11/05	1205	1242	0	1242	Depth 35 feet, on bottom
08/09/05	1223	2520	630	3150	Depth 42 feet, on bottom
09/27/05	1303	496	5	501	Depth 60 feet, on bottom
10/19/05	1144	111	0	111	Depth 48 feet, on bottom
11/29/05	1220	0	122	122	Depth 80 feet, on bottom
01/10/06	1020	7	649	656	Depth 80 feet, on bottom
03/09/06*	1216	28	0	28	Depth 80 feet, on bottom
03/10/06*	1143	86	0	86	Depth 80 feet, on bottom
04/18/06	1118	311	0	311	Depth 80 feet, on bottom
02/01/07	1128	0	176	176	Depth 55-60 feet, on bottom – 2 shots
03/15/07	1117	7	91	98	Depth 45 feet, on bottom
04/25/07	1247	382	0	382	
06/07/07	1310	0	0	0	Depth 40-45 feet
06/13/07	1008	494	55	549	Depth 35 feet, on bottom
07/31/07	1147	690	172	862	Depth 40 feet, on bottom
09/05/07	1246	132	0	132	
Average		333	128	461	
2.5 pound charges – surface, on barrel					

Date	Time	Herring	Surf Smelt	Total	Comments
01/13/05#	1040	9	9	18	
04/07/05#	1010	0	0	0	
04/29/05	1248	0	50	50	
08/10/05#	1246	9	9	18	
09/27/05	1037	37	0	37	
12/01/05#	1040	35	35	70	
01/11/06	1001	0	49	49	
03/10/06	1234	0	0	0	
03/10/06	1253	0	64	64	
04/18/06	1204	348	0	348	
09/26/06	1002	59	59	118	3 shots
10/12/06#	1155	31	31	62	
04/18/07	1034	0	61	61	
09/06/07	1121	8	0	8	
10/05/07	1140	0	169	169	
Average		36	36	72	

Data did not identify fish species floating on surface after detonation, so the total number killed was divided between herring and surf smelt equally.
* Data did not document the percentage of each fish species identified as floating on surface. The total number killed was divided equally between fish species identified. For both 3/9/06 and 3/10/06, the fish species identified were herring and shiner surf perch. For 10/12/06, herring and surf smelt were identified.

Trawling surveys in Skagit Bay were conducted in shallower, nearshore waters and not in deep water where the EOD training occurs. However, the variability in the number of herring and surf smelt found on the surface after a detonation is consistent with the variability observed in the trawling surveys (Table 8, see Figure 5 for trawling locations). The trawling data show that for any given site, the number of herring and surf smelt fluctuates. For example, the site closest to Crescent Harbor, and one of the sites within the action area (Utsalady) has an average mean catch per tow for herring ranging from 10 in June to 1,000 in August and September. Surf smelt numbers ranged from 5 in October to 170 in September. However, the trawling data indicate considerable variability in the numbers of herring and surf smelt sampled in the different months. Similar variability in the data is observed with the number of herring and surf smelt that float to the surface after a detonation.

Table 8 2001 mean catch per tow for herring and surf smelt for tow net sampling in Skagit Bay.

	May		June		July		August		September		October	
	Herring	**Surf Smelt**	**Herring**	**Surf Smelt**	**Herring**	**Surf Smelt**	**Herring**	**Surf Smelt**	**Herring**	**Surf Smelt**	**Herring**	**Surf Smelt**
Hoypus			11	20	105	200	2500	90	3000	160	800	150
Lone Tree	0.5		30	70	15	70	900	70	500	60	200	20
NF Flats				50					20		200	10
PBD Flats			40	275			1000	110	2000	20	800	140
SF Flats			7	25					500	30	8	5
Similk	6		100	180	80	490	2000	10	1500	10	250	80
Snee Oosh			18	40	100	160	40	45	50	10	6	10
Strawberry Pt.			25				250	130	200	5		
Utsalady			10	25			1000	45	1000	170	800	5

The data from the Navy on the number of herring and surf smelt floating on the surface after a detonation is likely under representing the actual number and species of fish killed because the surface counts are not conducted immediately after the detonation and not all fish killed float. After a detonation, the blast zone must be secured, for safety reasons, prior to any surveys being conducted. For surface counts, the delay may not result in a large difference in numbers of fish floating and observed. Currents within Crescent Harbor may cause the fish to move away from the detonation site, but survey boats can move with the floating fish to get an accurate number. Because explosive detonation can result in rupture of gas (air or swim) bladders in fish, not all fish killed or injured by a detonation will float. Studies have found that 30 percent to over 80 percent of fish killed by an underwater explosive sink rather then float to the surface (Teleki and Chamberlain 1978, Thomas and Washington 1998). Because the Navy only surveys floating fish, the actually number of forage fish that are killed, may actually be substantially higher. What the effect of the underwater detonations has on the forage fish populations is unknown.

Pacific herring

Pacific herring populations are the only forage fish that are monitored by WDFW annually (Pentilla 2007). Spawning of Pacific herring varies with the different stocks but generally occurs from late January through April (Pentilla 2007). Pacific herring are found within Puget Sound throughout the year (Stout et al 2001, Pentilla 2007). The pre-spawn holding area for the Skagit Bay herring stock is located just south of Crescent Harbor and located completely within the Crescent Harbor action area (Figure 2). Herring have the greatest potential to be impacted from January through March during the pre-spawn holding time as they will be congregating and migrating closer to the detonation sites.

The Holmes Harbor herring stock's spawning locations are also completely within the Crescent Harbor action area, but at the extreme southern end. No known pre-spawn holding area exists for this stock. Because of the distance from the detonation site to the spawning areas, the EOD training detonations are not expected to impact spawning. However, as these herring spawn and move into Saratoga Passage, they may migrate north and be killed or injured by detonations.

Figure 6 2001 Tow net site locations in Skagit Bay (Rice et al. 2002 in litt.). Crescent Harbor location is not exact location of townet sampling. Location was described as being in-shore of detonation site (C. Rice, NOAA Fisheries, pers. comm. 2007).

The effect that the underwater detonations may have on the Pacific herring population is unknown. To help analyze the potential impact of the detonations on the herring stock populations, we estimated the biomass of the herring killed and compared that to the spawning biomass for the Skagit Bay and Holmes Harbor herring stocks. The Navy will be conducting ten 2.5 lbs detonations through December, 2009. For our analysis, we assumed that the worse case scenario for a single 2.5 lbs detonation would be the largest number of herring killed that was documented by the Navy's surface monitoring data (Table 7). On June 3, 2004, for a five-pound charge, 3,760 herring were killed. The largest number of herring killed for a 2.5 lbs charge was 2,520 on August 9, 2005. Because of the variability in herring density from the Skagit Bay trawling data (Table 5) each month, we used the number killed from the 5-lbs charge for our analysis. Because not all fish float, we assumed that 80 percent of the fish killed from a detonation sank (Thomas and Washington 1998). Therefore, the total potential number of herring killed was 18,800 individuals. To estimate the total biomass of those individuals killed, we used the length/weight regression from Reilly and Moore (1986):

$$Ln(W) = -12.82 + 3.34ln(L)$$

Stick (2005) provided mean lengths of age 2, 3, 4, and 5 year olds for different stocks in Puget Sound. The average of the mean lengths was used to calculate the average weight for an individual herring (Skagit Bay herring stock - 157 mm, Holmes Harbor herring stock – 180 mm). Average weight per individual herring is 4.07 g for the Skagit Bay stock and 4.52 g for the Holmes Harbor stock. The total biomass of the 18,800 herring estimated to be killed would be 0.0765 tons for the Skagit Bay stock and 0.0850 tons for the Holmes Harbor stock. These values assume that all herring killed from the detonation originated from the same stock. The biomass killed from the detonation is 0.004 percent and 0.017 percent of the five-year mean spawner biomass for the Skagit Bay and Holmes Harbor herring stocks, respectively. With 10 charges through December, 2009, the total biomass killed would only represent 0.04 percent and 0.17 percent of the mean spawner biomass for the Skagit Bay and Holmes Harbor stocks. The recent trends of the Skagit Bay and Holmes Harbor stocks are stable and increasing, respectively. Therefore, the Navy EOD training, while killing Pacific herring, cannot be shown to be significantly affecting the abundance of these two herring stocks.

Surf smelt

Surf smelt are found throughout Puget Sound at all times of the year and spawn throughout the year (WDFW 2008). Little is known about their adult life stage but it is assumed they may stay near their spawning areas (Pentilla 2007). Surf smelt populations within the Crescent Bay action area may be impacted because the known spawning locations occur along the shorelines both west and east of the detonation area. Even though surf smelt are shoreline oriented, they do migrate out to waters 60 ft in depth. Most EOD detonations have occurred in waters less then 60 ft (Table 7). Therefore, surf smelt are susceptible to death or injury from the detonations. No monitoring of surf smelt abundance is conducted in Puget Sound. Therefore, no quantitative analysis can be conducted on the number or biomass of surf smelt killed from Navy EOD detonations. Therefore, for the purpose of this analysis, we can simply assume that there will be a measurable reduction in surf smelt numbers, but cannot determine whether this reduction will result in a reduction to the overall population of surf smelt in the Crescent Harbor action area.

Sand lance

Pacific sand lance can be found within Puget Sound throughout the year (Pentilla 2007). Pacific sand lance spawn in late fall and winter (Robards et al 1999). During the day in the spring and summer, sand land occur within the water column during the day and bury themselves in the substrate during the night. Pacific sand lance may be exposed to the detonations year-round, but are more likely to be exposed when they occur in the water column during the day. Pacific sand lance lack a gas bladder; therefore, they will not be killed by ruptures of the gas bladder, which in turn may make them less susceptible to the EOD detonations. However, gas bladder ruptures are not the only injury that may be sustained from exposure to elevated SELs.

Within the action area, sand lance spawn in the same general locations as surf smelt, but the spawning grounds are much smaller. A small spawning area is located in Crescent Harbor, however, a larger area exists on both the east and west side of Holmes Harbor.

The data collected by the Navy monitoring of detonations did not document specific sand lance mortalities. This species occurs within the water column during the time the detonations may occur. However, sand lance are more prone to sink than float because they do not have a gas bladder. Therefore, we cannot discount sand lance may be killed or injured by the detonations. No monitoring occurs of sand lance abundance throughout Puget Sound. Therefore, no analysis can be conducted on the number or biomass of sand lance killed from Navy EOD detonations. Therefore, for the purpose of this analysis, we can simply assume that there will be a measurable reduction in sand lance numbers, but we cannot determine whether this reduction will result in a reduction to the overall population of sand lance in the Crescent Harbor action area.

Bull trout Effects from Prey mortality

We anticipate there will be measurable reductions in the numbers of prey available to bull trout in the action area. However, we do not know how the EOD training detonations will impact the different forage fish populations. Data are not available that indicate that prey are limiting for bull trout in the marine environment, or that the detonations are having significant effects on availability of forage fish for bull trout. Therefore, we anticipate effects of forage fish mortality to be insignificant for bull trout.

Effects to Murrelets

Direct effects result from the proposed action and include the effects of interrelated and interdependent actions. The primary direct effects of the proposed project derive from the nature, extent, and duration of the training exercises, both under and above water, which may reduce the murrelet population size as a result of direct mortality of adults and juveniles. In addition, because some activities will occur during the nesting season, chick mortality could occur if a nesting adult is killed or injured. The significance of these impacts on the murrelet population depends on the extent to which the action affects the rate of population change. The impacts are additive to other factors that are already negatively affecting the population.

Stressors

Negative effects may occur during the training exercises from the underwater blasts, the floating mine detonations, and the surface support. Murrelets underwater or on the water's surface may be affected as a result of a) elevated underwater pressure levels; b) water plume; c) flying debris; d) elevated above water sound levels; e) helicopter downwash; f) increased activity levels from support boats, divers, and helicopters; and g) reduced forage availability.

Exposure

As presented in the environmental baseline murrelets likely occur year-round in the Crescent Harbor action area with the numbers increasing in late fall/early winter and declining in late winter/early spring.

While the action area occurs within Conservation Zone 1, we cannot assume that the action will only affect murrelets associated with Conservation Zone 1 for the following reasons: a) the activities will occur throughout the year; b) recent studies indicate murrelets move freely between Conservation Zones 1 and 2 during the breeding season when population surveys are conducted; and c) studies indicate murrelets may emigrate out of Zone 1 or may immigrate into Zone 1 from Zone 2 or British Columbia during the non-breeding season. While there are differences in the murrelet density estimates between the breeding season and the winter season in the action area, which may indicate the proportion of murrelets that might be attributable to immigration from Zone 2 or British Columbia, it would not take into account murrelets that move around within Zone 1 in search of food sources or sheltered areas during inclement weather. Therefore, it is not reasonable to attempt to distribute the associated effects to the Zone 1, Zone 2, and British Columbia breeding populations. Therefore, for purposes of this analysis, we will consider a reasonable worst-case scenario and begin our analysis by attributing all of the effects of the action to the Zone 1 population.

Throughout the year adults and subadults are performing normal behaviors to support themselves. In addition, during the late winter/early spring adults and subadults are undergoing the prealternate molt and adults are preparing for breeding; in the spring/summer, breeding adults are incubating and provisioning chicks; and in the late summer/fall adults and subadults are undergoing the pre-basic molt and chicks are coming into the marine environment. The Navy EOD underwater and floating mine detonations will occur between October 2008 and July 2009; therefore, one or more murrelet life stages may be exposed, either directly or indirectly by the Navy EOD activities.

Analysis of the probable murrelet responses to Navy EOD Activities

Our assessment will first evaluate those aspects of the Navy's activities that have the potential for lethal and sublethal injury, and then those activities that have the potential for behavioral and physiological responses. Some activities, such as underwater detonations could result in both injury and behavioral effects, depending on the distance from the detonation. Given the lack of empirical data on the probable responses of murrelets to many of the Navy EOD activities, we reviewed the best scientific and commercial data on the probable responses of other species. We then use this information to make inferences about the probable responses of murrelets.

Activities that could result in lethal or sublethal injuries

Detonations

Both underwater and surface detonations have the potential to generate sound levels that result in physical injury to murrelets. However, the differences between the two types of detonations will be described below. We describe potential effects, thresholds for these potential effects, quantify the areas where these effects may occur, and finally quantify to the extent possible, the number of murrelets exposed to these effects.

Effects of elevated underwater sound levels

Barotrauma. High underwater sound pressure levels (SPLs) are known to have negative physiological and neurological effects on a wide variety of vertebrate species including fishes, mammals, and birds (Cudahy and Ellison 2002; Fothergill et al. 2001; Steevens et al. 1999; U.S. Department of Defense 2002; Yelverton and Richmond 1981; 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). The injuries associated with exposure to high SPLs are referred to as barotraumas, and include hemorrhage and rupture of internal organs, hemorrhaged eyes, temporary stunning, and ruptured eardrums (Hastings and Popper 2005; Turnpenny and Nedwell 1994; Yelverton and Richmond 1981; Yelverton et al. 1973; Yelverton et al. 1975). Death from barotrauma can be instantaneous, occurring within minutes after exposure, or several days later (Abbott et al. 2002). Gas-filled spaces, such as lungs and sinuses, are particularly susceptible to the effects of underwater sound. The most dramatic effects occur during exposure to blasts and high-energy impulse noise because the dramatic pressure drop from a high pressure in adipose tissue and muscle to a low pressure within the gas-filled spaces can cause rupture of the hollow organ (Gisiner 1998). The effects can vary significantly depending on the location of the blast and individual in relation to each other, the bottom, and the surface (Gisiner 1998). 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 1981). These data indicate that, at a coarse scale, physical responses may be similar across taxonomic groups.

Data related to seabirds is primarily derived from evaluations of the effects of underwater blasting and seismic testing. Observations by Cooper (1982) found jackass penguins (*Spheniscus demersus*), cape cormorants (*Phalacrocorax capensis*) and kelp gulls (*Larus dominicanus*) were killed by underwater blasts. Fitch and Young (1948) found that diving cormorants were consistently killed by seismic blasts, and pelicans were frequently killed, but only when their heads were below water. Unfortunately, the distances at which these birds were killed were not reported. Cooper (1982) also noted that a series of blasts spaced out over a period of time can result in the mortality of an increasing number of seabirds as more birds are attracted to the area by dead or stunned prey. Similar observations have been noted during seismic explorations (Fitch and Young 1948; Stemp 1985).

Yelverton et al. (1973; 1981) exposed many fish species, submerged mallard ducks (*Anas platyrhnchos*) and Rouen (*Anas sp.*) ducks, and various terrestrial mammals to underwater explosions. Common to all the species that were exposed to underwater blasts were injuries to air and gas filled organs, including eardrums. The ducks that died all had pulmonary hemorrhage, and ruptured livers and kidneys; the majority had coronary air embolisms, ruptured air sacs, and ruptured ear drums (Yelverton et al. 1973; 1981). Birds killed in Yelverton's study (1973) had short survival times (3 minutes to 5 hours) and all exhibited labored breathing, appeared comatose, and were unable to stand on their own. The short survival time was attributed to cerebral and coronary air embolism resulting from air entering the circulation through the damaged lungs.

Another mechanism of injury and death resulting from high SPLs is "rectified diffusion", or the formation and growth of bubbles in tissue. Rectified diffusion can cause inflammation and cellular damage because of increased stress and strain (Stroetz et al. 2001; Vlahakis and Hubmayr 2000) and blockage or rupture of capillaries, arteries, and veins (Crum and Mao 1996). Crum and Mao (1996) analyzed bubble growth underwater by rectified diffusion caused by sound signals at low frequencies (less than 5,000 Hz), long pulse widths, and atmospheric pressure.

Injuries to internal organs, such as the lungs, heart, and brain can also be caused by air emboli (Mayorga 1997, p. 19). Air emboli are thought to originate in the lungs and travel to other vital organs to cause sudden death. Even in the absence of air emboli-induced sudden death, lung contusion can be incapacitating and lethal if extensive (Mayorga 1997, p. 21). Croll et al. (1992) predict that common murres (*Uria aalge*) make some adjustment to prevent decompression sickness (the bends) that could result from diving. When there is a reduction in blood flow to the muscles and peripheral organs, as occurs when murres dive, then nitrogen tension differences would be close to those that may cause bubble formation. However, murres may reduce this problem by allowing some blood to circulate to the muscles and peripheral organs during the dive. By regulating blood flow, murres could avoid decompression sickness. However, a diving bird that is carefully balancing oxygen consumption and nitrogen absorption that is hit by a compression wave that damages the lungs or air sacs is likely to either a) rise to the surface too quickly, not allowing for nitrogen to off-gas naturally through the lungs, which can result in air bubble forming in the blood stream which can cause significant injuries and potentially death or b) have bubbles formed in the blood stream or tissues which will expand as the bird begins to surface, resulting in significant injuries and potentially death.

Physical injury to aquatic organisms may not result in immediate mortality. If an animal is injured, death may occur several hours or days later, or injuries may be sublethal. For example, necropsy results from Sacramento blackfish (*Othodon microlepidotus*) exposed to high SPLs showed fish with extensive internal bleeding and a ruptured heart chamber were still capable of swimming for several hours before death (Abbott et al. 2002). Some of the ducks in the lethal zone of the Yelverton et al. (1973) study survived; however, necropsies on these birds, as well as many of the ducks that were just beyond the lethal zone, indicated they had sustained extensive lung hemorrhage and liver and kidney damage. Studies on humans and other species show these types of injuries can be incapacitating, which for an animal in the wild can result in premature death. For a diving seabird, these types of injuries may make it difficult to fly or dive, either of which may cause further injury (as in the case of air emboli). Without diving, murrelets would be unable to evade predators, forage, and if rearing a chick, may not be able to fly to deliver food to the chick.

Vision. Blast exposure experiments by Petras et al. (1997, p. 46-47) resulted in visual system injuries in 83 percent of the rats they exposed to at least 173 kPa which demonstrates that blast exposure can induce permanent injury to some of the brains' central visual pathways. We recognize these experiments were conducted in air rather than water; however, eye hemorrhages have also been seen in fish species (Hastings and Popper 2005). Therefore, it is reasonable to assume that birds will also be susceptible to eye injuries. Murrelets rely upon their vision to forage, navigate above and below water, find nesting habitat, and evade predators. Therefore, any injuries to the visual system from exposure to the blast could impair their ability to carry out essential life functions. Severe injuries to the visual system are likely to lead to premature death, particularly from predation or starvation.

Food Intake. A single exposure to a sublethal blast pressure wave reduced the exercise performance and food intake of rats on the day of exposure and for subsequent recovery days, possibly as a result of subtle injuries to the lungs and gastrointestinal tracts (Bauman et al. 1997). Peak pressures of 129 kPa (222 dB SPLPeak) will result in perforation and hemorrhage of the air filled bowel (Bauman et al., 1997). Although the entire digestive tract from the esophagus to the anus can be affected, the most likely targets are the small and large bowel or areas of trapped gas. Sublethal exposures of 83 kPa (218 dB SPLPeak) result in minor petechial submucosal lesion of the bowel (Bauman et al., 1997). Although these lesions were not immediately life-threatening, Bauman et al. (1997) associated them with reduction of food intake in rats.

Hearing. The ear is almost always affected in significant blast overpressure exposure (Mayorga 1997, p. 18) and relatively severe acoustic overexposures that can lead to irreparable damage. Exposure to blast overpressure may result in permanent or temporary hearing damage depending on factors such as the spectral characteristics of the acoustic stimulus as well as its duration and the level and the amount of exposure (Saunders and Tilney 1982; Gisiner et al. 1998). While there are no data available on the effects of acoustic overexposure on aquatic birds, there are data for terrestrial birds using pure tone exposures (see, for example, Saunders and Dooling 1974; Ryals et al. 1999), which we extrapolate to aquatic birds for the purposes of this analysis. We recognize that there are differences between pure tones and impulsive sounds, variability between bird species' physiological response to sound, and differences between aquatic and in-air sound environments. However, in light of the absence of data specific to murrelets in an aquatic environment, we used information from the studies referenced above to conduct our analysis.

There may be considerable differences among birds in the degree of damage suffered from noise exposure and the extent and time of recovery. Ryals et al. (1999; p. 86) found there are large differences between species in susceptibility to hair cell damage, hearing loss, and auditory recovery. Their results showed dramatic differences in the amount of threshold shift and in the amount and time to behavioral recovery. For example in one trial, quail had an initial 70 dB threshold shift that remained unchanged for 8-9 days, recovered at about 2 dB/day from days 9 to 50, and had no further recovery after day 50, resulting in a permanent threshold shift of about 20 dB that was still evident 1 year after exposure. In contrast, budgerigars had an initial threshold shift of about 40 dB and recovered to within 10 dB of pre-exposure levels within 3 days. In some trials there was no hair cell damage and complete hair cell loss in others (Ryals et al. 1999).

Large permanent threshold shifts may be moderated in a number of bird species because sensory hair cells regenerate (e.g., Corwin and Cotanche 1988; Ryals and Rubel 1988). If only hair cells are lost or damaged, studies on several bird species have shown that hair cell regeneration results in the return to near normal auditory sensitivity with a lingering permanent threshold shift of up to 20 dB (Ryals et al. 1999). For example, the quail from Ryals et al (1999) that were sacrificed 7 days post-exposure showed hair cell regeneration; however, those that were sacrificed 1-year post-exposure had whole areas devoid of hair cells within roughly the same areas; suggesting that either the initial damage was very extensive and regrowth did not occur, or that the hair cell regeneration seen after 7 days could not be maintained over the long-term. While sensory hair cells may regenerate, recovery may take several day to weeks, and such recovery does not mean that the replacement hair cells are sending the same kinds of information to the brain as were sent by the original hair cells or that there is full recovery of function.

While most bioacoustic specialists consider temporary hearing damage referred to as Temporary Threshold Shift (TTS) to be physiological fatigue, and not injury (Popper et al. 2006b), an organism that is experiencing TTS may suffer consequences of not being able to detect biologically relevant sounds such as approaching predators or prey, and/or mates attempting to communicate. Recent anecdotal information collected during monitoring of seabird response to pile driving for bridge and ferry terminal projects in Washington, have revealed information on behavioral responses to pile driving and documented behaviors that could be indicative of physiological effects. During replacement of the Hood Canal Floating Bridge a pigeon guillemot (*Cepphus columba*) dove within 75 meters of impact pile driving and quickly surfaced. It was then observed having difficulty getting airborne and shaking its head (Entranco and Hamer Environmental 2005). In January of 2007, monitoring staff at the Anacortes Ferry Terminal replacement project detected a murrelet within 20 meters of active pile driving. The bird was behaving aberrantly and monitoring staff followed it closely while simultaneously communicating with the contractor to cease pile driving. For approximately 15 minutes the bird drifted very close to shore, was listing to one side, and was seen paddling with only one foot. The observers noted that while most seabirds were leaving the area during pile driving, this bird did not dive or fly. After a few minutes the bird attempted to fly, but touched the water twice before landing again. Eventually the bird dove and was not observed again (Washington State Ferries 2007). Although it is impossible to know whether these individuals were suffering from TTS, the behavior they exhibited could have made them more vulnerable to aerial predators. For the purposes of this consultation, we will consider TTS to encompass two types of effects to individual murrelets, (a) a temporary hearing shift resulting from sensory hair cell loss that may take days or weeks to recover and (b) a temporary hearing shift brought on by sensory cell fatigue that may result in significant behavioral changes, but which is not considered injury.

Because an affected individual may not be able to detect biologically relevant sounds as a result of a permanent injury or during a sensory hair cell recovery phase, there may be significant adverse effects to the affected individual. In particular, murrelets are known to vocalize with their mate throughout the year, with cooperative foraging partners, with cohorts when coming inland, and with begging chicks. The inability to communicate could reduce their pair bonding abilities and foraging efficiency. Murrelets rely upon their hearing, especially while attending a nest, to detect potential predators, corvids in particular. Hearing impairment, even for a limited time, may increase predation risk.

Thresholds for lethal and sublethal effects from underwater detonations.

Underwater detonations can result in a variety of injuries to organisms exposed to elevated SPLs. Biologically key variables that factor into the degree to which an animal is affected include size, anatomical variation, and location in the water column (Gisiner et al. 1998). The Yelverton and Richmond (1981) and Yelverton et al. (1973) studies identified injury thresholds in relation to the size of the charge, the distance at which the charge was detonated, and the mass of the animal exposed. For fish and mammals, the Yelverton (1981) and Yelverton et al. (1973) studies found a correlation between the size of fish and mammals, and the impulse level needed to elicit an injury; that is, the greater the mass (weight of the fish/mammal), the greater impulse level needed to cause mortality or injury. Conversely, an organism with a smaller mass would sustain injury from a smaller impulse. While Yelverton did not do this analysis for birds, it is reasonable to expect that this correlation also applies to birds. The mean mass of the birds used in Yelverton's study was 1.16 kg for the mallards and 2.33 kg for Rouen ducks. Adult murrelets are generally much smaller, averaging 0.22 kg (Watanuki and Burger 1999, Hull et al. 2002). Given the correlations observed with fish and mammals in regards to weight and blast size, it is likely that murrelets would be impacted by even lower impulse levels than those identified by Yelverton for mallard and Rouen ducks.

Based upon the thresholds observed, Yelverton et al. (1973) developed a set of criteria at which injury and mortality resulting from exposure to underwater detonations could be expected for birds diving below the surface (Table 9). These thresholds are based on the impulse from an underwater blast, which is a better damage parameter than peak overpressure (Yelverton et al. 1973, Yelverton 1981). Because data are not available for developing a specific impulse level at which murrelets would be impacted, we will use the criteria established by Yelverton et al. (1973). Therefore, we assume murrelets will be mortally wounded by impulse levels of 138 Pa-sec or greater and significantly injured by impulse levels of 41 Pa-sec or greater. As described above, these criteria may underestimate mortality and injuries sustained by murrelets due to their smaller size.

A separate method for determining the maximum lateral extent of injury that is based on species weight is presented in O'Keefe and Young (1984). Because of the uncertainty associated with this type of calculation, the authors recommended multiplying the maximum lateral extent by at least a factor of two in order to provide an adequate margin of safety. However, we chose not to use this formula because of the uncertainty. Rather, we chose to accept the uncertainty of applying the criteria developed by Yelverton et al. (1973) to a much smaller bird.

Table 9 Blast attenuation criteria for injuries and mortality expected for birds (duck/mallards) diving below the surface as identified by Yelverton et al. (1973) and Yelverton (1981)

Criteria	Impulse (Pa-sec)
50% mortality - Survivors seriously injured and might not survive on their own.	310
1% mortality - Most survivors appeared unhurt, but sustained injuries to lungs, liver, and kidneys.	248
No mortality - Slight blast injuries and a low probability of eardrum rupture.	138
Low probability of trivial lung injuries and no eardrum rupture.	69
Safe level. No injuries.*	41

* Injuries that would be detectable only by histological examination, e.g. inner ear damage, were not considered.

Hearing. In previous consultations, the Service has anticipated physical effects, other than barotrauma, to occur above 180 dB_{peak} (USFWS 2008). Therefore, we anticipate that all murrelets underwater within the action area at the time of detonation that are exposed to 180 dB_{peak} or greater will be potentially subject to physical effects.

Estimated area in which murrelets may be exposed to mortality and/or injury underwater from detonations.

The Navy will conduct six 2.5-lb underwater detonations at the Crescent Harbor training area: one in November 2008, three in February 2009, and two in July 2009. Using the weak shock theory equations from Richardson et al. (1995) for characteristics of marine explosions, we calculated the range ($R_{distance}$) in meters that an impulse (Pa-sec) created by the 2.5 lb (1.13 Kg) C4 charges would take to attenuate to 41 Pa-sec (injury zone). The Richardson et al. (1995) formulas are based on trinitrotoluene, which has a lower energy than the C-4 explosives used by the Navy; therefore, we applied a factor of 1.1 to the C4 charge weight in order to derive an equivalent trinitrotoluene charge weight. The injury zone for a 2.5-lb charge at Crescent Harbor was calculated to be 210 meters.

The Richardson et al. (1995) formulas consider the charge depth and the bottom depth. We used 95-foot bottom depth for Crescent Harbor based on the deepest depth within the training area outlined in the Navy's Biological Assessment. For the purposes of this calculation, we assumed the depth of the charge and the receiver (in this case an individual murrelet) to be the same (i.e. on the seafloor). Based on murrelet foraging strategies, murrelets may not be at the seafloor. However, they could be very close; therefore, it is reasonable to assume for calculating an area of impact that they occur at the same depth as the charge.

Charges set in deeper or shallower water may have a greater or lesser distance of attenuation. Cavitation or refraction can change the impulse and lead to an increased impulse level at greater distances before the pressure attenuates beyond the injury zone levels. Because of the complexity required to adjust for bottom placement, cavitation, and refraction, we assumed the sea floor composition and water depth do not vary throughout the training areas. In addition, for the purposes of this consultation we assumed the acoustic energy would be constant throughout the vertical water column at a given horizontal range from the detonation. The underwater detonations are generally set on a substrate of mud, sand, or a combination of both, which in comparison to rock is relatively soft, thus it can absorb some of the energy from the explosion. The softer the substrate the more energy it can absorb without reflecting it into water column (NMFS 2008). The amount of energy absorbed is unknown; however, any reduction in energy transmission into the water column is beneficial in minimizing the effects of each detonation.

The Navy will also conduct four floating mine detonations (2.5 lbs of C-4): 1 in October 2008, 2 in April 2009, and 1 in June 2009. Floating mine detonations will transmit about 30 dB to 40 dB less energy into the water than subsurface detonations of similar a size (2.5 lbs of C-4). In addition, the energy, at least the vast majority, will propagate vertically into the water column with about thirteen degrees of dispersion (C. Greene, Greeneridge Sciences, pers. comm. 2006). Assuming a circle 3 feet in diameter (the approximate area occupied by a 55 gallon drum on its side), this would be the area that would transmit energy into the water column. Assuming the 13 degree energy dispersion as the energy propagates vertically into the water column, the area impacted by the downward energy pulse would be a circle with a radius of 23.4 ft at a depth of 95 ft. Another assumption is that any murrelets in the impact volume will be killed or injured independent of the actual amount of energy in the area of impact. Assuming a worst case, the impact area was considered a cylinder with a radius of 23.4 ft from 95 ft deep to the surface. This results in an impact area of 1,723.25 ft^2 (0.0002 sq km) at the surface.

Hearing. In order to calculate the distance at which the elevated SPL created by a 2.5-lb underwater detonation will attenuate to below 180 $dB_{peak,}$ we applied the practical spreading model. The range at which physical effects could be anticipated is 392 miles. However, the pressure wave will encounter land at considerably less distance. Therefore, we anticipate that the 2.5-lb underwater detonations will result in an SPL that exceeds 180 dB_{peak} throughout the entire action area.

The floating mine detonations may also result in SPLs that exceed 180 dB_{peak} within some or all of the action area, or they may not. The information provided by the Navy and the scientific data available to us does not readily enable us to derive a dB_{peak} measurement for these detonations. Without a dB_{peak} measurement, we cannot know if or the distance at which the SPL exceeds 180 dB_{peak}. Therefore, we cannot evaluate whether murrelets underwater may be susceptible to hearing injuries resulting from the floating mine detonations.

> Likelihood of murrelet exposure to mortality and/or injury underwater from detonations (includes murrelets underwater that are exposed to elevated underwater SPLs created by the floating mine detonations).

For the purposes of the analysis, we used the Poisson distribution to estimate the probability of one or more murrelets being exposed by one or more underwater or floating mine detonations or by the flying debris created by the floating mine detonations. The Poisson distribution is a discrete probability distribution that expresses the probability of a number of events (murrelets) occurring in a fixed period of time (detonation) if these events occur with a known average rate (murrelet density) and their occurrence is independent of the previous event.

We used Poisson's approximation of the binomial distribution to estimate the probabilities of 0, 1, or more murrelets occurring within the mortality/injury zone using the following formula: $P(X=0) = e^{-\mu}$; $P(X=1)=e^{-\mu}(\mu)$; $P(X=2)=(e^{-\mu})(\mu^2)/2$; etc (where X = occurrences in a unit of space (or time) which in our case is 0, 1, or more murrelets; μ = population mean number of occurrences per unit of space (or time), which in our case is the murrelet density within the mortality/injury area) (Zar 1984).

Using this method, we determined that there is a greater than 50 percent probability that 1 or more murrelets will occur within the mortality/injury areas associated with some of the detonations. However, the probability of occurrence may be 0.2, 0.02, or as low or lower than 0.001 for some detonations. In order to develop a biologically sensitive approach to quantifying murrelet exposure derived from probabilities of exposure less than 100 percent, we chose to use a probability of 10 percent as the break point at or above which we will consider 1 or more murrelets to occur and be subject to injury or mortality. For probabilities below 10 percent we will consider 0 murrelets to occur. We chose 10 percent for the following reasons:

- There is currently insufficient recruitment of juveniles to sustain a murrelet population in the listed range of the species; 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; the species' capability to recover from lethal perturbations at the population or metapopulation (Conservation Zone) scale is low; murrelet metapopulations are currently not self-sustaining. Therefore, actions resulting in mortality of breeding adults, eggs, or nestlings will contribute to the population decline of murrelets in the coterminous United States. Therefore, the status of the murrelet suggests a conservative approach should be used.

- Using a 50 percent breakpoint would appear to be a simple, logical course of action from a mathematical standpoint, in that there is an equal likelihood that a murrelet will or will not occur within the mortality/injury area at the time of detonation. This was suggested as an alternative. However, under this scenario, if the estimated probability was 0.50, there is also an equal chance of being wrong. Given the species status, using this threshold is not prudent for the conservation of the species because the risk of being wrong is too great. On the other hand, using 1 percent seems to be overly conservative, in that there is a 99 percent likelihood that no murrelets will occur in the mortality/injury area. Therefore, we chose 10 percent as a reasonably sensitive, intermediate value.

Estimation of the number of murrelets exposed to mortality and/or injury underwater from detonations (includes murrelets underwater that are exposed to elevated underwater SPLs created by the floating mine detonations)

In order to reduce the potential for the exposure of murrelets to underwater detonations, the Navy has committed to implementing the murrelet survey protocol out to 500 m for every underwater detonation. If murrelets are detected, the detonation will not occur. However, the survey will not detect all murrelets.

Using data from Evans Mack et al. (2002), we evaluated the Navy's murrelet survey protocol methods (including 2 observers, transect width of 100 m, boat speed equal to or less than 10 knots per hour, and two boats surveying in pattern designed to cover entire area twice), and determined that the probability of detecting a single murrelet would likely range from about 0.78 to 0.95. We took a conservative approach and assume the probability of detection is 0.78. Therefore, we will assume that 78 percent of the murrelets that may occur within the range where injury could occur will be detected during the survey and 22 percent will go undetected, and therefore may be subject to mortality and/or injury.

The Navy's murrelet survey method is designed to be implemented prior to the charges being set. All of the charges will use a manual detonation, which can have a lag time of up to 10 minutes, when the detonations cannot be halted and during which murrelets could enter the observed zone and be subject to mortality and/or injury. We have no method under which we can estimate this number of murrelets, but will assume these birds are accounted for in the 22 percent undetected murrelets.

We also needed to consider whether murrelets would be underwater at the time of detonation, where they would be injured or killed. There is very limited information regarding murrelet at-sea activity patterns, especially outside of the breeding season. Murrelets loaf, preen, pair-bond, mate, and forage at-sea. The focus of the following discussion is to determine the number of murrelets that may be underwater at the time of a detonation. Because murrelets are underwater while foraging, the discussion will focus on information known about murrelet foraging behavior.

Murrelets are wing-propelled pursuit divers that forage both during the day and at night (Carter and Sealy 1986). Henkel et al. (2003) found that the single individual they followed throughout a 24-hr period foraged throughout the daylight hours. Hamilton et al (2005) found a similar pattern of foraging throughout the day in the Xantus murrelet. Murrelets can make substantial changes in foraging sites within the breeding season. However, many birds routinely forage in the same general areas and at productive foraging sites (Carter and Sealy 1990, Whitworth et al. 2000, Becker 2001, Hull et al. 2001, Mason et al. 2002, and Piatt et al. 2007). Data on murrelet year-round foraging patterns are not available, but it is reasonable to surmise that their patterns of daily foraging and routinely foraging in the same general areas holds true throughout the year.

During the breeding season, the peak number of murrelets at feeding sites can occur at various times of the day. However, numbers generally increase early in the morning, decline gradually throughout the day, and sometimes increase again in the evening (Carter and Sealy 1990, Rodway et al. 1995, Day and Nigro 2000, Speckman et al 2000, Ronconi and Burger 2008, p. 250). In Alaska, murrelet at-sea counts were greatest during high and falling tides (Speckman et al. 2000), which may concentrate prey. Other alcids also exhibit a tidal rhythm in their feeding patterns (common murre (Slater 1976), ancient murrelets (Gaston et al. 1993), pigeon guillemots (Vermeer et al. 1993), and least auklets (Piatt et al. 1990b)).

Murrelets usually feed in shallow, near-shore waters between 5 m (16.4 ft) (Holm and Burger 2000, p. 319) and 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 bimodal 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 and Butler and Jones 1997). Jodice and Collopy's (1999) data suggest murrelets follow this same pattern as they forage for fish. In their study, Pacific sand lance (*Ammodytes hexapterus*), which occur throughout the water column undertook daily vertical migrations. Murrelets observed foraging in deeper water likely do so when upwelling, tidal rips, and daily activity patterns concentrate prey near the surface (Strachan et al. 1995).

Butler and Jones (1997) indicate diving birds may spend a large proportion of their time underwater, with foraging occurring in bouts during which a number of dives follow one another in relatively quick succession interspersed with relatively short pauses at the surface. Jodice and Collopy (1999) found murrelets follow this foraging pattern. Murrelet dive duration ranges from 8 seconds to 115 seconds, although most dives last between 25 and 45 seconds (Day and Nigro 2000, Jodice and Collopy 1999, Thoresen 1989, Watanuki and Burger 1999). The mean surface intervals between dives were 13 to 21 seconds, although the amount of time diving to time pausing varied within and between the individual murrelets (Jodice and Collopy 1999). Variations in dive-cycle patterns may be related to prey-capture effort. Jodice and Collopy (1999) observed an increase in dive bout duration when sea-state conditions worsened, which may reflect the increased effort required to locate, pursue, and capture prey, possibly because of increases in turbidity and associated decreases in light levels. For example, in an Alaska study, murrelets avoided feeding in waters with less than 2 meters of visibility (Day et al. 2003)

Prey type and availability appear to drive murrelet foraging behavior. Therefore, for the purposes of this consultation, the Service will make the following assumptions: (1) the at-sea activity patterns exhibited by murrelets during the breeding season are consistent throughout the year, (2) murrelets routinely return to productive feeding sites, (3) murrelets forage throughout the day, and (4) murrelets forage throughout the water column down to 157 ft. The action area has waters shallower than 157 ft and murrelets have been documented to occur at various times throughout the year, indicating that some murrelets find this area to be a productive feeding site. Therefore, murrelets may be present and actively foraging within the action area when a detonation takes place.

In Alaska, Day and Nigro found the proportion of murrelets feeding was between 40 and 60 percent, but differed by year, habitat type, sea-surface temperature and salinity, distance from shore, and water depth. In British Columbia, Ronconi and Burger (2008, p. 253) found the average proportion of birds foraging ranged from approximately 15 to 50 percent depending on location, time of day, breeding phase, year, and prey availability. However, these data were only collected during the summer breeding season(s).

The foraging bouts measured by Jodice and Collopy (1999) lasted 27 to 33 minutes, with 49 to 62 percent of that time spent underwater. The mean percent of time spent under water during foraging bouts measured by Varoujean and Williams (1995) on the same birds was found to be 64 to 72 percent. Mean foraging bouts measured by Henkel et al. (2003) ranged from 9 to 29 minutes, with a mean of 63 percent time spent underwater. A single bird observed by Henkel et al. (2003) spent 23.4 percent of the daylight hours engaged in diving bouts, which translates to 15.1 percent of the daylight hours spent underwater; however the researchers did not observe all diving bouts so the birds could have been engaged in foraging activities for a greater percentage of the day than was reported.

We recognize that not all murrelets within the action area are likely to be underwater at the time of detonation. However, we do not have data on measured daily activity patterns in any one season, much less throughout the year. Therefore, in order to predict the number of murrelets that may be underwater at any given moment, we will make the following assumptions based upon the information provided above: all murrelets within the action area are actively foraging and each individual murrelet spends up to 72 percent of that foraging bout underwater (based on the maximum mean percent of time spent underwater during a foraging bout as measured by Varoujean and Williams (1995)). Therefore, we will assume that 72 percent of all murrelets will be underwater at the time of detonation.

The distance derived by the weak shock theory equation is the distance from the charge at depth (i.e. 95 feet). In order to define the area of potential mortality and injury (injury/mortality zone), we defined a cylinder of 210 m extending from the sea floor to the surface. The estimated number of murrelets likely to occur within this area where injury and/or mortality could occur was derived by multiplying the monthly murrelet density estimate by the injury/mortality zone. The total estimated number of murrelets that could occur within the zone was then multiplied by 22 percent to estimate the total number of murrelets anticipated to occur within the injury zone that will go undetected during the survey and could be exposed to mortality or injury. The total estimated murrelets exposed was then multiplied by 72 percent to estimate the total number of murrelets anticipated to be underwater at the time of detonation and could be subject to injury and/or mortality. For the months when the estimated number of murrelets was less than one, we used the Poisson distribution to estimate the probability of one or more murrelets being exposed to an underwater detonation. When the probability was 10 percent or greater, we rounded up to one individual potentially being exposed to injury or mortality for each detonation. The Navy will conduct six 2.5-lb underwater detonations at the Crescent Harbor training area: 1 in November 2008, 3 in February 2009, and 2 in July 2009. Table 10 provides a summary of the estimated number of murrelets anticipated to be underwater at the time of detonation and could be subject to injury and/or mortality as a result of exposure to elevated SPLs underwater. Specific calculations and estimations are in Appendix D.

Table 10 Estimated number of murrelets anticipated to be underwater at the time of detonation and could be subject to injury and/or mortality.

Month with underwater detonation	Number of detonations per month	Murrelets
November 2008	1	1
February 2009	3	3
July 2009	2	0
Total		4

The Navy will conduct four floating mine detonations (2.5 lbs of C-4): one in October 2008, two in April 2009, and one in June 2009. However, the probability of murrelets being underwater within the mortality/injury area at the time of detonation of the floating mines was less than 10 percent in all cases. Therefore, we do not anticipate murrelets to be subject to mortality or barotrauma injuries resulting from underwater elevated SPLs associated with the floating mine detonations.

Assumptions on the potential for recovering a dead murrelet:

Our opinion is most murrelets that are killed while underwater will not be observed because they are likely to sink based on the following data:

a. Unlike other birds, some diving birds (including murrelets) have relatively solid bones (Erhlich et al. 1988, p. 507) to decrease their buoyancy and make diving easier.
b. A study by Wilson et al. (1992) indicated that the buoyancy of a dead bird is inversely related to depth (i.e. there is a depth at which the bird becomes neutral, then negatively bouyant). Diving species store a lower volume of air in their feathers than partially or non-diving species. When divested of feathers and respiratory air spaces and placed in fresh water, 91 percent of diving species sank, as opposed to 50 percent of partial and 35 percent of nondivers (Wilson et al 1992). Birds with higher body densities (such as auks and penguins) have low energy expenditure because they are neutrally bouyant at depth (have the least air in the feathers) (Wilson et al. 1992).
c. The influence of bouyancy on the cost of diving varies dramatically with dive depth in birds because air volumes in the respiratory system and plumage change with hydrostatic pressure (Wilson et al. 1992, Lovvorn et al. 1999, 2004; Enstipp et al. 2006). As the thickness of the insulative layer of air in bird plumage is compressed with increasing depth, heat flux across this layer is expected to increase and buoyancy decreases (Wilson et al. 1992; Gremillet et al 1998).
d. The unique structure of avian parabronchial respiratory system is dependent upon a constant volume of the lung during respiration for its function (Dunker 1972). The bird lung is rather rigid and attached along its dorsal surface to the ribs and vertebrae, while the associated air sac system is compliant. While the bird lung should not be collapsible, Jones and Furilla (1987) demonstrated that the anatomy

of diving birds probably allows for the collapse of the air sacs. Therefore, as the respiratory system is compressed according to Boyle's Law, (pressure x volume = constant), the air sacs must collapse and the air contained within move into the more rigid lung. However, as stated above, the lungs are particularly susceptible to rupture as a result of exposure to elevated SPLs and injuries may further reduce the air held in the lungs; thereby, further reducing bouyancy.

Estimation of murrelets exposed to injury on the surface from underwater detonations

The underwater detonations are not expected to result in elevated SPLs above the surface of the water because the water surface acts as barrier by reflecting the pressure wave back downward. However, birds on the surface could be affected by the underwater detonation because they are partially above and below the surface. In Yelverton's (1973) studies, ducks on the surface of the water did not show external signs of injury appeared underwater explosions; however, upon necropsy, the pattern of injuries was similar to those exhibited by the submerged ducks except for the absence of kidney damage (Yelverton 1973).

The principles and assumptions explained above in the thresholds for lethal and sublethal effects underwater will also be applied for our analysis of potential impacts from the underwater detonation to murrelets on the surface. Based on observed thresholds, Yelverton et al. (1973) developed a set of criteria at which injury and mortality resulting from exposure to underwater detonations could be expected for birds sitting on the surface (Table 11). These thresholds are based on the impulse from an underwater blast, which is a better damage parameter than peak overpressure (Yelverton et al. 1973, Yelverton 1981). Because we have not developed a method for determining a specific impulse level at which murrelets would be impacted, we will use the criteria established by Yelverton (1981). Therefore, we assume murrelets would be injured by impulse levels greater than 207 Pa-sec.

Table 11 Underwater Blast Criteria for Injuries Expected for birds (duck/mallards) on the water's surface as identified by Yelverton (1981)

Criteria	Impulse (Pa-sec)
50% mortality - Survivors seriously injured and might not survive on their own.	896-1034
1% mortality - Most survivors had moderate blast injuries and should survive on their own	690-827
No mortality - Slight blast injuries.	276-414
Safe level. No injuries.*	207

* Injuries that would be detectable only by histological examination were not considered.

Observations of seabirds, such as fulmars, gulls, and pelicans, indicate some birds may be attracted to forage on the stunned/dead fish after a detonation (Stemp 1985). Birds in these observations, where then exposed to injury resulting from further detonations. Murrelets are unlikely to be attracted to this foraging opportunity; however if any murrelets do enter the area after a blast, they will not be exposed to further elevated underwater SPLs because the Navy will only detonate one charge during each exercise.

The same rationale and methods used to estimate the area in which murrelets may be exposed to mortality and injury underwater (see "*Estimation of area in which murrelets may be exposed to mortality and/or injury underwater from detonations*" above) were applied to attenuate the impulses created by the different charge sizes to 207 Pa-sec (injury zone for birds on the surface). The calculated on-the-surface injury zone is 11 m for a 2.5-lb charge detonated underwater at Crescent Harbor.

In addition, the same rationale and methods used to estimate the number of murrelets exposed to mortality and injury underwater (see "*Estimation of murrelets exposed to mortality and/or injury underwater from detonations*" above) were applied to estimate the number of murrelets on the surface exposed to injury from the underwater detonations. We will assume that 78 percent of the murrelets that may occur within the range where injury could occur will be detected during the survey and 22 percent will go undetected and may be subject to injury. Of the birds that go undetected, we assumed that 72 percent are likely to be underwater at the time of detonation; therefore, we will assume the other 28 percent will be on the surface and exposed to injury. As with underwater mortality and injury, when the probability of exposure was 10 percent or greater we considered one individual to be exposed to injury. In all cases, the probability of murrelets being exposed to injury on the surface at the time of detonation was less than 10 percent. Therefore, we do not anticipate murrelets on the surface to be subject to injury due to elevated underwater SPLs associated with the underwater detonations.

Estimation of the number of murrelets exposed to injury in the form of hearing impairment from underwater and floating mine detonations

We do not have density information for murrelets which is appropriate to use for the entire action area. The underwater detonations will result in SPLs that will exceed 180 dB_{peak} throughout the action area. Therefore, we anticipate that all murrelets within the action area could experience effects to hearing. The blast overpressure that murrelets will experience underwater within the action area will decrease as the pressure wave moves away from the detonation site; therefore, the effects to the ear are likely to range from irreparable damage to temporary threshold shift to no injury. However, we have no information to predict at what distance effects may decrease from injury to temporary threshold shift to no injury. Therefore, for the purposes of this consultation, we will assume the following:

> The blast overpressure within the mortality/injury areas associated with the underwater detonations will be severe and is likely to result in irreparable damage to the ears.

Therefore, we anticipate all murrelets within the mortality/injury zone to be subject to injury as a result of irreparable damage to the ears.

The blast overpressure beyond the mortality/injury areas associated with the underwater detonations will be less severe but will be well above 180 dB_{peak}; therefore, damage to the ears could be severe enough that hearing could be impaired for a number of days or weeks as recovery occurs. Severity of hearing impairment is expected to vary across the action area. Hearing impairment may increase the risk of predation on individuals or their chicks or may result in the inability to communicate, thereby reducing their pair bonding abilities and/or foraging efficiency (these effects are described in the Behavior Section). We are not aware of any data that would allow us to ascertain the duration and magnitude of hearing loss for murrelets. While we anticipate all murrelets within the action area outside of the mortality/injury zone could be subject to injury as a result of cellular damage resulting in hearing impairment, we cannot determine the extent or duration of the damage, nor the number of individuals that will be injured. However, we anticipate there will be fitness (productivity) consequences to some individual murrelets within the action area (approximately 239 km^2).

As stated previously, a method for determining whether the floating mine detonations will result in SPLs that exceed 180 dB_{peak} is not available. Therefore, we cannot determine the number of murrelets that may be exposed to hearing impairment associated with the floating mine detonations.

Summary of lethal and sublethal effects from exposure to elevated underwater sound levels

The estimated number of murrelets killed or injured includes a considerable amount of uncertainty. The available density estimates may not accurately present murrelet abundance in the action area. The seabird monitoring protocol may be less or more efficient than we have anticipated. The mortality and injury thresholds are derived from data on other species and under different conditions, which may not present an adequate threshold for murrelets. However, we believe the data we have used is the best scientific data available and provides a reasonable estimation of the type, extent, and magnitude of injuries to murrelets that will be caused by exposure to Navy EOD activities.

Based on our assumptions and analysis, we anticipate four murrelets will suffer lethal or sublethal effects resulting from underwater exposure to SPLs in excess of 41 Pa-sec created by the underwater detonations. Sublethal injuries that do not immediately result in mortality could include internal organ damage, loss of vision, or hearing loss, all of which can significantly impair an individuals ability to carry out essential life functions such as flying, diving, breeding, feeding, and predator avoidance. We anticipate these injuries to result in reduced survival or loss of future reproduction.

Based on our assumptions and analysis, we do not anticipate murrelets will be subject to lethal or sublethal barotraumas while underwater from exposure to elevated SPLs created by the floating mine detonations and we do not anticipate murrelets will be exposed to lethal or sublethal barotraumas while on the surface from exposure to elevated SPLs created by the underwater detonations.

We anticipate murrelets underwater beyond the mortality/injury zone in the action area (approximately 239 km^2) will suffer hearing impairment from exposure to SPLs in excess of 180 dB_{peak} created by the underwater detonations. Depending on the magnitude and duration of the hearing impairment, it may reduce an individual murrelets ability to communicate, thereby reducing their pair bonding abilities and/or foraging efficiency. If a breeding adult is injured by an underwater detonation conducted during the breeding season, the hearing impairment suffered by the adult may significantly increase the risk of predation on its chick. However, we cannot determine the extent or duration of the hearing impairment, nor the number of individuals that will be affected. Nonetheless, we anticipate murrelets within the action area will be injured and for some of these individuals survival or productivity (i.e. fitness) will be reduced.

Water Plume

Stemp (1985) reported seabirds (primarily fulmars, kittiwakes, and gulls) were often stunned and a few were killed by the water blasts created by underwater detonations. Birds were killed if they were directly over large (25 – 125 kg) detonations that produced high (25-30 m) water blasts. In the third year of Stemp's (1985) study, mortalities were eliminated when the energy sources were changed to airguns and very small charges (0.23 kg), such that there was no appreciable effect on the water's surface. The Navy predicts there will be a water plume resulting from the detonations (see BA pg 105) but are unable to provided an estimation of how high the plumes may be or what force the plume may exhibit. Even though the 2.5-lb charges to be used by the Navy are less than half the size of the charges Stemp (1985) observed to kill birds, they are still likely to have an appreciable effect on the water's surface and may result in mortality or injury.

Implementation of the murrelet monitoring protocol greatly reduces the likelihood of murrelets being on the surface directly above any of the detonations. Except as stated above, we do not anticipate the monitoring protocol to detect 100 percent of the murrelets; therefore, 22 percent of the murrelets may go undetected and be subject to effects from the water plume. In addition, birds may enter the area and land on the surface during the approximately 10 minutes between the time the charge is set and detonation occurs. We currently have no method to estimate if or how often this is likely to occur, but will assume that these birds are captured in the 22 percent of undetected birds.

We will assume the area of the surface disrupted by the water plume is no greater than the area of the surface within which injury from the underwater detonation might occur (see elevated underwater SPL section). Therefore, the probability estimation made for murrelets exposed to injury on the surface can be used to estimate the probability of murrelets being exposed to the water plume, which is less than 10 percent. Therefore, we do not anticipate murrelets on the surface to be injured by the water blast associated with the underwater detonations.

Flying Debris

The Navy anticipates that debris from the floating mine detonations will be propelled up to 378 ft from the detonation point before hitting the water. If murrelets were struck by the flying debris, they may be killed or injured. A distance of 378 ft in all directions results in an 0.04082 km^2 area of impact. Implementation of the murrelet monitoring protocol greatly reduces the likelihood of murrelets occurring in the area of impact, although as previously stated, we do not anticipate the monitoring protocol to detect 100 percent of the murrelets. Therefore, 22 percent of the murrelets may go undetected and be exposed to the flying debris. In addition, birds may enter the area and land on the surface during the approximately 10 minutes between the time the charge is set and detonation occurs. We currently have no method to estimate if or how often this is likely to occur, but will assume that these birds are captured in the 22 percent of undetected birds. Of the birds that go undetected, we assumed that 72 percent are likely to be underwater at the time of detonation; therefore, we will assume the other 28 percent will be on the surface and exposed to mortality or injury within the area of impact. Under all the scenarios for which we did calculations, the probability of murrelets being exposed to injury on the surface from the flying debris was less than 10 percent. Therefore, we do not anticipate murrelets on the surface to be injured by the flying debris associated with the floating mine detonations.

Helicopters

About 50 percent of the floating mine training insertions are completed with a MH-60 Sierra helicopter. The helicopter takes off from Ault Field, flying at an elevation of about 500 ft, approaches Crescent Harbor from the north and flies around the harbor going about 70-80 knots looking for the float mark that identifies the simulated mine. The helicopter then descends and slows to < 1 knot and hovers about 10-20 ft above the water to insert the swimmers. The helicopter then flies to the survival area (NW shoreline of the Seaplane Base) were it waits for the charge to be set. On approximately 25 percent of these training exercises each year, the swimmers are extracted by helicopter, in which case, the helicopter returns to Crescent Harbor, slows to < 1 knot and hovers to retrieve swimmers.

The stressors that need to be considered related to helicopters include sound, visual image (predator), collision, and rotor wash. The sound associated with helicopters is discussed in the Elevated Above Water Sound Pressure Levels section.

The Navy did not provide an estimate of baseline aircraft use of this area; however, the associated station is a Naval Air Station with various aircraft that may come and go above Crescent Harbor. However, these flights likely do not include low level flight or hovering. The primary murrelet predators are other bird species (e.g. peregrines); therefore, murrelets are attuned to threats from above. We will assume that murrelets will perceive the approaching helicopter as a threat and will respond as they would to a potential aerial predator, by diving and/or heightening their awareness.

The use of the helicopter is fair-weather dependant; therefore, we expect murrelets that are in flight coming in or out of the area will be able to see the helicopter and avoid collision. 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 will assume any murrelet that flushes is likely to fly away from the perceived threat (helicopter), thus avoiding the likelihood of collision. Therefore, we will assume that murrelets are not likely to collide with the helicopter.

As the helicopter descends and hovers, downwash will be created at the water's surface. Rotor side and down wash are correlated to the helicopter's characteristics, such as speed, height, rotor span, and mass. At speeds less than 15 knots, the helicopter is considered to be hovering, at which the "downwash zone" is determined by 1.5 times the diameter of the rotor disk (K. White, pers. comm. 1994), which in this case is 81 ft (1.5 times 54-ft total blade length). Downwash immediately under the helicopter is about 60 mph, but when the helicopter is above 100 ft, downwash at the water's surface will be more like a breeze (Approximately 15 mph) (Karen White, U.S. Army (ret), pers. comm. 2001). After the helicopter achieves effective translational lift (usually at speeds greater than 25 knots), downwash is reduced in intensity and distance by 50 percent or more (K. White. pers. comm. 1994). Therefore, as the helicopter descends below 100 ft and begins to hover, murrelets that are within the downwash area will be exposed to "winds" of at least 60 mph.

In order to estimate the number of murrelets exposed to downwash, we calculated an area on the surface that is 81 ft wide by the distance it will take the helicopter to descend from 100 ft to 10 ft. We used right triangle trigonometry to estimate this distance, based on a 20-degree and 30-degree angle of descent. The areas of exposure are 1.86 km^2 and 1.17 km^2 for 20-degree and 30-degree angles of descent, respectively. The same rationale and methods used to estimate the number of murrelets exposed to mortality and injury above were applied to estimate the number of murrelets on the surface exposed to downwash. The probability of exposure of at least 10 percent leads us to round to one individual exposed to downwash in all months of the year, except April through August, when the probability is less than 10 percent. The Navy will conduct 4 floating mine detonations: 1 in October 2008, 2 in April 2009, and 1 in June 2009. Of these, 50 percent of which will utilize helicopters to insert divers; therefore, we anticipate helicopters to be used on at least 2 of the floating mine exercises. Three of the four floating mine exercises will occur between April and August; therefore, if helicopters are used during these exercises, we do not anticipate any murrelets to be exposed to downwash. One murrelet may be exposed to downwash if a helicopter is used during the October 2008 floating mine detonation.

Published literature regarding helicopter impacts on wildlife focus on noise and visual stimuli, rather than potential injuries caused by downwash; however, we cannot discount that effects may occur. Therefore, for the purposes of this analysis we will make the following assumptions. Murrelets are subject to natural wind events (sometimes in excess of 60 mph), throughout their lives, both in the terrestrial and marine environments, but the direction of the "wind" created by the helicopter comes straight down, rather than from the side so it does not simulate a natural wind event. We anticipate murrelets to perceive the approaching helicopter as an aerial threat and their primary response will be to dive. The length and distance of the murrelet's dive may not be far enough or long enough to avoid the helicopter as it hovers, which may cause the murrelet to dive repeatedly to escape the perceived threat. However, it is expected that the likelihood of injuries from the downwash will be insignificant because of the diving. Effects due to the behavioral response to helicopters are addressed in the following sections.

Activities that could result in Behavioral Responses

When an animal encounters humans or human activities, ranging from low-flying helicopter to the quiet wildlife photographer, an animal's response appears to follow the same economic principles used by prey when they encounter predators (Beale and Monaghan 2004; Frid 2003; Frid and Dill 2002; Gill et al. 2001; Harrington and Veitch 1992; Lima 1998; Romero 2004). The level of perceived risk may result from a combination of factors that characterize disturbance stimuli, along with factors related to natural predation risk (e.g., Papouchis et al. 2001). In response to that perceived threat, animals can experience physiological changes that prepare them for flight or fight responses or they can experience physiological changes with chronic exposure to stressors that have more serious consequences such as interruptions of essential behavioral or physiological events, alteration of an animal's time budget, or some combinations of these responses (Frid and Dill 2002; Romero 2004; Sapolsky et al. 2000; Walker et al. 2005).

The behavioral response of animals to human disturbance have been documented to cause animals to abandon nesting and foraging sites (Henson and Grant 1991; Gill et al. 1996; Fowler 1999), cause animals to increase their activity levels and suffer premature deaths or reduced reproductive success when their energy expenditures exceed their energy budgets (Daan et al. 1996; Giese 1996, Mullner et al. 2004;), or cause animals to experience higher predation rates when they adopt risk-prone foraging or migratory strategies (Frid and Dill 2002).

There are no known studies or data 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 attempts, and precluded access to suitable foraging habitat. The aspects of the Navy EOD activities that may elicit a behavioral response from a murrelet include exposure to elevated SPLs underwater and above water and helicopters. The following discussion presents our analysis process for determining an individual's likelihood of exposure to elevated SPLs that could result in a behavioral response and then provides a discussion on how murrelets are likely to respond.

Elevated SPLs underwater

High underwater SPLs can cause a variety of behavioral responses that have not been well studied. There is a continuum of effects, but there is no easily identifiable point at which behavioral responses transition to physical effects. Further confounding the issue is the fact that most of the information on the behavioral effects of underwater sound is from studies using pure tone sounds. Sounds generated by underwater blasts, however, are impulsive sounds and are made up of multiple frequencies/tones, making comparisons with existing data difficult.

There is no information on the effects of behavior disruption on murrelets resulting from high underwater SPLs and limited information on other types of seabirds. Richardson et al. (1995-not marine mammal noise book) speculated that a high underwater sound pulse (from underwater explosions) may interrupt foraging dives and cause a return to the surface, or that some might leave the area; however, he also found that available evidence suggested that the latter is unlikely. Stemp (1985) found the number of Northern fulmars (*Fulmarus glacialis*), black-legged kittiwakes (*Rissa tridactyla*), and thick-billed murres (*Uria lomvia*) that were within a few hundreds meters of a seismic vessel and were exposed to repeated underwater explosions did not differ consistently during periods with and without explosions.

Other data relevant to the effects of underwater sound on birds is from a study conducted on common eiders (*Somateria molissima*) using underwater noise as means to deter them from preying on mussel farms (Ross et al. 2001). In this study, after actual hazing of the eiders with motor boats, recordings of motor boats were played underwater. The study concluded that the motor boat sounds played underwater were effective at keeping eiders away. These findings suggest that some diving birds are able to detect and alter their behavior based on sound in the underwater environment.

Threshold for behavioral changes from elevated SPLs underwater

With the exception of the few bird studies mentioned above, behavioral response information must be drawn and extrapolated from literature on fish in order to evaluate potential effects to murrelets. Turnpenny et al. (1994) attempted to determine a level of underwater sound that would elicit behavioral responses in brown trout, bass, sole, and whiting. With brown trout an avoidance reaction occurred above 150 dB_{rms} and other reactions (e.g., a momentary startle), were noted at 170-175 dB_{rms}. The report references Hastings' "safe limit" recommendation of 150 dB_{rms} and concludes that the Hastings' "safe limit" provides a reasonable margin below the lowest levels where fish injury was observed. In an associated literature review, Turnpenny and Nedwell (1994) also state that the Hastings' 150 dB_{rms} limit did not appear overly stringent and that its application seemed justifiable. Additionally, observations by Feist et al. (1992) suggest that sound levels in this range may also disrupt normal migratory behavior of juvenile salmon.

More recently, Fewtrell (2003) held fish in cages in marine waters and exposed them to seismic airgun impulses. The study detected significant increases in behavioral responses when sound pressure levels exceeded 158 – 163 $dB_{rms.}$ Responses included alarm responses, faster swimming speeds, and tighter groups and movement toward the lower portion of the cage. It is difficult to discern the significance of these behavioral responses. The study also evaluated physiological stress response by measuring plasma cortisol and glucose levels and found no statistically significant changes. Conversely, Santulli et al. (1999) found evidence of increased stress hormones after exposing caged European bass to seismic survey noise.

Clearly, there is a substantial gap in scientific knowledge on this topic. The most recent study by Fewtrell presents, at least, some experimental data on behavioral responses of fishes to impulsive sounds above 158 dB_{rms}. Given the large amount of uncertainty, however, that lies not only in extrapolating from experimental data to the field, but also between sound sources (airguns vs. blasting), and also from one species to another, we believe it is appropriate to utilize a conservative threshold. As such, for the purposes of this analysis, the Service will anticipate that SPLs in excess of 150 dB_{rms} can cause behavioral changes in murrelets.

Estimation of murrelets exposed to underwater elevated SPLs which could result in behavioral changes

To estimate the geographic area in which effects are expected, the distance at which transmission loss (TL) attenuates the pressures to below the thresholds must be estimated. Calculating TL is extremely complicated, and is likely to be site-specific. The Service has determined that a practical spreading model, as described by (Davidson 2004) [TL = 15*Log(R)] is the appropriate model to estimate the distances at which injury and behavioral disruption are expected. This model assumes that SPLs decrease at a rate of 4.5 dB per doubling distance.

Generally, the Service would apply the practical spreading model to estimate the distance at which SPLs are no longer in excess of 150 dB_{rms} (the dB below which we assume significant behavioral changes do not occur). However, at this time we have not been able to determine a maximum dB_{rms} generated by the detonations, which is needed in order to apply the model. Therefore, we cannot predict numerically the underwater area over which murrelets will be exposed to SPLs in excess of 150 dB_{rms}.

However, we do have a calculated dB_{peak} for the underwater detonations. In general, dB_{rms} is approximately 20 dB lower than dB_{peak}. When we apply the practical spreading model, the range at which behavioral changes would be exhibited for a 2.5-lb charge is 1,820 miles. However, the elevated SPL would encounter land at considerably less distance. Therefore, we assume that all murrelets underwater within the action area (approximately 239 km^2) at the time of detonation will be exposed to SPLs exceeding 150 dB_{rms} and may exhibit behavioral changes.

Summary of Elevated Underwater Sound Levels Thresholds resulting in Behavioral Responses

We anticipate all murrelets exposed to underwater SPLs in excess of 150 dB_{rms} to potentially exhibit behavioral changes. The 2.5-lb charges will result in SPLs in excess of 150 dB_{rms}, which will not attentuate below this threshold prior to encountering land. Therefore, we anticipate all murrelets underwater in the action area (approximately 239 km^2) at the time of the detonation that are not killed or injured to be exposed to SPLs in excess of 150 dB_{rms} and to potentially exhibit behavioral changes.

Elevated Above Water Sound Pressure Levels

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 2003). There are two sources of elevated SPLs above water associated with the Navy EOD activities, the floating mine detonations and the helicopters. Elevated above water SPLs may result in murrelets flushing, relocating out of the area, interrupting foraging bouts, and interrupting resting attempts.

Floating Mine Detonations. The Navy did not provide an estimate of the dB created by the floating mine detonations. Therefore, we approached this using two different methods. The first was based on using the dB (SPL) re 1µPa calculated for the 2.5-lb underwater detonation (see methods in underwater section), converting to dB (SPL) re 20µPa for in air, then attenuating the dB (SPL) to 92 dBA (we recognize these are not the same reference) using the basic formula of 6 dB attenuation for every doubling of distance. The second method used formulas from the Blasters Handbook (Dupont 1980) for blasts in air (Pressure (psi) = 82(R/W^0.33)^-1.2, where R = range in feet and W = charge weight in pounds), then followed the same attenuation of -6 dB for every doubling of distance. Under either method, the in-air sound does not attenuate to 92 dB for at least 100 miles across the water. The sound will reach land in all directions considerably closer than 100 miles. Once reaching land, the sound will no longer affect murrelets in the marine environment, and will not affect murrelets in the terrestrial environment because there is no suitable terrestrial habitat within these areas. Therefore, we anticipate that all murrelets within the action area (approximately 239 km^2) that are on the surface at the time of a floating mine detonation will be exposed to elevated SPLs.

Helicopters. The Navy did not provide dB levels for the MH-60 Sierra; however, this ship is equivalent to the Army's UH-60 Blackhawk. Sound measurements indicate that the Blackhawk produces sound of at least 108 dB(A) (USDOD 2004; King et al. 1996), which is in excess of 92 dB(A). As the helicopter slows and begins its hover, the sound will increase at the water's surface. Because the helicopter flies around Crescent Harbor searching for the float mark, descends, hovers to off-load divers, rises, leaves area, returns, hovers to pick up divers, rises, and leaves area we will assume that all of the murrelets on the surface in Crescent Harbor will be exposed to elevated SPLs when a helicopter is used to insert and/or remove divers for the floating mine detonations.

Boat and Diver Activity

Boats will be used to conduct the murrelet surveys, to insert and remove the divers, and to provide security for both the underwater and surface detonations. The Crescent Harbor training site, outside of training exercises, is open to the public; therefore, the boat and diver activities associated with the EOD operations will be less than the normal/everyday boat and diver activities to which murrelets are exposed. Our assumption is that if murrelets use these sites, they are accustomed to the daily activity levels. On any given training day, the activity level at this site may actually be reduced because the Navy restricts access. Therefore, we do not anticipate the Navy EOD boat and diver activities to significantly affect murrelets at the Crescent Harbor training area.

Behavioral Responses to underwater and above water elevated SPLs and Navy surface activities

Based on the evidence available from empirical studies of animal responses to human disturbance, murrelets are likely to exhibit one of several behavioral responses upon being exposed to the Navy EOD activities: (1) they may try to avoid exposure to activities that they perceive as threatening by flushing, relocating out of the area, interrupting foraging attempts, increased diving, or interrupting resting attempts; (2) the activities may command a murrelet's attention and reduce its ability to perform other behaviors, such as pair bonding, foraging, or resting; (3) they may exhibit disorientation or behaviors associated with “allostasis” or physiological stress responses; or (4) they may continue their pre-disturbance behavior and cope with the behavioral consequences. Murrelets might experience one of these behavioral responses or they might experience a combination of several of these behaviors (for example, a murrelet might continue its pre-disturbance behavior for a period of time, then try to avoid the activities after it experiences the consequences of physiological stress).

Each of the activities considered in this BO is likely to elicit different responses. Murrelets are likely to respond to elevated SPLs underwater by interrupting their foraging dive, dropping or swallowing fish intended for chick provisioning, and disorientation. Elevated above-water SPLs created by the helicopter and detonations of the floating mines may result in murrelets flushing, relocating out of the area, interrupting foraging bouts, and interrupting resting attempts.

Exposure to elevated underwater SPLs may cause avoidance of suitable foraging habitat. However, each of the detonations is a single occurrence and the occurrences are spread throughout the year. Therefore, other than temporary disturbance or displacement, is it unlikely the Navy EOD activities will preclude murrelets from accessing suitable foraging habitat within the action area.

We anticipate murrelets will perceive the approaching helicopter as a threat and will respond as they would to a potential aerial predator, by diving and/or heightening their awareness. However, the length and distance of the murrelet’s dive may not be far enough or long enough to avoid the helicopter as it hovers, which may cause the murrelet to dive repeatedly to escape the perceived threat. The response to a potential predator and the increased diving behavior to escape the helicopter may be interrupting foraging bouts or resting attempts.

We do not anticipate the Navy EOD boat and diver activities to affect murrelets because these activities are likely to be less than the normal/everyday boat and diver traffic to which we assume the murrelets using this area are accustomed.

Any murrelets within the action area at the time of a training exercise could potentially have one or more behavioral responses, although responses are likely to vey greatly. These various behavioral responses could result in a reduction in time spent foraging, increased expenditure of energy (i.e. less time resting), and allostasis (stress).

<u>Effects from Behavioral Responses and sublethal injury (effects to hearing)</u>

We anticipate that effects from behavior alteration and effects to hearing would be manifested in reduced foraging ability, increased energy expenditure, allostasis, and an increased risk of predation. These are discussed below.

Reduced Foraging Ability

Murrelet survival and reproduction is dependant upon an adequate quantity of high quality food throughout the year. Adequate food resources are necessary to survive winter, undergo molts, prepare for breeding in the spring, and to feed chicks during rearing. Wintertime distribution of murrelets appears to be related to concentrations of prey species (Dawson et al. 2007). Murrelets must select foraging sites that provide adequate prey resources, such as consistent levels of higher trophic-level fishes (Becker 2001), which are within swimming distance (Carter and Stein 1995, Nelson 1997) during the pre-basic molt when they are flightless. Murrelets can make substantial changes in foraging sites during the breeding season, but many birds routinely forage in the same general areas and at productive foraging sites, (Carter and Sealy 1990, Whitworth et al. 2000, Becker 2001, Hull et al. 2001, Mason et al. 2002, and Piatt et al. 2007).

Murrelet diets appear to reflect what is most abundant and/or of the highest quality of prey available at the time (Becker et al. 2007; Kuletz 2005). However, evidence from California and British Columbia indicates that historic prey was of higher quality than prey currently used by murrelets. Specifically, they have shifted to lower trophic-level food items (e.g. krill, sandlance, and rock fishes) in response to reductions of higher-trophic level prey (e.g sardines in California) (Becker and Beissinger 2006, Norris et al. 2007).

The potential effects of the decline in higher trophic-level food items are most significant during egg development (Becker and Beissinger 2006). Murrelets lay a single egg weighing about 25 percent of their prebreeding body mass, which suggests that egg production is energetically costly and dependant on the availability of adequate prey. For example, a large proportion (50-90 percent) of murrelets foregoes breeding in central California and may do so because they cannot find sufficient food resources during preparation for breeding (Peery et al. 2004).

Prey quality can contribute substantially to the reproductive success or failure of seabirds. Dietary energy content is often the limiting factor for seabird breeding success (Litzow et al. 2002). Research on a variety of seabirds related to the murrelet indicates reproductive success and chick survival is higher when diets consist of high-lipid content prey (Litzow et al. 2002; Romano et al. 2006). Nestlings reared on high-lipid prey ingest more energy per unit of biomass and metabolize it more efficiently (Romano et al. 2006) documented large differences in the body mass growth of nestlings fed different diets, although there was less difference in the growth of wing feathers. This suggests undernourished nestlings may allocate nutrients to wing growth instead of mass gain, thereby increasing the chance that the nestling will be underweight at fledging. Litzow et al. (2002) theorize that below some threshold of high-lipid prey availability, the guillemots they studied were unable to achieve the maximum rates of provisioning needed for chicks to fully develop. Prey type (high vs. low-lipid content) may also affect stress levels. Studies by Kitaysky (et al.1999, 2003, 2005, 2007) indicate baseline levels of corticosterone are significantly higher in nestlings fed pollock (low-lipid content) than in those fed an equal biomass of sand lance or herring.

Adult murrelets typically feed larger fish (i.e. age-1+ herring) to chicks and feed on smaller fish themselves. Kuletz (2006) found that age-1 herring are the optimum prey resource for raising murrelet chicks because a herring weighing about 23 grams delivers about 1.37 kJoule/fish. If chicks are fed smaller herring or other fish species, more of those fish need to be delivered per day to get a similar energy delivery. For example, the number of age-2 sand lance (12 grams, 68 kJoule/fish) required for a murrelet to reach fledging weight is double the number of age-1 herring needed to obtain an equivalent weight.

Because of the difference in energy content between prey species, Kuletz (2006) found that murrelets delivering fish other than age-1 herring may have to increase prey deliveries by up to 4.2 times per day to deliver the kJoules necessary for a chick to reach fledging weight. This can result in a substantial increase in energy expenditure by the parents, both in capturing prey and delivering it to the chick. Increases in prey capture and delivery efforts by the adults results in reduced adult body condition by end of the breeding season, and increases the predation risks to adults and chicks as more trips inland are required (Kuletz 2006). While increasing the number of trips may be possible, Ronconi and Burger (2008) found that even though murrelets increased their foraging effort during years of low prey availability, they were not able to maintain normal levels of reproductive success. This may be because adults were unable or unwilling to adequately adjust chick provisioning rates, because of the predation risks associated with nest attendance during the day.

Adult seabirds may undertake either a “fixed” or “flexible” investment in their reproductive efforts (Velando and Alonso-Alvarez 2003). For example, a long-lived seabird may have a “flexible” reproductive effort in accordance with offspring demand and condition, such that when food is easily available and parents are in good condition they can compensate to some extent to meet chick requirements, but they may be unable to do so when resources are less available. Other seabirds may have a “fixed” level of investment in their current reproduction, independent of offspring requirements, such that they cannot compensate to meet chick requirements. Ronconi and Burger (2008) hypothesize that murrelet life-history strategy likely follows the “fixed” investment hypothesis, whereby adults compromise reproductive investment (i.e. they do not initiate nesting or abandon the nest) to ensure their own survival when available forage is inadequate or not synchronized with breeding activities.

A lack of high quality forage at the appropriate time of year may explain the low nest initiation rates and nesting success observed by Bloxton and Raphael (2008) and the low juvenile-to-adult ratios observed by Raphael in Conservation Zone 1. In other words, murrelets are not initiating nesting or abandoning during incubation/chick rearing in order to ensure their own survival. For those murrelets that do initiate nesting and begin chick rearing, capture and delivery of sand lance further compromises their 1) breeding success, because they may not be able to deliver the quantity of prey necessary for chicks to reach fledging weight and 2) survival, because attending a nest during the day increases likelihood of predation upon both the adult and chick. Thus, changes in marine prey availability may be a limiting factor to the lifetime reproductive output of murrelets (Becker et al. 2007, Norris et al. 2007, Ronconi and Burger 2008).

The Navy EOD activities may reduce an individual murrelet’s foraging capabilities and/or success in a variety of ways: (1) forage fish will be killed by the underwater detonations, potentially reducing prey abundance; (2) sublethal injuries may reduce or impair a murrelet’s ability to dive or cooperatively forage with cohorts; (3) the underwater detonations may cause an adult murrelet to drop or swallow a fish intended for chick provisioning; (4) the activities may cause a murrelet to relocate to a less desirable foraging location; and (5) foraging may be interrupted or delayed.

Murrelet presence (i.e. bird densities and distribution) in the action area indicates prey are available throughout the year within the action area, and are concentrated at specific locations. Of particular importance are prey that provide higher lipid content, such as herring and sand lance. The Navy EOD detonations will result in the mortality of murrelet prey species (See discussion on effects to Forage Fish in Bull Trout Section). However, the impact this mortality will have on forage fish availability is unknown. Forage fish mortality will occur during both murrelet molting periods, the winter, and the murrelet breeding season, which could affect their ability to undergo molt, survive winter, or may cause an adult murrelet to compromise their reproductive investment (i.e. not initiate nesting or abandon an active nest) to ensure their own survival. However, the magnitude of the effects to individual murrelets from a reduction in prey is unknown.

Murrelets spend 30 days incubating an egg (15 days/mate, every other 24-hrs) and 30 days rearing a chick. Activities that cause an adult murrelet to delay or abandon a foraging opportunity or relocate to a less productive foraging area may result in compromised reproduction if an adult was unable to adequately forage and (a) begins its turn incubating and departs prematurely or (b) doesn't relieve its mate. Activities during the breeding season that cause an adult murrelet to delay or abandon a foraging opportunity, relocate to a less productive foraging area, or drop/swallow a fish intended for a chick may result in (a) the adult compromising (abandoning) reproduction, (b) reduced adult body condition as the adult makes more foraging dives or trips inland, or (c) reduced chick condition because the chick does not receive the kJoules necessary to reach fledging weight.

The Navy will conduct 5 training exercises (3 floating mine and 2 underwater detonations) during the 2009 breeding season. Each of these exercises will be 1 day or a portion of a day during which the activities may cause murrelets to interrupt or delay foraging attempts, drop/swallow fish intended for chicks, or relocate to a lower quality foraging area. While these exercises are spread out during the breeding season, any 3 of the exercises could overlap with the full length of an individual's 60 day breeding cycle, thus impairing the success of their breeding.

Murrelets are also sensitive to disruptions of foraging during the prebasic molt, when they are flightless and cannot relocate easily. Therefore, activities during this time of year that disrupt foraging can result in (a) increased energy expended attempting to relocate, (b) relocation to a lower quality foraging area, (c) longer time taken to undergo the molt process, (d) increased stress, or (e) reduced fitness. The intensity of these effects is likely linked to the duration of the disruption. The activities at Crescent Harbor will be one day or a portion of a day for each training exercise to be held in October and November 2009; therefore, murrelets may increase their energy expenditure trying to move away (which would not include flying) and possibly relocate to a lower quality foraging area. However, this disruption would be short-term and they could choose to return after the exercises. Therefore, we do not anticipate effects that could result from long-term disruption of foraging during the prebasic molt, such as longer molt time or reduced fitness.

Energy Expenditure

Negative impacts on a birds' daily energy budget can occur when outside influences reduce foraging and/or increase energetically costly behaviors, such as diving and flight (diving ducks: Korschgen et al. 1985, American coot [*Fulica americana*]: Schummer and Eddleman 2003). Research on marbled and Kittlitz's (*Brachyramphus brevirostris*) murrelets document that these species are negatively affected by human activities in the marine environment (Kuletz 1996; Hamer and Thompson 1997; Agness et al. 2008; Bellefleur et al. 2008). Reactions to disturbances include both flying and diving. Flying is energetically expensive for alcids, due to their short wings and heavy bodies (Pennycuick 1987). Although significantly more murrelets choose to dive rather than fly (Hamer and Thompson 1997; Agness et al. 2008; Bellefluer et al. 2008), they will react by flying when approached from greater distances or at faster speeds and juveniles are more likely to fly than adults (Bellefluer et al. 2008). Of the murrelets that reacted by flying, 83 percent left the feeding area (> 200 m) (Bellefleur et al. 2008).

Adult marbled and Kittlitz's murrelets holding fish commonly respond to disturbance by diving, regardless of disturbance speed, size, or approach distance (Speckman et al. 2004; Agness et al. 2008). This dive behavior was not observed for fish-holders in the absence of disturbance; therefore, the combination of the time and effort invested in the held fish, the greater flight lift-off cost (due to fish mass), and the unwillingness of the bird to expend energy by taking off, may make a dive response the only prudent option. In addition, Speckman et al. (2004) found some murrelets ate fish they were holding if repeatedly disturbed. The biological impacts of this behavior could be significant to the adult murrelet that expends additional energy to catch another fish and to their chick if a meal is not delivered (Speckman et al. 2004).

Outside influences that lead to more diving or flying will increase the energy expended and reduce the energy reserves. This could lead to decreased survival rates for adults, subadults, and/or chicks, depending upon the time of year when this increased energy expenditure occurs. 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. As discussed in the foraging section, murrelets likely have a "fixed" level of investment in their reproduction and are unable to compensate should foraging be reduced or additional energy expenditure be required; therefore, they may choose to abandon reproduction in order to ensure their own survival. During the prebasic 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.

We anticipate murrelets' energy expenditure will be increased above normal when they flush; relocate out of the area; increase their diving effort to replace lost foraging opportunities, replace prey dropped or swallowed, or to escape from perceived predators (i.e. helicopters and boats); and increase their diving and inland flights to feed a chick in order to compensate for a dead or injured mate.

Between October 2008 and December 2009, the Navy EOD will conduct 10 training exercises:

(a) 2 exercises during the prebasic molt; (b) 3 exercises in February 2009 as murrelets are undergoing the pre-alternate molt and preparing for breeding; and (c) 5 exercises during the breeding season. Each of the exercises will be one day, during which we anticipate murrelets within the action area (approximately 239 km^2) may increase their energy expenditure above normal levels.

There is a potential that increased energy expended during the prealternate molt and breeding could affect nest initiation or result in reduced nest success in 2009, but should not result in long-term reduced fitness or reproductive success of individuals.

Allostasis

Stress is an ambiguous term. Therefore "stress" researchers have begun using the term "allostasis" to define the process through which organisms maintain stability by actively adjusting behaviorally and physiologically to both predictable (e.g. seasonal changes) and unpredictable events (e.g. storms, predation) (McEwen and Wingfield 2003, Korte et al. 2004). A classic stress response begins when an animal's central nervous system perceives a potential threat to its homeostasis, thereby triggering a biological response that consists of a combination of behavioral responses, autonomic nervous system responses, and neuroendocrine responses (Buchanan 2000). Allostatic load refers to the cumulative wear and tear on the body as the adrenal hormones, neurotransmitters, or immuno-cytokines are released in response to the event. The benefits of allostasis and the costs of allostatic load produce trade-offs in health and disease.

In the case of many stressors, an animal's first and most economical (in terms of biotic costs) response is behavioral avoidance of the potential stressor or avoidance of continued exposure to a stressor. An animal's second line of defense to stressors involves the autonomic nervous system and the classical "fight or flight" response which produces changes in heart rate, blood pressure, and gastrointestinal activity (Buchanan 2000, McEwen and Wingfield 2003, Korte et al. 2004) that humans commonly associate with "stress". These responses have a relatively short duration and may or may not have significant long-term effect on an animal's fitness. When an animal does not have sufficient energy reserves to satisfy the energetic costs of a stress response, energy resources must be diverted from other biotic functions, which impair those functions that experience the diversion (allostatic load). For example, when a stress response diverts energy away from growth in young animals, those animals may experience stunted growth. When mounting a stress response diverts energy from egg production, an animal's reproductive success and its fitness will suffer.

The behavioral and physiological reactions to short- versus long-term stress will vary in extent and consequence. The rapid onset of an unpredictable stress event, such as a predatory attack, will bring on stress responses that are designed to aid an animal through immediate short periods of stress. Stress continuing over longer periods (i.e. days to weeks) may result in deleterious chronic effects like increased susceptability to fatigue and disease (Buchanan 2000).

Relationships between the physiological mechanisms, animal behavior, and the costs of stress responses have been documented in seabirds (Holberton et al. 1996, Hood et al. 1998, Kitaysky et al. 1999) and a variety of other vertebrates (Jessop et al. 2003, Krausman et al. 2004, Romano et al. 2004, Smith et al 2004a and 2004b, Trimper et al. 1998). Although no information has been collected on the physiological response of murrelets to stress, the studies on other seabirds and vertebrates would lead us to expect some murrelets to experience physiological stress responses upon exposure to the underwater detonations, the floating mine detonations, and the helicopters. Because of the relatively short duration of the training exercises, we do not expect these responses to continue long enough to have fitness consequences for individual murrelets. However, those murrelets that are injured (hearing impairment) may experience physiological responses that would be classified as "allostatic load" that may result in deleterious chronic effects that reduce the fitness of those individuals.

Risk of Predation

The Navy EOD activities can increase the risk of predation on murrelets in a number of ways. Murrelets could be exposed to additional predation as they move from place to place. In order to avoid predators, trips back and forth to the nest are best conducted under cover of darkness. This helps prevent predators from seeing the adults enter and exit the nest. Trips that must be conducted during daylight hours become perilous to the adults and young, by exposing them to the predators. If murrelets are forced to leave an acceptable foraging area or drop or swallow fish intended for a chick, and additional foraging effort is required, the adult must weigh the risk of compromising the chick's growth and ability to reach fledging weight against the risk of predation associated with conducting an *additional* daytime flight. We anticipate the risk of predation on breeding adults will be increased by the exercises conducted in June and July 2009 that potentially necessitate additional foraging time and flights inland during the daytime.

Risk of predation may also be increased if an individual suffers a hearing impairment. While we presume murrelets are primarily vision-oriented when foraging and detecting predators, they rely upon their hearing to communicate with foraging cohorts and mates, which may also facilitate predator avoidance in the marine environment. We anticipate the risk of predation due to hearing impairment in adults, subadults, and recently fledged chicks in the action area to be potentially increased by the underwater detonations that will be conducted in November 2008 and February and July 2009.

Murrelets rely on their hearing in the terrestrial environment (during incubation and chick rearing) to detect predators, such as corvid species. Their response to detection of a corvid is to freeze and hunker down until the threat has subsided. If they cannot hear the corvid, they risk drawing attention to the nest, either through continued movement or by premature departure, which can result in chick predation. We anticipate the risk of predation on chicks to be increased due to breeding adult hearing impairments that may occur as a result of the underwater detonations conducted in July 2009. Hearing impairments sustained from the underwater detonations conducted in February may also result in increased predation risk if hearing has not sufficiently recovered prior to breeding.

Summary of effects from behavioral responses and sublethal injury (effects to hearing)

All murrelets within the action area (approximately 239 km^2) during the floating mine exercises will be exposed to elevated SPLs created by the detonations and by the helicopters (when they are used). All murrelets underwater within the action area at the time of an underwater detonation will be exposed to elevated SPLs that may cause hearing loss. Responses to these exposures may result in flushing (diving or flying), relocation to another area, and interruption or delay of foraging or resting. We anticipate these responses will be manifested in reduced foraging ability, increased energy expenditure, increased stress, and increased risk of predation.

A variety of potential effects have been described that we believe could result in measureable impacts to individual murrelets arising from one or multiple stressors. However, there is considerable uncertainty regarding the magnitude and duration of these effects to individuals. Many variables exist that influence the magnitude of these effects, ranging from the proximity of the detonation to the condition of the individual. However, we cannot determine the extent or duration of the adverse effect, nor the number of individuals that would be affected. Nonetheless, we anticipate there will be a significant disruption in normal behavior that may cause reduced survival or productivity (i.e., fitness) to some individual murrelets within the action area (approximately 239 km^2) as a result of behavioral responses to elevated SPLs and hearing impairments.

<u>Summary of Effects of the Action on Murrelets</u>

Murrelets occur year-round in the Crescent Harbor action area and may be affected while underwater or on the water's surface as a result of exposure to elevated SPLs, the water plume, flying debris, helicopter downwash and/or increased boat, diver, and helicopter activity levels. Exposed murrelets may be killed, suffer sublethal injuries, or exhibit behavioral changes that are manifested in reduced foraging ability, increased energy expenditure, increased stress, and/or increased predation risk.

All murrelet life stages will be exposed to the Navy EOD activities. Adults and subadults will be exposed to all of the detonations, and may be killed, suffer sublethal injuries, and/or exhibit behavioral changes. Eggs and chicks may be indirectly affected by the detonations occurring in April, June, and July 2009 through the loss or injury of a parent.

The most significant impact to murrelets as a result of the Navy EOD activities will be mortality or sublethal injuries. Sublethal injuries that do not immediately result in mortality could include internal organ damage, loss of vision, or hearing loss, all of which can significantly impair an individuals ability to carry out essential life functions such as flying, diving, breeding, feeding, and predator avoidance. We anticipate up to four murrelets may be killed or be subject to sublethal injuries as a result of exposure to elevated underwater SPLs.

The reproductive success of adult murrelets may be affected as a result of exposure to Navy EOD activities if (a) a murrelet's mate is killed outside of the breeding season and the surviving individual is unable to procure a new mate for one or more breeding seasons; (b) a murrelet's mate is injured during the breeding season and the surviving individual is not able to complete incubation or deliver a sufficient quantity of food to the chick, thereby resulting in the loss of an egg or chick due to predation or starvation; or (c) foraging capability is reduced which can result in a lack of nest initiation, nest failure due to abandonment, an extended chick rearing period, or lower fledging body mass. The detonations will take place during the winter, spring, and summer. Therefore, any of these three scenarios is likely to affect reproduction in 2009 or subsequent years.

We anticipate all murrelets underwater in the action area (approximately 239 km^2) will potentially suffer hearing impairment from exposure to elevated SPLs created by the underwater detonations. Hearing impairment may significantly reduce an individual murrelets ability to communicate, thereby reducing their pair bonding abilities and/or foraging efficiency. If a breeding adult suffers hearing impairment, it may significantly increase the risk of predation on its chick. However, we cannot determine the extent or duration of the hearing impairment, nor the number of individuals that will be affected. Nonetheless, we anticipate murrelet's within the action area will be injured and some of these individuals will have reduced survival or productivity.

All murrelets within the action area (approximately 239 km^2) are likely to exhibit behavioral changes in response to hearing impairments, elevated SPLs, and perceived threats. Behaviors may include flushing (diving or flying), relocation to another area, and interruptions or delays in foraging or resting. We anticipate these behavioral responses could result in reduced foraging ability, increased energy expenditure, increased stress, and an increased risk of predation. Measurable impacts to individual murrelets may arise from any one or multiples of these behavioral responses. However, we cannot determine the extent or duration of the adverse effect, nor the number of individuals that will be affected. Nonetheless, we anticipate there will be a significant disruption in normal behavior that may cause reduced survival or productivity (fitness) to some individual murrelets within the action area.

We do not anticipate murrelets will be subject to lethal or sublethal barotraumas while underwater from exposure to elevated SPLs created by the floating mine detonations. We do not anticipate murrelets will be exposed to lethal or sublethal barotraumas while on the surface from exposure to elevated SPLs created by the underwater detonations. We do not anticipate murrelets will be subject to mortality or injury resulting from the underwater detonation water plume, the floating mine flying debris, or the helicopter downwash.

CUMULATIVE EFFECTS

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 BO. 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.

Waters within the action area are not isolated, but are part of Puget Sound, which is influenced by the rivers and streams that flow from the Cascade and Olympic Mountains. Puget Sound is on the receiving end for millions of gallons of water that run through forested, agricultural, industrial, and residential lands. Projects throughout these lands impact the water quality within the rivers and streams and influence the water quality within Puget Sound. In addition, Puget Sound waters are influenced by stormwater that drains from urbanized areas around Puget Sound.

There are ongoing activities within and adjacent to the action area, including boat traffic, development, and urbanization that will continue and increase in the future. The population estimates for the counties surrounding the action area are expected to increase by 40 to 60 percent between 2005 and 2030 (see Table 12). Similar increases in population growth are expected for other counties surrounding Puget Sound.

Table 12 Estimated population growth between 2005 and 2030 for Island and Skagit Counties.

	Population		
County	**2005**	**2030**	**Percent Increase**
Island	76,000	107,000	40%
Skagit	111,000	178,000	60%

Data obtained from the Washington State Office of Financial Management. Sept 21, 2008 from http://www.ofm.wa.gov/pop/gma/projections07.asp. Medium projections.

In these counties, the economy is shifting from forestry, fish and agriculture uses toward housing and light industry. The housing industry has boomed and waterfronts are being converted to residential areas (Lyshall 2008). In Skagit County, agriculture remains important and the county is try to protect agricultural resources and not have agricultural land converted to urban and suburban development. Increases in development and urbanization result in increased traffic, impervious surfaces, and stormwater runoff. This results in increased treated and untreated stormwater discharges and degraded water quality.

Bull trout, murrelets, and their prey species are likely to be impacted by these activities. The response to exposure will depend on the level of contaminants discharged, which is dependent upon many factors (e.g., existence of stormwater Best Management Practices, maintenance of the stormwater Best Management Practices, time between rain events). We do expect that significant dilution will occur when stormwater is discharged into the Puget Sound. However, at this time we are unable to conclude if the contaminant levels in future stormwater runoff will be detectable in the marine environment and result in adverse effects.

In many areas surrounding the action areas, agencies and non-profit organizations are buying and conserving the land and habitats to protect Puget Sound. The Whidbey-Camano Land Trust acquires land and conservation easements and provides expertise to landowners to protect conservation value of their lands (http://www.wclt.org/about/index.html). Since 1984, the Whidbey-Camano Land Trust has protected 5,187 acres, with another 1,474 acres in progress (Lyshall 2008). Skagit Land Trust protects over 5,000 acres in Skagit County through conservation easements and acquisitions. The Nature Conservancy works with landowners to protect wildlife habitat and improve water quality. Protection of lands will benefit Puget Sound in the long run by improving water quality and increasing habitat for bull trout, murrelets, and their forage species.

Climate Change

The following discussion on climate change is general in nature. At this time, it is difficult to describe specific effects from climate change in the action area. However, those elements of climate change discussed here that result in changes to the marine environment are those that are most likely applicable to the action area.

Global climate change, and the related warming of global climate, have been well documented (IPCC 2007; ISAB 2007, WWF 2003). Evidence of global climate change/warming includes widespread increases in average air and ocean temperatures and accelerated melting of glaciers, and rising sea level. Given the increasing certainty that climate change is occurring and is accelerating (IPCC 2007; Battin et al. 2007), we can no longer assume that climate conditions in the future will resemble those in the past.

Patterns consistent with changes in climate have already been observed in the range of many species and in a wide range of environmental trends (ISAB 2007; Hari et al. 2006; Rieman et al. 2007). In the northern hemisphere, the duration of ice cover over lakes and rivers has decreased by almost 20 days since the mid-1800's (WWF 2003). The range of many species has shifted poleward and elevationally upward. For cold-water associated salmonids in mountainous regions, where their upper distribution is often limited by impassable barriers, an upward thermal shift in suitable habitat can result in a reduction in range, which in turn can lead to a population decline (Hari et al. 2006).

In the Pacific Northwest, most climate change predictive models project warmer air temperatures, increases in winter precipitation, and decreases in summer precipitation. Warmer temperatures will lead to more precipitation falling as rain rather than snow. As the seasonal amount of snow pack diminishes, the timing and volume of stream flow are likely to change and peak river flows are likely to increase in affected areas. Higher air temperatures are also likely to increase water temperatures (ISAB 2007). For example, stream gauge data from western Washington over the past 5 to 25 years indicate a marked increasing trend in water temperatures in most major rivers (WDOE 2008).

There are a number of climate change driven factors that are likely to affect the water quality and productivity of nearshore marine habitat used by anadromous bull trout and foraging murrelets. Future global sea-level rise is likely to accelerate as a result of global warming and this may lead to exacerbating problems with fecal coliform contamination resulting from increased septic system leakage. Sea-level rise will also affect the photic zone, which is a key component for productive eelgrass beds. Eelgrass beds provide forage opportunities for bull trout and important habitat for bull trout and murrelet prey species such as Pacific herring. Increased winter rains as a result of climate change are predicted for the Pacific Northwest, which will likely lead to increased stormwater runoff. Changes in timing and magnitude of freshwater input could affect the salinity, dissolved oxygen levels, circulation, stratification and mixing of Puget Sound and Hood Canal, which in turn could alter the health of marine organisms that support productivity in these waters. Increases in water temperature, both in the marine nearshore waters and in the lower rivers, through which bull trout migrate on the way to spawning habitat, could result in fewer spawners or spawners in poor condition arriving at the spawning grounds. The degree to which these changes affect marine nearshore areas will vary with specific characteristics of the area, its location in the Sound, the Straits, or Hood Canal, its freshwater sources, and the dynamics of the ecosystem in that particular area (Snover et al. 2005).

<u>Bull Trout</u>

Climate change has the potential to profoundly alter the aquatic ecosystems upon which the bull trout depends via alterations in water yield, peak flows, and water temperatures in streams and large waterbodies, and an increase in the frequency and magnitude of catastrophic wildfires in adjacent terrestrial habitats (Bisson et al. 2003).

All life stages of the bull trout rely on cold water. Increasing air temperatures are likely to impact the availability of suitable cold water habitat. For example, ground water temperature is generally correlated with mean annual air temperature, and has been shown to strongly influence the distribution of other chars. Ground water temperature is linked to bull trout selection of spawning sites, and has been shown to influence the survival of embryos and early juvenile rearing of bull trout (Rieman et al. 2007). Increases in air temperature are likely to be reflected in increases in both surface and groundwater temperatures.

Climate change is likely to affect both the frequency and magnitude of fires, especially in warmer, drier areas such as are found on the eastside of the Cascade Mountains. Bisson et al. (2003) note that the forest that naturally occurred in a particular area may or may not be the forest that will be responding to the fire regimes of an altered climate. In several studies related to the effect of large fires on bull trout populations, bull trout appear to have adapted to past fire disturbances through mechanisms such as dispersal and plasticity. However, as stated earlier, the future may well be different from the past and extreme fire events may have a dramatic effect on bull trout and other aquatic species, especially in the context of continued habitat loss, simplification and fragmentation of aquatic systems, and the introduction and expansion of exotic species (Bisson et al. 2003).

Migratory bull trout can be found in lakes, large rivers and marine waters. Probable physical effects of climate change to rivers that are relevant to migratory bull trout include increased competition and predation due to a shift in distribution of both predator and prey species and reduced freshwater survival because of increased stream temperatures, reduced summer flows, and increased winter flows resulting in scouring and sedimentation (Irvine 2004).

Physical effects of climate change on lakes are likely to impact migratory adfluvial bull trout that seasonally rely upon lakes for their greater availability of prey and access to tributaries. Climate-warming impacts to lakes will likely lead to longer periods of thermal stratification, and coldwater fish such as adfluvial bull trout will be restricted to these bottom layers for greater periods of time. Deeper thermoclines resulting from climate change may further reduce the area of suitable temperatures in the bottom layers and intensify competition for food (WWF 2003).

Bull trout require very cold water for spawning and incubation, and suitable spawning habitat is often found in accessible higher elevation tributaries and headwaters of rivers. However, impacts on hydrology associated with climate change are likely to cause shifts in timing, magnitude and distribution of peak flows, and these changes are predicted to be most pronounced in high elevation stream basins (Battin et al. 2007). The increased magnitude of winter peak flows in high elevation areas is likely to impact the location, timing, and success of spawning and incubation for the bull trout and Pacific salmon species. Although lower elevation river reaches are not expected to experience as severe an impact from alterations in stream hydrology, they are unlikely to provide suitably cold temperatures for bull trout spawning, incubation and juvenile rearing.

As climate change progresses and stream temperatures warm, thermal refugia will be critical to the persistence of many bull trout populations. Thermal refugia are important for providing bull trout with patches of suitable habitat during migration through or to make feeding forays into areas with greater than optimal temperatures.

There is still a great deal of uncertainty associated with predictions relative to the timing, location, and magnitude of future climate change. It is also likely that the intensity of effects will vary by region and some populations of bull trout appear to face higher risk than others (ISAB 2007; Rieman et al. 2007). Several studies indicate that climate change has the potential to impact ecosystems in nearly all streams throughout the state of Washington (ISAB 2007, Battin et al. 2007, Rieman et al. 2007). In streams and rivers with temperatures approaching or at the upper limit of suitable water temperatures, there is little, if any, likelihood that bull trout will be able to adapt to or avoid the effects of climate change and global warming. There is little doubt that climate change is and will be an important factor affecting bull trout distribution. As their distribution contracts, patch size decreases and connectivity is truncated, bull trout populations that may be currently connected may face increasing isolation, which could accelerate the rate of local extirpation beyond that resulting from changes in stream temperature alone (Rieman et al. 2007). Due to variations in landform and geographic location across the range of the bull trout, it appears that some populations face higher risks than others do. Bull trout in areas with currently degraded water temperatures and/or at the southern edge of its range may already be at risk of adverse impacts from current as well as future climate change.

Murrelet

Climate change has the potential to profoundly alter the aquatic and terrestrial ecosystems upon which the murrelet depends. Murrelet productivity is highest in cool ocean conditions (Becker et al. 2007); therefore, an overall increase in ocean temperatures could have severe negative effects on murrelet survival and recovery.

Climate change is likely to affect the frequency and magnitude of catastrophic wildfires, which affects amount, distribution, and quality of nesting habitat. Bisson et al. (2003) note that the forests that naturally occur in a particular area may or may not be the forests that will remain under an altered climate. The future may well be different than the past and extreme fire events may have a dramatic effect on murrelets, especially in the context of continued loss, simplification, and fragmentation of aquatic and terrestrial habitats, and the introduction and expansion of exotic aquatic and terrestrial species (Bisson et al. 2003).

There is still a great deal of uncertainty associated with predictions relative to the timing, location, and magnitude of future climate change. It is also likely that the intensity of effects will vary by region (ISAB 2007), although the scale of that variation may exceed that of states. There is little doubt that climate change is and will be an important factor affecting both murrelet distribution and abundance in the Puget Sound.

INTEGRATION AND SYNTHESIS

Bull Trout

The preceding analysis for bull trout including the status of the species at the range-wide and action area scales, the environmental baseline, the effects of the action, indirect effects and cumulative effects, form the foundation for determining if the proposed action is reasonably expected to appreciably reduce the bull trout's likelihood of survival and recovery in the wild due to a reduction in its reproduction, numbers, or distribution (i.e., jeopardy). This section describes the key findings of these analyses and discusses them at the local population, core area, and IRU scales.

Current Status of Bull Trout

Five IRUs were identified during the listing process. The conservation roles of each IRU is to maintain or expand the current distribution of the bull trout within core areas; maintain stable or increasing trends in bull trout abundance; maintain/restore suitable habitat conditions for all bull trout life history stages and strategies; and conserve genetic diversity and provide opportunities for genetic exchange. Collectively, these criteria constitute the intended survival and recovery function of the IRUs.

The action area is located within the Coastal-Puget Sound IRU. This IRU currently contains 14 core areas and 67 local populations. The anadromous life history form is unique to this IRU. The marine environment provides enhanced foraging opportunities and a migration corridor to non-natal foraging areas. Within the Coastal-Puget Sound IRU, bull trout are distributed throughout most of the large rivers and associated tributary systems. Local extirpations have occurred. Many remaining populations are isolated or fragmented and abundance has declined, especially in the southeastern portion of the IRU.

Bull trout present within the action area can be from the Lower Skagit River, Stillaguamish River, and the Snohomish/Skykomish River core areas. Core areas are the smallest scale for restoring/maintaining a functioning metapopulation of bull trout because they contain the habitat qualities necessary for bull trout to spawn, rear, forage, overwinter, and migrate and the contiguous habitat necessary to minimize local extirpations of the bull trout due to catastrophic events.

The Lower Skagit River core area consists of 19 local populations and has the highest population abundance with the number of adults ranging between 2,500 to 10,000 (FWS 2006). The short-term trend in population numbers is increasing and overall it has a low risk for habitat degradation and population declines. The Snohomish/Skykomish River core area has four local populations and has a population of 1,000 to 2,500 adults. The population trend is increasing and the overall risk is ranked as potential risk for limited or declining numbers and habitat degradation. The Stillaguamish River core area consists of four local populations and has a smaller population with 250 to 1,000 adults. The population trend is unknown and its overall risk is ranked as "at risk" for very limited or declining number and habitat degradation and the core area is vulnerable to extirpation. While population trend data from redds are available, demographic data are not.

The Crescent Harbor action area is located within Puget Sound. In general, the environmental baseline of the action area is influenced by on-going activities that occur within watersheds that drain into Puget Sound. Water quality is highly influenced by stormwater runoff, wastewater discharges, and nonpoint sources. Toxins that enter Puget Sound remain in the system and can enter the food chain. NAS Whidbey Island has modified some of the shoreline in Crescent Harbor. The Navy has constructed seawalls, bulkheads, and protected parts of the shoreline with riprap. The rest of the shoreline is in a natural state with some high bluffs that provide sediment to Crescent Harbor.

The Crescent Harbor action area is highly influenced by the Skagit River that drains directly into the action area. The waters within the action area become stratified during the summer with surface waters ranging between 10 to 13 degrees C. Dissolved oxygen concentrations are highest in the surface waters (up to 15 mg/L), but do not meet levels needed for most salmonid species in deeper waters, below the thermocline (< 5 mg/L). A variety of habitats are found throughout the action area including shallow subtidal bays, mud flats, and open mixed-coarse beaches. Some areas have been modified by dredging, armoring and the construction of piers and docks.

Direct Effects to Bull Trout

The Navy EOD training results in detonations of 2.5 lbs charges of explosives to disable inert mines. The training involves both underwater and surface detonations. Prior to underwater detonations, the mine and explosive are lowered to the seafloor to minimize explosive impacts into the water column. Surface detonations occur out of the water on a 55 gallon drum that is floating in the water.

The primary adverse effect results from underwater detonations which generate a pressure wave that can kill or physically injure bull trout. Underwater detonations result in a kill or injury zone that radiates out 486 ft from the explosive, or has a volume of 70.4 million cubic feet. The Service estimates that the EOD Training will result in the loss or injury of five bull trout from the effects of the explosive detonations through December, 2009. No other quantifiable direct effects to bull trout are anticipated from the action.

The detonations of the EOD Training also result in mortality of forage fish. Herring and surf smelt mortality in the thousands of individuals has been documented. Sand lance, another forage fish species that is common in Crescent Harbor and Puget Sound, has not been observed during Navy surface monitoring because they lack a swim bladder, so any individuals that are killed during a detonation will sink and not float. However, it is assumed that they are killed as well. The number of forage fish that are killed due to the Navy EOD training, based only on surface counts, varies depending on the month in which the detonations occur. In addition, forage fish are highly migratory and it is difficult to determine the impact of their mortality on specific populations when it is unknown what population or spawning area they are from. The worst case scenarios for impacts to the Skagit Bay and Holmes Harbor herring stocks from the Navy EOD detonations through December 2009 show that approximately 0.04 percent and 0.17 percent, respectively, of the mean spawner biomass are killed. In summary, the impact on the overall populations of the different forage fish species from detonations is unknown. Therefore, while there are effects to bull trout from reductions in prey, we are unable to describe the magnitude of those effects and we believe them to be insignificant.

Cumulative effects in the action area will continue to stress bull trout in the action area. Population growth in Island and Skagit Counties is estimated to increase 40 to 60 percent, respectively, in the next 20 years. This growth results in increased development and urbanization. The lands surrounding the action area are mostly agriculture and population growth can result in conversion of this land to houses and light industry that increases impervious surfaces such as roads and buildings. Increases in impervious surfaces results in increases in the amount of stormwater and contaminants that enter the action area. Shorelines will continue to be modified to meet the needs of the population. Climate change will result in increased temperatures and changes in the natural hydrology of Puget Sound streams. The diversity and abundance of the plants and animals may change as they adapt to different climate changes. However, uncertainty exists on the response of bull trout to potential impacts of climate change.

Population and Species Level Consequences

A qualitative evaluation of the effects to bull trout populations is provided, because demographic data are not available for a quantitative analysis.

The bull trout in the action area are likely from three core areas: Lower Skagit River, Snohomish/Skykomish Rivers, and the Stillaguamish River. The Lower Skagit River core area is the closest to the action area, and has the highest population of bull trout. The total population of the Lower Skagit River core area is estimated to be between 2,500 to 10,000 adults with an increasing trend in the population (despite legal sport harvest). The Stillaguamish River core area has a smaller total population of 250 to 1,000 adults and the population trend is unknown. The Snohomish/Skykomish Rivers core area has a total population of 1,000 to 2,500 adults and has an increasing trend in population. Because the Lower Skagit River core area enters directly into the action area, and has a high population abundance, we believe the majority of bull trout killed or injured would most likely be from this core area. The remainder of the bull trout killed would be from the Snohomish/Skykomish and Stillaguamish core areas. Given the number of individuals killed relative to the size of the core populations, we do not anticipate that there will be an appreciable change to the reproduction, numbers or distribution of bull trout in any of the three core areas.

The three core areas in which these bull trout may be from constitute 27 local populations out of the 67 (40.3 percent) within the Coastal-Puget Sound IRU. Therefore, the EOD training will not appreciably reduce the bull trout's likelihood of survival and recovery in the wild due to a reduction in its reproduction, numbers, or distribution at the scale of the IRU. The EOD training will also not have a measurable effect on the anadromous component of bull trout that is vital to this IRU.

Murrelet

Murrelets in the action areas are expected to be exposed to several stressors resulting in lethal, sub-lethal, and behavioral effects that will vary in time and space throughout the action area. These stressors include visual, auditory, and physical stressors on individual adults and fledglings caused by underwater and surface detonations, and associated air and water-based support.

<u>Approach to the Risk Analysis</u>

In accordance with regulations under section 7 of the Act, the risk posed by the action will be assessed in terms of whether the stressors caused by the action will appreciably reduce the likelihood of survival and recovery of murrelets. Just as the continued existence of a "species" depends upon the fate of the populations that comprise them, so the continued existence of populations are determined by the fate of individuals that comprise the population. In other words, the abundance and distribution of murrelets within the listed range depends upon whether or not the number of individuals in murrelet populations increase or decrease as a function of survival rates, growth, migration, and reproduction.

In the *Effects* section, we identified the consequences to those individuals exposed to several stressors caused by the action: rapid and high magnitude changes in SPLs through the air and water, and the elevated presence of humans and mechanized equipment in the marine environment. These stressors are expected to have lethal, sublethal, and behavioral consequences that may diminish the capability of murrelets to live, grow, mature, migrate, and reproduce. Most significant is the likely mortality of four murrelets potentially occurring within 210 meters of the underwater detonations. For murrelets located at greater distances from the detonation sites, we described the potential change in "fitness" of an unquantifiable number of murrelets due to their exposure to sublethal underwater SPLs and exposure to increased SPLs below and above water from the floating mine detonations. 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 therefore assessed the possible reduction in

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[3] Fitness is the response of an individual organism or a population of organisms to natural selection and is commonly measured by an individual's reproductive success or, for a population, 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.

fitness of murrelets that are exposed to the detonations, as well as the mortality that we expect to occur, in regards to how that will affect the survival and recovery of murrelets. In other words, we evaluated the potential change in demographic survival rates and reproductive fitness as a result of the action to determine if the likelihood of survival and recovery will be appreciably reduced.

Using the best scientific and commercial data available, we describe the nature of the lethal, sublethal, and behavioral impacts and whether the demographic impacts are likely to reduce the viability of the affected Conservation Zone which, in turn, could affect the viability of the murrelet within its listed range. Reducing the fitness of individuals in a population is not always sufficient to reduce the viability of a population, nor is reducing the viability of a population always sufficient to reduce the viability of a species. Thus, this final analysis will include the base conditions of the population (Conservation Zone 1) and species (listed range) as reference points.

The base conditions used for evaluating the consequence of impacts to individuals at the scale of the affected Conservation Zone are presented in the *Environmental Baseline* and *Status of the Species in the Action Area* sections of this BO. In particular, we assess the consequences of lethal and sublethal impacts by describing the expected changes, if any, in murrelet reproduction, numbers, and distribution as the basis to describing the overall risk of murrelet extinction or probability of species conservation. We infer from McShane et al. (2004) and others (see Ralph et al. 1995 and Cam et al. 2003) that the current breeding success is significantly below the level required to insure the long-term survival of the species in all Conservation Zones (1-6). Our final determination in this BO, which will include any identified effects from the *Cumulative Effects* section, is based upon whether or not the murrelet within its listed range is likely to experience a further reduction in viability (survival and recovery) and whether or not that reduction is likely to be appreciable.

Factors of Population Change

The factors that govern observed population changes are classified into three general categories: stabilizing, non-stabilizing, and cyclic (Rickleffs 1979). Stabilizing influences generate population patterns that maintain populations near an equilibrium point and vary depending upon whether a given population is experiencing negative or positive population growth. Stabilizing factors, referred to as density-dependant factors, influence the number of births and deaths in a population (ratio of births to deaths) primarily through behavioral mechanisms relating to competition for resources (food, habitat, territoriality, etc.), and predation pressures. Non-stabilizing, density independent factors affect population size without regard to the population equilibrium point (global climate change, habitat loss, stochastic events, anthropogenic exploitation, etc.). Other populations are predominately influenced by cyclic factors (i.e., food supply, precipitation, etc.) and simply oscillate.

Populations with negative growth (i.e., deaths exceed births) are more susceptible to extinction when density independent mechanisms are the dominant influence (Rickleffs 1979). This increased risk of extinction arises from the failure of species to adapt quickly enough to "solve" the excessive death rate (Rickleffs 1979). Although extinction is a chance event, it is not a random event when density independent, non-stabilizing factors drive populations to extinction.

Extinction as a chance event is influenced by two corollaries: the size of a population and the reference time period. Extinction is more likely with smaller populations in any given time period and more likely over time with any given population size (Soule et al. 1987). In other words, extinction as a chance event is expected for all species if given enough time. Consequently, one cannot predict the likelihood of extinction without establishing a reference time period. Once established, the likelihood (probability) of extinction can be stated by evaluating the relevant density dependent and independent factors that govern population change, giving special attention to those factors that drive populations to extinction.

For example, the factors that led to the extinction of the great auk (*Pinguinus impennis*), a seabird in the Alcidae family, illustrate the influence that density independent factors can have on a species persistence. In the early 1700's, the great auk was an abundant flightless North Atlantic seabird. However, it possessed little ability to respond to sustained exploitation (non-stabilizing, density independent factor), because the species was generally unable to avoid capture and had a naturally low annual reproductive rate of one egg per breeding female (Montevecchi and Kirk 1996). Although the species was adapted to predation as a density-dependent factor, hunters and explorers (a density independent influence) effectively triggered a high adult mortality rate and low breeding success rate. Despite the abundant availability of breeding habitat, the great auk was driven to extinction by 1844 (Montevecchi and Kirk 1996), presumably because reproductive potential was unable to compensate for human-caused mortality of breeders and reduced breeding success from egg collection.

To determine the importance of demographic consequences caused by the action, we compare estimates of population parameters (adult survival and fecundity) with and without the action. We begin this analysis with a more detailed investigation of the population status of Conservation Zone 1, as briefly presented in the *Status of the Species* section of this opinion. We then consider both the short- and long-term changes in demographic survival rates and fecundity in relation to the survival and recovery of the species, first at the scale of Conservation Zone 1 and then throughout the listed range.

<u>Current Status of the Murrelet Population</u>

Conservation Zone 1

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 (McShane et al. 2005; Cam et al. 2003; Ralph et al. 1995). Therefore, mortality for the action could accelerate this negative population trend in Conservation Zone 1. This analysis is intended to determine the magnitude of the consequences of the action and whether that magnitude will appreciably suppress the viability of murrelets in Conservation Zone 1. Such consequences must then be evaluated to determine whether the impact would appreciably reduce the likelihood of survival and recovery of murrelets in their listed range.

Zone Model Results

Using the estimated 2001 zonal population size of 8,900 murrelets from Huff et al. (2003), a 2 percent annual immigration rate, and continued losses of murrelets from oil spills and gill nets, McShane et al. (2004) estimated Conservation Zone 1 has a 25 percent probability of going extinct by year 2100. Of greatest concern was the estimate for lambda (λ), the intrinsic rate of population growth, estimated below 1.0 (range of -2.2 percent to -3.4 percent annual population change) for all time intervals between 2001-2040. A $\lambda = 1.0$ is necessary for the Conservation Zone population to remain at its current abundance.

The population model for Conservation Zone 1 is most sensitive to fecundity (McShane et al. 2004). When the fecundity estimate of 0.089 was used (derived from date-corrected at-sea adult-to-juvenile ratios from Conservation Zones 1 and 2) in comparison to fecundity rates of 0.38-0.54 from telemetry studies in British Columbia, the probability of extinction increased to 100 percent and the time to extinction was shortened to 2060.

The recent demography data from Washington do not support the use of the high fecundity estimates. The most recent (2007) date-corrected at-sea juvenile-to-adult ratios specific to Conservation Zone 1 are estimated to be between 0.06 and 0.08. Based upon this information, the Service concludes murrelets in Conservation Zone 1 are highly vulnerable to extinction within the next 100 years. The most current estimate of the population size (2007) in Conservation Zone 1 is 6,985 (4,100 – 10,382, 95 percent CI) (Falxa et al. 2008).

Project Risk to Murrelet Population Viability

Consequences to Murrelet Demography

To evaluate the first population-level effect, we estimated the change in demographic survival rates (95 percent CI) in three demographic classes (juvenile, subadult, and adult). Murrelet abundance in each class was extrapolated from an assumed juvenile ratio of 0.061. Then, using estimated demographic rates summarized by McShane et al. (2004) as the existing condition, we considered calculating the expected change in survivorship in each age class (Table 13) from a proportional loss in each age class of the four murrelet mortalities. However, we elected to only calculate changes in adult survivorship because mortality is most likely to occur to adult murrelets based upon the extremely low relative abundance of juvenile and subadult-aged murrelets in Conservation Zone 1.

The estimated 2007 population size for murrelets in Conservation Zone 1 is 6,985 (4,100 – 10,382, 95 percent CI) (Falxa et al. 2008). From the predicted mortality of four adult murrelets, we calculated the change in adult survivorship using the upper and lower limits of the 95 percent CI of the estimated population. This resulted in an undetectable change (at a 0.000 significance) for the upper population estimate of 10,382 murrelets (upper 95 percent CI). Adult survivorship for lower population estimate of 4,105 murrelets (lower 95 percent CI) changed from 0.880 to

0.879 (Table 13).

Table 13 The projected changes in murrelet abundance, demography, and adult survival (S) as a result of the proposed 2008-2009 Navy EOD activities. Differences attributed to the proposed action are denoted by bold and italicized text.

Current (2008-2009) Murrelet Population Estimate (Pre-project)		**Estimated Number and Survival in Each Demographic Class (Pre-Project)**			
		Juvenile (S=0.610)	Subadult (S=0.780)	Adult (S=0.880)	Calculated Juvenile Ratio[1] (Juveniles:After hatch year pairs)
Upper 95%CI	10,382	307	184	9,891	0.0609
Estimated Size	**6,985**	**207**	**124**	**6,654**	
Lower 95%CI	4,105	122	73	3,910	0.0613
New (2010) Murrelet Population Estimate (Post-project)		**Estimated Number and Survival (S) in Each Demographic Class (Post-Project)**			
		Juvenile (S=0.610)	Subadult (S=0.780)	Adult (S=0.880)	Calculated Juvenile Ratio (Juveniles:After hatch year pairs)
Upper 95%CI	10,378	307	184	***9,887***	0.0610
Estimated Size	**6,981**	**207**	**124**	***6,650***	
Lower 95%CI	4,101	122	73	***3,906*** ***(S_{new}=0.879)***	0.0613

[1] Juvenile ratio calculated as follows: #juveniles / ((#subadults + # adults) x 0.5)

Effects to Murrelet Reproduction (Conservation Zone 1)

The second population-level effect we considered was the change in murrelet reproductive potential that may occur in subsequent generations. We calculated the consequence of four adult-aged murrelet mortalities (two females) on the long-term reproductive potential of the subpopulation using the following assumptions (constants): adult breeding rate (0.65), juvenile ratio (0.0621), murrelet abundance of 6,985 (Conservation Zone 1), murrelet life span (15 years), fecundity (0.096 young/nest attempt)[4], 1:1 sex ratio, and the demographic rates presented in Table 13. Hypothetically, four adult murrelets would likely produce two juvenile murrelets (arriving at sea) during the period 2010 – 2028 during the first generation and these young, on average, would be expected to produce an additional two murrelets during their lifetime in the second and third generations (2024-2045) following implementation of this action (Appendix E). Thus, a total (direct and indirect) loss of eight murrelets would be expected during the 2010-2045 period (four females).

Behavioral responses and sublethal injury (effects to hearing)

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[4] Fecundity (#young/nest attempt) = 9.6 % is derived from a juvenile ratio (# hatch yr birds:after hatch year pairs) of 0.060 as follows: 207 young/3,389 after-hatch-year pairs = 0.061 juv. ratio. Assuming 62 pairs (207 x 0.60 juvenile survival) of the 3,389 AHYprs are age 2, the number of breeding-aged adult pairs is estimated to be 3,327 (6,954 individuals). At an adult breeding rate of 65%, 2,163 pairs will breed and produce 207 young that arrive at sea. Thus, 207 young/2,163 nest attempts=0.096 young/nest attempt (9.6%), is derived from the population estimate by Falxa et al. (2008) of 6,985 murrelets.

Based on our review of the best available scientific and commercial information, we conclude that all murrelets underwater in the action area (approximately 239 km^2) at the time of the underwater detonations are likely to be injured by exposure to SPLs in excess of 180 dB_{peak}. This injury would be in the form of hearing loss. We also anticipate that murrelets underwater and on the surface during the floating mine detonations will experience a significant disruption in normal breeding or feeding behaviors. However, there is considerable uncertainty regarding the magnitude and duration of these effects to individuals.

Responses to project activities may include flushing (diving or flying), relocation to another area, and interruption or delay of foraging or resting. Individuals may exhibit one or more of these responses, the consequence of which may include reduced foraging ability, increased energy expenditure, increased stress, and increased risk of predation. These consequences are expected to lead to reduced survival or productivity (i.e., fitness) of an unknown number of individual murrelets within the action area.

Consequences at the Population of Listed Range Scales

Achieving a viable, well-distributed murrelet population for recovery of the murrelet in the coterminous United States requires that at least four of the six Zones contain viable populations (U.S. Fish and Wildlife Service 1997a). The key to maintaining murrelet numbers, distribution, and reproductive performance identified in the Recovery Plan include 1) protecting and improving the quality of the marine environment and 2) reducing adult and juvenile mortality in the marine environment.

Current population estimates indicate four Conservation Zones contain relatively robust numbers of murrelets (Zones 1 - 4). However, the historical frequency of sudden, wide-spread lethal impacts from oil spills (Bentivoglio et al. 2002; Ford et al. 2001), coupled with an exceedingly low annual reproduction of murrelets, raises significant uncertainty for the viability and long-term survival of the species (McShane et al 2005). The limited ability to detect a decline in population abundance with at-sea surveys is also problematic (Ralph et al. 1995). Although the removal of 3.4 million acres of old growth habitat in Washington and Oregon was identified as a significant listing factor in the 1992 determination to list the species (50 CFR 17:45328-45337), the environmental factors that currently lead to low breeding success are the greatest threats to murrelet recovery and survival. Breeding success throughout the species' listed range is currently too low to maintain or increase populations (Ralph et al. 2001, McShane et al. 2005). The calculated λ in all Conservation Zones during the current decade (2001-2010) ranges from -3 percent to -6.2 percent (McShane et al. 2004).

With the evidence indicating murrelet populations currently are incapable of achieving sufficient reproduction to maintain population viability throughout the listed range, we agree with Ralph et al. (1995) and conclude that the low annual maximum reproductive capability of female murrelets, among the lowest of all alcids, warrants greatest attention. The inherently low annual reproductive capability of the species, coupled with the suite of mortality factors affecting murrelets in Conservation Zone 1, indicate that the species is perilously constrained to negative growth in the foreseeable future. Thus, the survival and recovery of the species appears to be dependent upon the protection/improvement of adult survival and breeding success.

Using juvenile ratios as an index of breeding success (McShane et al. 2004), the Service concludes fecundity is well below the necessary level needed to maintain the current murrelet abundance. In California (Conservation Zones 4, 5, and 6), the leading causes for the low fecundity are predation and food abundance in the marine environment (Peery et al. 2004). We expect these factors to be the leading factors of poor breeding success in Washington (Conservation Zones 1 and 2) and Oregon (Conservation Zones 3 and 4) as well.

Although Conservation Zone 1 has the highest population estimate of all zones, it should not be assumed that the population is stable. Survey information indicates the rate of population growth is negative ($\lambda < 1.0$). Two hypotheses have been offered to explain the relationship between marbled murrelet population size and population growth. First, immigration of breeding murrelets is occurring from nearby coastal British Columbia (supported by the sensitivity analysis in the demographic zone models indicated a high sensitivity to immigration rate and fecundity, McShane et al. 2004). Second, the number of non-breeding murrelets emigrating from northern local populations (Raphael 2006) may be higher than expected and may cause skewed juvenile ratios which may mask otherwise stable murrelet fecundity of a very small, resident breeding population. Thus, population size or growth may be masked by immigration (Raphael 2006).

To evaluate the loss of four murrelets, we assumed the following: 1) that the action-caused mortality will be an additive mortality source and 2) the future population growth rate for the species will remain negative (for all Conservation Zones) for at least the next several years. Thus, the consequence of additional murrelet mortality is straightforward - the two female, breeding-aged murrelets “removed” from the murrelet population by the underwater detonations, and any reproduction later in time from these two females, is not expected to be replaced through natural reproduction at any time in the foreseeable future.

Evidence suggests that the species is highly constrained by poor fecundity (McShane et al. 2004). The latest (2007) estimate of murrelet abundance for Conservation Zones 1-5 within the range of the NWFP Murrelet Effectiveness Monitoring Program is 17,354 (95 percent CI: 12,743 – 21,851) the lowest since the program was initiated in 2000 (Falxa et al. 2008).

To determine whether this permanent loss of two breeding-aged murrelets (and any future reproduction) will appreciably reduce the likelihood of murrelet persistence, we considered the number of females present in the estimated population for the listed range. With the current population size of 17,354 murrelets (Falxa et al. 2008), we estimate the population contains approximately 8,677 females and approximately 40 percent of the females (3,493) are expected to occur in Conservation Zone 1. Considering the estimated -3.40 percent annual rate of population change in Conservation Zone 1 during the next decade (McShane et al. 2004, pg. 3-52), the number of females is expected to decrease by approximately 119 individuals annually. This action will increase the annual estimated loss to 121 females in 2008-2009 (-3.45 percent, derived from 121 females removed from all mortality sources/3,493 total females) and approximately 123 females sometime during the remainder of the decade (-3.52 percent; these two additional females are the hypothetical offspring of the first two females).

In addition, some female murrelets that experience reduced hearing loss are expected to have a lower probability of survival and/or reproductive contribution. In addition, there would be a loss of reproduction from behavioral effects. This would incrementally reduce the number of female murrelets available for mating, although we are unable to quantify these effects. However, we expect that the effects to reproductive output would vary greatly between individuals, and would not necessarily be permanent in all individuals. Given these considerations, we do not anticipate that these effects, in addition to the effects previously described from mortality, would appreciably affect the likelihood of persistence of murrelets in Conservation Zone 1.

Therefore, based upon the magnitude of the change in female abundance, we do not expect murrelet persistence in Conservation Zone 1 to be appreciably reduced due to the action, nor do we expect an appreciable reduction in persistence at the scale of the listed range of the species. We expect that the abundance of female murrelets is sufficiently high to make the loss of female murrelets biologically insignificant, either at the Conservation Zone 1 or at the DPS scale.

Conclusion

In our analysis, we identified lethal and sublethal effects expected to occur to murrelets in the action area during implementation of this action. These effects, from underwater and surface detonations, include: 1) immediate mortality and/or delayed mortality from serious (lethal) physical injury to four adult murrelets (including two females); 2) the future loss of reproduction from the mortality of two females; 3) a reduction in fitness for an unquantifiable number of murrelets in the action area that experience sublethal injuries from underwater detonations; and 4) a reduction in fitness for an unquantifiable number of murrelets in the action area that exhibit behavioral changes from underwater and floating mine detonations. The sublethal injuries and behavioral changes are expected to result in a significant impairment of essential breeding and feeding behaviors.

Although we anticipate impacts to murrelet fitness, adult survival and the reproductive performance at the population scale (Conservation Zone 1) is likely to remain effectively unchanged. Thus, we do not expect the proposed action to result in an appreciable reduction in the likelihood of murrelet survival and recovery at the listed range of the species. We base this conclusion on the analysis presented in this section where no biologically measurable change in adult survivorship was detected nor was a biologically significant reduction in the overall fecundity of the species detected. In other words, we do not expect that the combined effects of 1) the initial loss of 4 murrelets (2 females) in 2008-2009 and the subsequent loss of 4 more murrelets (2 females) during 2010-2045 from a rangewide population estimate of 17,354 murrelets (8,677 females) and 2) the possible reduction in fitness for murrelets in the action area (due to a reduced probability of survival or reproductive contribution) would appreciably change the likelihood of survival and recovery of the species. As a result, we conclude the Project will not jeopardize the continued existence of the murrelet.

CONCLUSION

Bull Trout

After reviewing the current status of bull trout, the environmental baseline for the action area, the effects of the proposed EOD training operation, and the cumulative effects, it is the Service's biological opinion that the EOD training operation, as proposed, is not likely to jeopardize the continued existence of the bull trout.

Murrelet

After reviewing the current status of the murrelet, the environmental baseline for the action area, the effects of the proposed EOD training operation, and the cumulative effects, it is the Service's biological opinion that the EOD training operation, as proposed, is not likely to jeopardize the continued existence of the murrelet.

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 Service 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 Service 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.

The measures described below are non-discretionary, and must be undertaken by the Navy so that they become binding conditions of any grant or permit issued to the Navy, as appropriate, for the exemption in section 7(o)(2) to apply. The Navy has a continuing duty to regulate the activity covered by this incidental take statement. If the Navy (1) fails to assume and implement the terms and conditions or (2) fails to require any contract personnel to adhere to the terms and conditions of the incidental take statement, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, the Navy must report the progress of the action and its impact on the species to the Service as specified in the incidental take statement [50 CFR §402.14(i)(3)].

AMOUNT OR EXTENT OF TAKE

<u>Bull Trout</u>

Incidental take of bull trout in the form of **harm** through death or physical injury from the direct effects of the pressure wave resulting from detonation of the explosive during the EOD training.

A total of five juvenile, sub-adult or adult bull trout in the Crescent Harbor action area will be harmed.

Murrelet

We anticipate incidental take of murrelets to result from the project as follows:

Incidental take of murrelets in the form of ***harm*** through mortality or sublethal injury from elevated underwater SPLs resulting from underwater detonations in November 2008 and February and July 2009. Incidental take of murrelets will be difficult to quantify because we anticipate birds that are mortally wounded are likely to sink and go undetected and human safety precautions preclude monitoring immediately after detonations occur.

- Murrelet presence and numbers in the action area are difficult to predict. With implementation of the seabird monitoring protocol, the potential for harm is greatly reduced but not eliminated. As such, the Service expects that no more than four murrelets will be incidentally ***harmed*** during the six underwater training exercises.

Incidental take of murrelets in the form of ***harm*** through damage to ears from elevated underwater SPLs resulting from underwater detonations in November 2008, February 2009, and July 2009. Incidental take of murrelets will be difficult to quantify because human safety precautions preclude monitoring immediately after detonations occur and the area of potential harm is so large that effective monitoring is not possible. Using habitat conditions as a surrogate indicator of take, the Service anticipates that the following amount of take will occur in the form of harm:

- The Service expects all murrelets within the action area (approximately 239 km^2) will be incidentally ***harmed*** in the form of sublethal injury by the six underwater training exercises.

Incidental take of murrelets in the form of ***harassment,*** through significant disruption of normal breeding, foraging, and sheltering behaviors from elevated underwater and above water SPLs and helicopter activities resulting from the underwater and floating mine training exercises taking place between November 2008 and December 2009. Incidental take of murrelets in the form of harassment will be difficult to quantify because the area of potential harassment is so large that effective monitoring is not possible. Using habitat conditions as a surrogate indicator of take, the Service anticipates that the following amount of take will occur in the form of harassment:

- The Service expects all murrelets within the action area (approximately 239 km^2) will be incidentally ***harassed*** by the ten training exercises.

EFFECT OF THE TAKE

Bull Trout

In the accompanying BO, the Service determined that this level of anticipated take is not likely to result in jeopardy to the species.

Murrelet

In the accompanying BO, the Service determined that this level of anticipated take is not likely to result in jeopardy to the species.

REASONABLE AND PRUDENT MEASURES

Bull Trout

The Service believes no reasonable and prudent measure(s) are necessary and appropriate to minimize impacts of incidental take of bull trout. Measures that are designed to minimize impacts to bull trout have been incorporated by the Navy into the action description.

Murrelet

The Service believes no reasonable and prudent measures are necessary and appropriate to minimize impacts of incidental take of murrelets. Measures that are designed to minimize impacts to murrelets have been incorporated by the Navy into the action description.

TERMS AND CONDITIONS

Bull Trout

In order to be exempt from the prohibitions of section 9 of the Act, the Navy must comply with the following terms and conditions, which outline required monitoring and reporting requirements in order to monitor the impacts of the incidental take. These terms and conditions are non-discretionary.

Terms and Conditions applicable to monitoring:

1. The Navy shall implement the In-water Training Monitoring and Trawl Sampling Plans (Appendix B). Data collected will include, but are not limited to, the date and time of detonation, species of fish collected, estimated numbers of fish killed and floating on the surface, and provide an estimate of the kill and injury radius for each detonation. Any bull trout will be salvaged and provided for necropsy (if timely necropsy cannot be performed, salvaged bull trout can be frozen).

Terms and Conditions applicable to reporting:

1. The Navy shall submit a monitoring report by December 31, 2009 to include, at a minimum:
    - Dates and times of all detonations (underwater and floating mine)
    - Location within training area and water depth for each detonation.
    - Necropsy results collected during the post-detonation implementation of the In-water Training Monitoring and Trawl Sampling Plans, as specified under monitoring requirement #1 above.

The Service believes that no more than the following incidental take will occur as a result of the proposed action:

- Five bull trout, in the form of harm, from the six underwater training exercises between October 2008 and December 2009.

The bull trout monitoring terms and conditions have been designed to ensure anticipated take is not exceeded. If, during the course of the action, the level of incidental take is exceeded, such incidental take represents new information requiring reinitiation of consultation. The Federal agency must immediately provide an explanation of the causes of the taking and review with the Service the need for reasonable and prudent measures to minimize take of bull trout.

<u>Murrelet</u>

In order to be exempt from the prohibitions of section 9 of the Act, the Navy must comply with the following terms and conditions, which outline required monitoring and reporting requirements in order to monitor the impacts of the incidental take. These terms and conditions are non-discretionary.

Terms and Conditions applicable to monitoring:

1. The Navy shall implement the seabird monitoring protocol (Appendix A) as soon as is safely possible, after each detonation during the months of November - February. The post blast search will focus on salvaging dead birds (any species) and documenting murrelets or other alcid species (such as pigeon guillemots, common murres, auklets, puffins) that are behaving abnormally. Data collected will include, but are not limited to, the date and time of detonation, the time survey is initiated and terminated, species of birds observed, and behavior and condition of bird. Any dead birds will be salvaged and provided for necropsy (if timely necropsy cannot be performed, salvaged birds can be frozen).

2. If any alcid species are detected outside of the area to be surveyed (500 m) during the pre-detonation seabird monitoring, the Navy shall have observers follow these birds before, during, and after the detonation and record behavior. Data collected will include, but is not limited to, time survey is initiated and terminated, species of birds observed, behavior(s) pre- and post-detonation, and time of detonation.

3. The Navy shall conduct hydroacoustic monitoring of underwater detonations:
    - In conjunction with the Service, the Navy will develop a protocol to collect hydroacoustic data. The protocol will be completed no later than January 31, 2009, and will begin to be implemented with the February 2009 underwater detonations.
    - A minimum of four underwater detonations will be monitored between October 2008 and December 2009. The four detonations to be monitored must provide an adequate representation of the Navy's use of the training area, including varying water depths and distance to shore.
    - At a minimum, the data will be collected at the following three locations: a) at the edge of the 210 meter mortality/severe injury zone or as close to this distance as is safe, b) at the southern edge of the action area (extent of harm and harassment area) in Saratoga Passage, and c) at the eastern edge of the action area near Skagit Bay.
    - Data to be collected at the three locations will need to measure the SPLs in such manner as to ensure the SPL has not exceeded 41 Pa-sec at 210 meters from the detonation and has not exceed 180 dB_{peak} at the edge of the action area.

Terms and Conditions applicable to reporting:

1. The Navy shall submit a monitoring report by December 31, 2009 to include, at a minimum:
    - Dates and times of all detonations (underwater and floating mine)
    - Location within training area and water depth for each detonation
    - Helicopter use: date(s) and daily duration
    - Necropsy results and behavioral data collected during the post-detonation implementation of the seabird monitoring protocol, as specified under monitoring requirement #1 above.
    - Data collected as specified under monitoring requirement #2 above.
    - Hydroacoustic data:
        a. Dates, times, and specific locations of data collection
        b. SPLs measured at each of the three specified locations for each detonation.

The Service believes that no more than the following incidental take will occur as a result of the proposed action:

- Four murrelets, in the form of harm, within 210 meters of the six underwater training exercises between November 2008 and December 2009.
- All murrelets, in the form of sublethal harm, within the action area during the six underwater training exercises to be conducted between November 2008 and December 2009.
- All murrelets, in the form of harassment, within the action area during the ten training exercises to be conducted between November 2008 and December 2009.

The murrelet monitoring terms and conditions have been designed to ensure anticipated take is not exceeded. If, during the course of the action, the level of incidental take is exceeded, such incidental take represents new information requiring reinitiation of consultation. The Federal agency must immediately provide an explanation of the causes of the taking and review with the Service the need for reasonable and prudent measures.

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 Services' Western Washington Fish and Wildlife Office at (360) 753-9440.

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.

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.

Bull Trout

- Conduct the Navy EOD training in a controlled environment, such as a lake, where listed fish are not present. The Service understands the needs of the Navy to conduct the EOD training in an environment similar to actual conditions experienced by Navy personnel. This requires constant, specialized, and realistic training. However, to protect listed species, training in a controlled environment would allow the Navy to provide unlimited explosive training to meet operational goals.

- If future training occurs in Puget Sound, dig a permanent pit in the substrate, for a steel or concrete box-type structure, in which all underwater detonations would occur to contain most of the blast energy.

Murrelet

- Implement the seabird monitoring protocol as soon as is safely possible, after all underwater and floating mine detonations. The post blast search will focus on salvaging dead birds and documenting birds that are behaving abnormally. Data collected should include the date and time of detonation, the time survey is initiated and terminated, species of birds observed, and behavior and condition of bird. Any dead birds will be salvaged and provided for necropsy (If timely necropsy cannot be performed, salvaged bird can be frozen).

- Conduct hydroacoustic monitoring for all detonations, floating mine and underwater.

- Provide murrelet and other alcid species identification training to all observers participating in the pre- and post-detonation seabird monitoring.

REINITIATION NOTICE

This concludes formal consultation on implementation of the proposed action. As provided in 50 CFR section 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 BO; (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 BO; 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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Appendix A

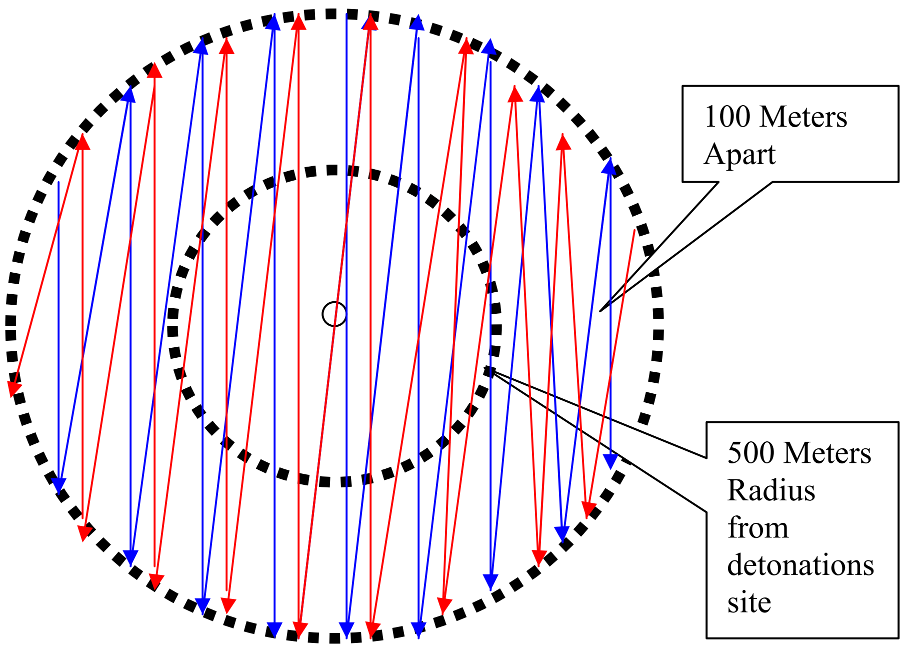
PROTOCOL
MONITORING FOR SEA BIRDS
for
EOD TRAINING EXERCISES

In an effort to reduce potential impacts to Marbled Murrelets the Navy will conduct sea bird surveys based on the following protocol. Since the Navy currently surveys for all sea birds and marine mammals that may be within the designated impact zone the same go, no go status will be applicable to murrelets as well.

1. Transect lines will be no more than 100 meters apart and beginning 50 meters from shore. If the sea-state is greater than Beaufort of 2 then the transect lines will be no more than 50 meters apart. In the case of fog or reduced visibility the surveyors must be able to see a minimum of 50 meters or the exercise cannot proceed.
2. Transect lines will be established using GPS;
3. Boat speed will be equal to or less than 10 knots per hour;
4. A minimum of 2 surveyors (not including the driver) for identification of sea birds per boat, two boat minimum;
5. The boats will approach from the opposite direction and toward the center or placement area of the charge and work their way to the outside or minimum radius. Once the survey is complete and the survey boats are a safe distance, the divers can place the charge and conduct the training. Initial surveys will be conducted out to a minimum of 500 meter radius from the detonation site or radius determined by charge size and location, whichever is greater and will be surveyed according to this protocol.
6. No detonation will occur if sea birds or marine mammals are within the 500 meter radius or the distance prescribed by the regulatory agencies;
7. Detonation should be at least 600 meters from shoreline;
8. Between March 15 and July 1 no charge larger than 1 pound can be used at Bangor; between July 1 and September 30 no charge over 2.5 pounds can be used at Crescent Harbor or Port Townsend unless it is 1,093 meters or greater from the nearest shoreline.
9. Detonation larger than 5 pounds should be done a minimum of 1000 meters from shore;
10. The surveyors will have the training to accomplish specific verification of species sited.
11. Visual observations with the aid of binoculars to identify species will be utilized during the survey, avian and mammalian.
12. At a minimum the survey report will have the sea-state, identify species and number of species, time of day, and weather conditions. This after action report will be submitted to USFWS and NMFS in accordance with the guidance provided in their respective

biological opinions. This report will suffice for notification of a threatened and or endangered species being identified in the action area.

As funding permits one of the surveyors will be trained to identify murrelets for population estimation purposes or a trained contractor will be used to obtain population estimation for murrelets.



1. As denoted on the drawing the transect lines will be no more than 100 meters apart. If the sea-state is greater than Beaufort of 2 the transect lines will be no more than 50 meters apart. In the case of fog or reduced visibility the surveyors must be able to see a minimum of 50 meters or the exercise cannot proceed.
2. Prior to placement of charges, all surveys will be conducted through the detonation site proceeding in opposite directions for each transect as indicated above.
3. Initial surveys will be conducted out to a minimum of 500 meter radius from the detonation site for any charge size according to the protocol. A larger radius will be surveyed when necessary, as indicated by the charge size and location. This larger radius will be surveyed in the same manner as the 500 meter radius area.
4. Any threatened and or endangered species identified within the impact area as delineated by the NMFS and USFWS biological opinions respectively will result in no placement of the explosive until the area is surveyed clear.

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Appendix B

Navy Region Northwest
Explosive Ordnance Disposal (EOD) Units
In-Water Training Monitoring Plan

1. Introduction

Navy Region Northwest EOD Units conduct in-water training approximately one day per month. The training consists of using underwater explosive charges to destroy or disable inert (dummy) mines. This EOD In-water Training Monitoring Plan was developed based on stratified random sampling method to accomplish the objectives in paragraph 2. Sampling will consist of deploying 15 circular 36-inch diameter sampling nets from a boat. The sampling nets will be placed on the bottom randomly around the detonation point. Following the detonation, the sampling nets will be retrieved by pulling them to the surface straight up through the water column. Once the sampling nets are onboard, fish species and quantities will be recorded.

2. Objectives

a. Monitor and estimate surface and subsurface ESA listed fish mortalities, if any, which result from EOD training detonations over a three-year period.

b. Gain an understanding of approximate numbers of surface and subsurface forage fish mortalities by species.

c. Monitor seasonal, temporal, and temperature variability related to mortalities of both listed species and forage fish.

d. If possible, establish a relationship between subsurface mortalities and surface-visible mortalities during monitoring plan execution so that the monitoring plan can be revisited to determine if surface counts only can be used to estimate total mortalities for the remainder of the 3-year monitoring program.

e. Provide frozen samples of incidentally captured live listed species and/or forage fish to NOAA Fisheries so that NOAA Fisheries can determine, if possible, potential sub-lethal effects.

f. Provide frozen samples of salmonids, forage fish, and ground fish mortalities to NOAA Fisheries so that NOAA Fisheries can determine, if possible, cause of death.

g. Retain any char for future FWS evaluations.

3. Net Sampling Monitoring Procedures*

a. Roles and Responsibilities

1) Monitoring Event Lead (MEL): A monitoring event lead will be established prior to the each monitoring event. This person will normally be the on-board biologist from a pool of three NRNW Biologists and one EFWNW Biologist.
1) Boat Operator: Two certified U.S. Navy boat operators from a pool of NAS Whidbey Island Site personnel will operate the two 21-foot boats.
2) Helper/Handler: A Helper/Handler from NAS Whidbey Island Site personnel will keep in constant communication with the EOD Unit Operations Officer and assist with sampling net placement and recovery and conduct the surface fish count.

b) Sampling Net Placement

1) Current direction and speed will be recorded prior to the sampling event.
2) Effective mortality zones will be initially determined from the Biological Assessment (BA) and previous surface monitoring observation data.
3) After EOD has set the target, a minimum of three 3-net clusters will be placed at a minimum of three down-current locations on the initial monitoring events as follows:
   a) 50M, 150M, and 300M or at distances and/or locations as adaptively determined within any given sampling event or series of monitoring events.
   b) A GPS reading will be noted on the event data record sheets (ERS) for each net cluster and for the detonation location on the ERS.
   c) Temperature of the water will be taken on the initial net placement and recorded on the ERS

c) Detonation of the Charge

1) The boat will stand off at a distance directed by the EOD Unit Operations Officer. The Operations Officer gives direction that it is safe to recover the nets.
2) Time of detonation will be noted on the ERS.

d) Sampling Net Recovery

1) Upon clearance from EOD after the detonations, the monitoring vessel will move to the cluster closest to the detonation site.
2) Estimates will be made of the number of floating impacted fish at each cluster during this move and recorded on the ERS.
3) The size of the areas represented by the net clusters in which estimates will be made will be pre-determined by an analysis as described in the data management section of this plan.
4) Time will be recorded on the ERS at the beginning of each cluster haul.

5) Nets with samples net will be placed into a storage bucket.
6) Sampling nets will be retrieved as quickly as possible.

e) Numbers/Species Determinations

1) It is ideal that counts and specification can be made on the boat and dead fish discarded over the side to avoid sample clutter.
2) Numbers and species will be recorded on the ERS.

f) Collection of Samples

1) At the direction of the MEL samples will be placed in zip lock bags.
2) A unique number will be assigned to each sample and recorded on the outside of the zip lock bag with an indelible black marker.
3) Where possible, a minimum of 10 fish of each species will be saved.
4) The unique number will be recorded on the ERS and notes will be made as to the nature of the sample and why the sample was collected.
5) Samples will be kept cool on the boat and will be frozen on return to the installation and forwarded to NOAA Fisheries within a pre-determined time.
6) Length will be measured for a 10 percent subset of each species captured, not to exceed 20 individuals in each species. If there are 20 or fewer individuals, up to ten individuals will be measured, depending on the number captured.
7) Include on the monitoring event data record sheet the name of the trained person identifying fish species.
8) For unidentifiable species that occur in significant numbers (greater than 10 individuals) a single individual will be bagged and frozen for NOAA Fisheries identification. Where there may be unidentifiable species that occur at numbers less than 10-fish NOAA Fisheries identification will be at the discretion of MEL. Alternatively, digital pictures can be taken and forwarded to NOAA Fisheries for identification.

g) Data Management Philosophy, Methods, and Protocols.

1) As stated above, the heretofore assumption has been that the 15-36"diameter net samples will be considered a subset of the entire impact area which could be as large as 1 km in diameter. Since trying to extrapolate this sample data over a large impact area will likely yield statistically insignificant results, it was decided to use cluster sampling methodologies and confine statistical analyses to predetermined areas around those clusters.
2) The basic philosophy of this plan, and the primary difference from concepts as originally proposed, comes from the recognition that it may be very difficult and cost prohibitive to sample and adequately characterize the total potential impact area of approximately 1km in diameter. Therefore, it is expedient to analyze discrete and

statistically manageable subsets of the impact area in such a way as to support the agreed-upon monitoring plan objectives.

3) Prior to the initial monitoring event water volumes to be represented by the net clusters will be determined based on agreed upon statistical error margins and/or CIs. These volumes represented by these areas could be on the order of 50' in diameter extending to the bottom. Fish densities will be calculated on cluster composite samples and extrapolated to determine the total number of affected fish in the water volume represented by the cluster. The number of net-captured fish will be related to the number of floating fish within the surface area represented by the cluster.
4) It is recognized that occurrences of significant densities of fish in the water column are, in an ecological term, very patchy. Fish are not evenly distributed but either occur in schools or are concentrated by the immediate availability of food. The primary food source for many species in open areas of Crescent Harbor, especially salmonids, are schools of forage fish such as herring and surf smelt. These are schooling species and are rarely found as individuals. It is most often the case that the highest incidence of potential mortality for salmonids should be directly associated with the occurrence of concentrations forage fish.
5) Total mortality will be determined by relating the combined subsurface and surface fish kill to the total volume of water filtered by the net sampling, as estimated by EOD post-detonation surveys within immediately after the detonation.

This plan will be refined using an adaptive management process. Lessons learned in initial sampling rounds will be used to refine future monitoring rounds. Therefore, methods may change somewhat from those in this plan.

4. Surface Sampling Monitoring Procedures

Upon detonation of charge and clearance by the EOD Operations Officer, the surface sampling boat will enter the detonation zone. Fish counts will be estimated by running transects at 15-meter intervals through the effective mortality zone as defined in Section 3b(2) above. Transects will be plotted on a GPS navigation system and run from the east edge of the effective mortality zone to the west edge. Each successive transect will be staggered down current by a distance necessary to compensate for current drift of the fish as determined by the current direction and speed measured in Section 3b(1) above. Boat speed for running transects will be determined for each sampling event based on current speed and size of fish kill being estimated. Transects will be run at a maximum speed which the fish kill can still be effectively estimated. Transect length, duration of count, and surface water visibility will be recorded on the Surface Sampling ERS. Transects will be run directly into and away from current direction. The boat observer will record fish visible at the surface on both sides of the boat out to 7.5 meters from the boat. Also, successful bird foraging attempts will be monitored and counted. The estimated total surface fish kill will be determined by combining the number of visible fish at the surface with the successful bird foraging attempts. Additionally, a gross estimate of species composition for fish counted will be recorded for the surface sampling event.

5. Equipment

a. Two boats (21-foot w/depth finder and navigation equipment) – one boat for the surface count and one for the net sampling.
b. Nets: Fifteen – 36” diameter, weighted, ½ inch mesh (stretched) and 100’ floating yellow poly rope and crab pot type markers.
c. Fifteen rubber net containers.
d. Large zip-lock bags for samples.
e. Teflon note boards
f. Scale (platform with a 0-50 pound scale)
g. Wax pens
h. Method instructions and equipment list in sealed clear plastic cover
i. Notebook with pre-standardized monitoring ERS on non-bleeding paper.
j. Indelible pens
k. Buckets.
l. Steel-cased thermometer or an equivalent electronic instrument (YSI) with underwater temperature probe.
m. One GPS Unit
n. Tide and current tables for Crescent Harbor.
o. Chronometers
p. Salmonid and forage fish visual keys encased in clear plastic
q. Portable radios to communicate with EOD Training Ops persons
r. Nautical Charts of the Training Site
s. Navigational plotting devices

Navy Region Northwest
Explosive Ordnance Disposal (EOD) Units
In-Water Training Monitoring Plan
Trawl Sampling Addendum

1. Introduction

The baseline plan is to do Quadrat sampling using 15-36” diameter nets. Details of this plan have been worked out between the Navy and the agencies.

The agencies requested that data collected by the Quadrat sampling by validated by a single event trawl to be conducted in conjunction with a sampling event during an EOD training operation.

2. Objectives

The overall objective is to assist in estimating the relationship between subsurface and surface counts. To simplify the monitoring effort over time, the monitoring plan will attempt to correlate the ratio of surface visible (floating) impacted fish with potential subsurface impacted fish. This may enable the project principals to estimate numbers of impacted fish by simple surface counts if a strong correlation is observed.

The objective of this trawl addendum is to validate data collected by the Quadrat sampling in the monitoring plan.

3. Monitoring Procedures

a. Roles and responsibilities

1) The overall trawling event lead will be the Master of the sampling vessel.
2) Trawling will be conducted per the agreed upon trawling plan to be discussed with the Navy Monitoring Event Lead (MEL) in advance of the trawling event.

b. Trawl trajectories

1) Trawl trajectories will be coordinated with the placement of the quadrat net clusters, which will be linearly located at varying distances down current from the EOD point of detonation.
2) One or more mid-water trawls will be conducted in a down current direction parallel to net clusters but distant enough as to not interfere with quadrat net recovery.
3) If it is agreed that bottom trawls are expedient or even possible within reasonable time frames. One or more trawls will be in the reverse direction toward the point of EOD detonation and immediately following down current trawls.

4) Trawl distances will be the same as the total quadrat sampling net maximum distance placement from the EOD point of detonation.

c. Data management

1) Data management protocols for counting and handling catches will be the same as for quadrat sampling.
2) Methods for statistical extrapolations of total mortality will be coordinated with the boat operator (Dr. Duggins, University of Washington, Friday Harbor Laboratories) but will include basic parameters such as volume of water filtered, among others.
3) Coordinated surface counts will be the same as those used for the quadrat sampling.
4) Area of impact, as per the calculations described in the monitoring plan will be the identical. The same determinations will be used for both the quadrat sampling and the trawls.
5) Data will be recorded in the same manner as in the monitoring plan.

d. Collection of Samples

1) Sample collection will be as described in the monitoring plan.

4. Other Considerations

This trawling plan will be adaptively managed. That is, as specific information becomes available about equipment and procedures from NOAA fisheries and the University of Washington operators, the above plan may be modified to meet the same objectives within a single trawling event.

(General Information)

Date/Time: **Location**:

Size/Depth of Explosive Charge: **Lat/Long of Detonation**:

Cloud Cover: **Wind Speed/Direction**: **Water Visibility**:

Tide Level: **Current Speed/Direction**: **MEL Name**:

(Fish Count Data)

Time of Survey Start: **Duration of Survey:**

Estimate Width of Area of Affect:

Average Length of Transects: **Number of Transects:**

Estimated Surface Fish	**Estimated Fish Taken By Birds**	**Estimated Surface Count (Total)**

Fish Species (Common name)	**Species Composition (Estimated Percentage of Total Fish Counted)**

Sampling Event General Comments and Notes:

(General Information)

Date/Time: **Location**:

Size/Depth of Explosive Charge: **Lat/Long of Detonation**:

Cloud Cover: **Wind Speed/Direction**: **Water Visibility**:

Tide Level: **Current Speed/Direction**: **MEL Name**:

(Fish Count Data)

Time of Survey Start: **Duration of Survey:**

Estimate Width of Area of Affect:

Average Length of Transects: **Number of Transects:**

Estimated Surface Fish	**Estimated Fish Taken By Birds**	**Estimated Surface Count (Total)**

Fish Species (Common name)	**Species Composition (Estimated Percentage of Total Fish Counted)**

Sampling Event General Comments and Notes:

Appendix C
Murrelet Density Estimates

Month	Density Estimate (murrelets/km^2)	Source
January	5.5	PSAMP 1993-2005 aerial surveys
February	5.5	Assumed same as January estimate
March	2.93	Interpolated equal density change between February and April estimates
April	0.35	Assumed same as May-July estimate
May – July	0.35	USFS EM 2000-2007 boat surveys
August	0.35	Assumed same as May-July estimate
September	2.07	Interpolated equal density change between August and November estimates
October	3.78	Interpolated equal density change between August and November estimates
November	5.5	Assumed same as December estimate
December	5.5	PSAMP 1993-2005 aerial surveys

Appendix D

Specific estimates and calculations used to derive estimated number of murrelets anticipated to be underwater or at the surface at the time of a detonation and could be subject to injury and/or mortality

	2008			2009										
	October	November	December	January	February	March	April	May	June	July	August	September	October	November	December
Murrelet Density (murrelets/sq km) (See Appendix C)	3.78	5.5	5.5	5.5	5.5	2.9	0.35	0.35	0.35	0.35	0.35	2.07	3.78	5.5	5.5
Murrelets that go undetected (22%)	0.832	1.210	1.210	1.210	1.210	0.638	0.077	0.077	0.077	0.077	0.077	0.455	0.832	1.210	1.210
Murrelets that are underwater (72%)	0.599	0.871	0.871	0.871	0.871	0.459	0.055	0.055	0.055	0.055	0.055	0.328	0.599	0.871	0.871
Murrelets that are on the surface (28%)	0.233	0.339	0.339	0.339	0.339	0.179	0.022	0.022	0.022	0.022	0.022	0.128	0.233	0.339	0.339

Underwater Detonations - Murrelets Underwater

Murrelets estimated to be underwater in Mortality/Injury Zone (0.14 km^2)	0.084	0.122	0.122	0.122	0.122	0.064	0.008	0.008	0.008	0.008	0.008	0.046	0.084	0.122	0.122
Probability of 1 murrelet being exposed to elevated SPLs	0.077	0.108	0.108	0.108	0.108	0.060	0.008	0.008	0.008	0.008	0.008	0.044	0.077	0.108	0.108
Probability of 2 murrelets being exposed to elevated SPLs	0.003	0.007	0.007	0.007	0.007	0.002	0.000	0.000	0.000	0.000	0.000	0.001	0.003	0.007	0.007
Number of Underwater Detonations Proposed	0	1	0	0	3	0	0	0	0	2	0	0	0	0	0
Number of murrelets anticipated to be underwater at the time of detonation and could be subject to injury and/or mortality	0	1	0	0	3	0	0	0	0	0	0	0	0	0	0

	2008			2009											
	October	**November**	**December**	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**
Murrelet Density (murrelets/sq km) (See Appendix C)	3.78	5.5	5.5	5.5	5.5	2.9	0.35	0.35	0.35	0.35	0.35	2.07	3.78	5.5	5.5
Murrelets that go undetected (22%)	0.832	1.210	1.210	1.210	1.210	0.638	0.077	0.077	0.077	0.077	0.077	0.455	0.832	1.210	1.210
Murrelets that are underwater (72%)	0.599	0.871	0.871	0.871	0.871	0.459	0.055	0.055	0.055	0.055	0.055	0.328	0.599	0.871	0.871
Murrelets that are on the surface (28%)	0.233	0.339	0.339	0.339	0.339	0.179	0.022	0.022	0.022	0.022	0.022	0.128	0.233	0.339	0.339
Underwater Detonations - Murrelets on the Surface															
Murrelets estimated to be on the surface in Mortality/Injury Zone (0.0004 km^2)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Probability of 1 murrelet on the surface being exposed to elevated SPL or water plume	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Number of Underwater Detonations Proposed	0	1	0	0	3	0	0	0	0	2	0	0	0	0	0
Number of murrelets anticipated to be on the surface at the time of underwater detonation and could be subject to injury and/or mortality	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Floating Mine Detonations - Murrelets on the Surface															
Murrelets estimated to be on the surface in Mortality/Injury Zone created by the flying debris (0.0417 km^2)	0.010	0.014	0.014	0.014	0.014	0.007	0.001	0.001	0.001	0.001	0.001	0.005	0.010	0.014	0.014

	2008			2009											
	October	November	December	January	February	March	April	May	June	July	August	September	October	November	December
Murrelet Density (murrelets/sq km) (See Appendix C)	3.78	5.5	5.5	5.5	5.5	2.9	0.35	0.35	0.35	0.35	0.35	2.07	3.78	5.5	5.5
Murrelets that go undetected (22%)	0.832	1.210	1.210	1.210	1.210	0.638	0.077	0.077	0.077	0.077	0.077	0.455	0.832	1.210	1.210
Murrelets that are underwater (72%)	0.599	0.871	0.871	0.871	0.871	0.459	0.055	0.055	0.055	0.055	0.055	0.328	0.599	0.871	0.871
Murrelets that are on the surface (28%)	0.233	0.339	0.339	0.339	0.339	0.179	0.022	0.022	0.022	0.022	0.022	0.128	0.233	0.339	0.339
Probability of 1 murrelet being exposed to flying debris	0.010	0.014	0.014	0.014	0.014	0.007	0.001	0.001	0.001	0.001	0.001	0.005	0.010	0.014	0.014
Number of Floating Detonations Proposed	1	0	0	0	0	0	2	0	1	0	0	0	0	0	0
Number of murrelets anticipated to be killed or injured by the flying debris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Floating Mine Detonations - Murrelets Underwater

Murrelets estimated to be underwater in Mortality/Injury Zone created by the floating mine detonations (0.0002 km^2)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Probability of 1 murrelet being exposed to elevated SPL underwater	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Number of Floating Detonations Proposed	1	0	0	0	0	0	2	0	1	0	0	0	0	0	0

	2008			2009											
	October	**November**	**December**	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**
Murrelet Density (murrelets/sq km) (See Appendix C)	3.78	5.5	5.5	5.5	5.5	2.9	0.35	0.35	0.35	0.35	0.35	2.07	3.78	5.5	5.5
Murrelets that go undetected (22%)	0.832	1.210	1.210	1.210	1.210	0.638	0.077	0.077	0.077	0.077	0.077	0.455	0.832	1.210	1.210
Murrelets that are underwater (72%)	0.599	0.871	0.871	0.871	0.871	0.459	0.055	0.055	0.055	0.055	0.055	0.328	0.599	0.871	0.871
Murrelets that are on the surface (28%)	0.233	0.339	0.339	0.339	0.339	0.179	0.022	0.022	0.022	0.022	0.022	0.128	0.233	0.339	0.339
Number of murrelets anticipated to be killed or injured underwater by the elevated SPLs from the floating mine detonations	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Helicopter Insertions (20 degree angle of descent) - Murrelets on the Surface

Murrelets on the surface in the helicopter downwash zone (1.86 km^2) (murrelet density x zone)	0.433	0.630	0.630	0.630	0.630	0.332	0.040	0.040	0.040	0.040	0.040	0.237	0.433	0.630	0.630
Probability of 1 murrelet being exposed to helicopter downwash	0.281	0.336	0.336	0.336	0.336	0.238	0.038	0.038	0.038	0.038	0.038	0.187	0.281	0.336	0.336
Probability of 2 murrelets being exposed to the helicopter downwash	0.061	0.106	0.106	0.106	0.106	0.040	0.001	0.001	0.001	0.001	0.001	0.022	0.061	0.106	0.106
Number of murrelets anticipated to be on the surface and could be subject to helicopter downwash	1	2	2	2	2	1	0	0	0	0	0	1	1	2	2
Number of Floating Detonations Proposed	1	0	0	0	0	0	2	0	1	0	0	0	0	0	0

	2008			2009											
	October	**November**	**December**	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**
Murrelet Density (murrelets/sq km) (See Appendix C)	3.78	5.5	5.5	5.5	5.5	2.9	0.35	0.35	0.35	0.35	0.35	2.07	3.78	5.5	5.5
Murrelets that go undetected (22%)	0.832	1.210	1.210	1.210	1.210	0.638	0.077	0.077	0.077	0.077	0.077	0.455	0.832	1.210	1.210
Murrelets that are underwater (72%)	0.599	0.871	0.871	0.871	0.871	0.459	0.055	0.055	0.055	0.055	0.055	0.328	0.599	0.871	0.871
Murrelets that are on the surface (28%)	0.233	0.339	0.339	0.339	0.339	0.179	0.022	0.022	0.022	0.022	0.022	0.128	0.233	0.339	0.339
Number of murrelets exposed to downwash if helicopter is used	1						0		0						

Appendix E

Estimating the demographic consequences of the predicted mortality of four marbled murrelets (*Brachyramphus marmoratus*) caused by underwater and floating mine detonations in the marine environment associated with a military ordnance training plan.

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November 2008

The U.S. Department of Defense (Navy) has developed an ordnance training plan for the Explosive Ordnance Detonation (EOD) Training Operation (Action). The Navy has requested formal consultation pursuant to the 1973 Endangered Species Act with the U.S. Fish and Wildlife Service (Service) for the Navy's anticipated impacts on two federally-listed species, the threatened bull trout and threatened marbled murrelet (murrelet).

The purpose of the training (November 2008 through December 2009) is for personnel to meet and maintain requirements for basic proficiency in combat and non-combat EOD Mine Countermeasures readiness. The training consists of using explosive charges to destroy or disable inert mines that are either underwater or floating on the surface.

The training will occur at Crescent Harbor. The Crescent Harbor training area is on the east side of Whidbey Island, next to the Naval Air Station (NAS) Whidbey Island Seaplane Base. This memorandum describes how estimates of population size and demographic parameters were derived and integrated into projections of the population-level effects of lethal consequences of four adult murrelets.

Approach to the Analysis

The objective of this analysis is to estimate the effect of 4 murrelet mortalities caused by the Action. We first constructed a demographic table to represent the structure of murrelet population occurring in Conservation Zone 1. This served as a basis to predict: 1) the probable age of the murrelet mortalities based upon the relative abundance of each age class (juvenile, subadult and adult); 2) changes in adult survivorship; and 3) a description of the reasonable consequences the mortally might have in terms of a change in reduced recruitment to adult-aged murrelets.

Population Demography

As a result of the development of the marine component of the Environmental Monitoring (EM) Program for the NWFP (Bentivoglio 2002), sampling procedures have been unified within the five Conservation Zones contained within NWFP lands. These efforts, along with a coordinated effort in Conservation Zone 6 to implement the same sampling protocol, have resulted in annual estimates of murrelet abundance for each Conservation Zone (Falxa et al. 2007, Bentivoglio 2002, Huff et al. 2003, McShane et al. 2004). Using the most recent population estimates from Falxa et al. 2007, Conservation Zone 1 has an estimated murrelet population size of 6,985 (Table 1). The young-of-year were considered less than 1 year old (0-1), subadults (1-2 years old), and adults (3 years old and greater).

Table 1. The number of marbled murrelets in each demographic class in Conservation Zone 1 in northwest Washington (derived from Falxa et al. 2007).

Population Size[1]	Breeding Adults[2]	Breeding Pairs[3]	Non-breeding Adults[4]	Subadults[5]	Juveniles[6]
6,985	4,325	2,163	2,329	124	207

[1] 2007 survey data from Conservation Zone 1; 95% CI = 4,105 (lower) and 10,382 (upper) (Falxa et al. 2008).
[2]No. of adults (6,654) x adult breeding rate (0.65).
[3]No. of breeding adults/2.
[4]No. of adults (6,654) – No. of breeding adults (4,325).
[5]No. of young (207) x 0.60 survival.
[6]No. of pairs of after-hatch-year murrelets (6,778/2) x 0.061 young/pair.

Step 1: Relative Abundance

From the information in Table 1, we estimate that adults, subadults, and juveniles comprise approximately 95.3 percent, 1.8 percent, and 3.0 percent of the population. As a result, we conclude the random mortality of 4 murrelets is most likely to occur to adults based upon their relative abundance.

Step 2: Changes in Adult Survivorship

The estimated changes in adult survivorship for the estimated population size (and upper/lower 95 percent CI) in Conservation Zone 1 (Falxa et al. 2008) are presented in Table 2. Based on a loss of 4 murrelets due to the Action, adult survival was estimated at 0.880 (no change) for the upper 95 percent confidence level and 0.879 for the lower 95 percent confidence level.

Table 2. The Instantaneous Change in demographic rates of survivorship in Zone 1 (2009) Subject to Project-caused Injury/mortality

adults	Juveniles	Hatch Year	Pop. Est	CI	
0.953	0.018	0.030	6985	U95%CI=	10382
				L95%CI=	4105

Current Estimated Murrelet Demographic Abundance (95 % CI)				Projected 12 month demographic abundance	Projected Demographic Changes in 12 months (With Project Effects)				
Juveniles: Number and Survival			**Median Survival**	**N**	**Loss**	**N**	**Subadult Survival (no change)**	**Change in Survival**	**% ▲ in Survival**
Upper	311	0.580	**0.610**	190	**0**	190	0.580	0.000	0.000
Lower	123	0.640		75		75	0.640	0.000	0.000
Subadults: Number and Survival			**Median Survival**	**N**	**Loss**	**N**	**Subadult Survival (no change)**	**Change in Survival**	**% ▲ in Survival**
Upper	187	0.740	**0.780**	146	**0**	146	0.740	0.000	0.000
Lower	74	0.820		58		58	0.820	0.000	0.000
Adults: Number and Survival			**Median Survival**	**N**	**Loss**	***New N***	***Adult Survival (new)***	**Change in Survival**	**% ▲ in Survival**
Upper	9894	0.830	**0.88**	8707	**4**	8703	0.880	-0.0004	-0.040
Lower	3912	0.920		3443		3439	0.879	-0.001	-0.100

Step 3: Effects on Reproduction and Recruitment

We also assessed whether reducing the number of adults by 4 would have a measurable effect on the future recruitment. Using the assumptions listed at the bottom of Table 3, we have determined approximately 4 young would be expected from 4 adult murrelets in Conservation Zone 1, with an estimate of 3 reaching adult age.

ESTIMATED FUTURE (2010-2045) LOSSES IN REPRODUCTION OF 4 ADULT MURRELETS ASSOCIATED WITH 10 PROPOSED UNDERWATER DETONATIONS (2008-2009) IN CONSERVATION ZONE 1.

YEAR	4 Adults (AD1-AD4) Directly Removed				Offspring Losses in Subsequent Generations (F1-F3)			
	AD1(♂)	AD2(♂)	AD3 (♀)	AD4(♀)	AD3-F1(♀)	AD4-F1(♂)	AD3-F2(♀)	AD3-F3(♀)
2008-2009	DEATH/INJURY FROM 2.5 LB., UNDERWATER DETONATIONS AT CRESENT HARBOR				INDIRECT EFFECTS			
2010								
2011								
2012								
2013								
2014								
2015								
2016								
2017						Fails to Survive to Adulthood		
2018								
2019								
2020								
2021								
2022								
2023								
2024								
2025								
2026								
2027								
2028								
2029								
2030								
2031								
2032								
2033								
2034								
2035								
2036								
2037								
2038								
2039								see assumption #1
2040								
2041								
2042								
2043								
2044								
2045								
2046								

KEY	
	NON-BREEDING YEAR
	BREEDING YEAR (NEST FAILURE)
	NATURAL MORTALITY
	YOUNG TO SEA
	IMMATURE BIRD

See next page for calculations and assumptions.

NO. NEST ATTEMPTS	3	4	5	7	7	7	7	7
NO. NON-BREEDING YEARS	1	2	3	3	4	4	4	4

NEST ATTEMPTS	ADULT BREEDING RATE	FECUNDITY (#young/nest attempt)	#Young to Sea
47	0.653	0.096	4.512

ASSUMPTIONS

1. The AD3-F3 juvenile fails to survive to adulthood. Thus, juvenile survival is 60% in the above example (3 of 5 young at sea survive to reproduce), which is slightly lower that the 70% selected for use in "Zone Models" in McShane et al. (2004).

2. Fecundity (#young/nest attempt) = 9.6 % is derived from a juvenile ratio (# hatch yr birds:after hatch year pairs) of 0.060 as follows: 207 young/3,389 AHYprs = 0.061 juv. ratio. Assuming 62 pairs (207 young x 0.60 juvenile survival=124 juveniles = 62 juvenile pairs) of the 3,389 AHYprs are age 2, the number of breeding-aged adult pairs is estimated to be 3,327 pairs (6,654 individuals). At an adult breeding rate of 65%, 2,163 pairs (3,327 adult pairs x 0.65) will breed and produce 207 young, or a 0.096 young nest attempt (207 young/2,163 nesting attempts). Thus, fecundity is estimated at 0.096 from a population estimate of 6,985 (see Table 1).

3. The calculated number of young arriving at sea (4.512) was rounded up to 5 young in the above graphic.

4. Lifespan of murrelets assumed to be 15 years.

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