United States Department of the Interior

FISH AND WILDLIFE SERVICE

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

JUL 21 2016

In Reply Refer To:
01EWFW00-2015-F-0251
X-Ref: 13410-2009-F-0082
13410-2009-F-0104

L.M. Foster
Director, Fleet Environmental Readiness Division
Department of the Navy
U.S. Pacific Fleet
250 Makalapa Drive
Pearl Harbor, Hawaii 96860-3131

Dear Mr. Foster:

This letter transmits the U. S. Fish and Wildlife Service's (Service) Biological Opinion (Opinion) on the U.S. Navy's (Navy) proposed Northwest Training and Testing program that occurs in the offshore waters of northern California, Oregon, and Washington, the inland waters of Puget Sound, and portions of the Olympic Peninsula, and its effects on the bull trout (*Salvelinus confluentus*), designated bull trout critical habitat, the marbled murrelet (*Brachyramphus marmoratus*), and the short-tailed albatross (*Phoebastria albatrus*). The Opinion also addresses the U.S. Forest Service's Special Use Permit for the Navy's Pacific Northwest Electronic Warfare Range activities within the Olympic National Forest. Formal consultation on the proposed actions was conducted in accordance with section 7 of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*) (ESA).

On January 20, 2015, the Service received your request for formal consultation on the effects to the bull trout and the marbled murrelet and for informal consultation on the effects to the northern spotted owl and the short-tailed albatross. The Service initiated formal consultation on June 4, 2015. On October 30, 2015, the Service informed John Mosher of your office, via email, that we did not concur with your "may affect, not likely to adversely affect" determination for the northern spotted owl (*Strix occidentalis caurina*) and the short-tailed albatross. The Navy then requested formal consultation on those species on November 3, 2015. In our final analysis of the effects to the northern spotted owl, we concurred with the Navy's original "not likely to adversely affect" determination for this species.

The enclosed Opinion is based on information provided in a biological evaluation, the Draft, Final and Supplemental Environmental Impact Statements, the Final Environmental Assessment for the Pacific Northwest Electronic Warfare Range, as well as through information shared through numerous meetings, telephone conversations and emails, and through other sources cited in the Opinion. A complete record of this consultation is on file at the Service's Washington Fish and Wildlife Office in Lacey, Washington.

The Biological Evaluation also included a request for Service concurrence with "not likely to adversely affect" determinations for certain listed resources. The enclosed document includes a section separate from the rest of the Opinion that addresses your concurrence requests. We included a concurrence for the streaked horned lark (*Eremophila alpestris strigata*), western snowy plover (*Charadrius nivosus nivosus*), and northern spotted owl. The rationale for these concurrences is included in the concurrence section.

If you have any questions regarding the enclosed Opinion, our response to your concurrence request(s), or our shared responsibilities under the ESA, please contact Martha Jensen at (360) 753-9000 or martha_l_jensen@fws.gov, or Jim Muck at (206) 526-4740 or jim_muck@fws.gov.

Sincerely,

Eric V. Rickerson, State Supervisor
Washington Fish and Wildlife Office

Enclosure

cc:
NB Kitsap-Bangor, Silverdale, WA (C. Kunz)
NB Kitsap-Bangor, Silverdale, WA (A. Balla-Holden)
NAS Whidbey Island, Oak Harbor, WA (J. Mosher)
EERD Navy Pentagon, Washington D.C. (M. K. Ebert)

Endangered Species Act - Section 7 Consultation

BIOLOGICAL OPINION

U.S. Fish and Wildlife Service Reference:
01EWFW00-2015-F-0251

Navy's Northwest Training and Testing Activities

Offshore Waters of Northern California, Oregon, and Washington,
the Inland Waters of Puget Sound,
and Portions of the Olympic Peninsula

Federal Action Agency:

Department of the Navy

Consultation Conducted By:

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

7/21/16

Eric V. Rickerson, State Supervisor
Washington Fish and Wildlife Office

Date

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ACRONYMS AND ABBREVIATIONS

AGL	Above ground level
ASEL	A-weighted Sound Exposure Level
ASW	Anti-submarine warfare
AUV	Autonomous Underwater Vehicle
BE	Biological Evaluation
CFR	Code of Federal Regulations
CI	Confidence Level
dB	Decibel
dBA	A-weighted decibel level
DBRC	Dabob Bay Range Complex
DEIS	Draft Environmental Impact Statement
DICASS	Directional command activated sonobuoy system
DT^2	Distance To Disturbance Thresholds
EM	Electromagnetic
EMR	Electromagnetic radiation
EOD	Explosive Ordnance Disposal
ESA	Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*)
EW	Electronic Warfare
FEIS	Final Environmental Impact Statement
FHWG	Fisheries Hydroacoustic Working Group
Forest Service	U.S. Forest Service
GC	glucocorticoids
GHG	greenhouse gas
GHz	Gigahertz
HDC	High duty cycle
HE	High Explosive
HF	High-frequency
Hz	Hertz
IEER	Improved extended echo ranging
INRMP	Integrated Natural Resource Management Plan
IPCC	Intergovernmental Panel on Climate Change
kHz	Kilohertz
km^2	square kilometers
lb	pound
LEQ	Equivalent Sound Level
LF	Low-frequency
M	Modem (acoustic)
MAC	Multistatic Active Coherent
MaxLEQ	Maximum Equivalent Sound Level
MEWTS	Mobile Electronic Warfare Training Systems
MF	Mid-frequency
MHz	Megahertz
MOA	Military Operations Area
MSL	Mean Sea Level

n/a	Not applicable (Navy did not provide distances
NAS	Naval Air Station
NAVBASE	Naval Base
Navy	U.S. Department of the Navy
NEPM	Non-Explosive Practice Munitions
nm	nautical mile
nm^2	nautical mile squared
NMFS	National Marine Fisheries Service
NRF	Nesting, Roosting and Foraging
NWFP	Northwest Forest Plan
NWFPEM	Northwest Forest Plan's Effectiveness Monitoring
NWTT	Northwest Training and Testing
OCNMS	Olympic Coast National Marine Sanctuary
ONF	Olympic National Forest
ONP	Olympic National Par
OPAREA	Operating area
Opinion	Biological Opinion
PCBs	polychlorinated biphenyls
PCE	Primary Constituent Element
Peak	Peak pressure
PS	Primary Sampling Unit
QRS	Quinault Range Site
RMS	root mean square
ROV	Remotely Operated Vehicle
rte	Range to Effects
RU	Recovery Unit
SAS	Synthetic Aperture Sonar
SD	Swimmer detection (sonar)
SEL	Sound Exposure Level
Service	U.S. Fish and Wildlife Service
snowy plover	Western snowy plover
SPL	sound pressure levels
spotted owl	northern spotted owl
SUS	Sound Underwater Signal
SWAG	Shock Wave Action Generator
T&C	Terms and Conditions
TORP	Torpedo
TS	Threshold shift
TTS	Temporary Threshold Shift
UUV	Unmanned Underwater Vehicle
VHF	Very high-frequency
WDFW	Washington Department of Fish and Wildlife
WDNR	Washington State Department of Natural Resources

1 INTRODUCTION

This document represents the U. S. Fish and Wildlife Service's (Service) Biological Opinion (Opinion) based on our review of the proposed U.S. Department of the Navy's (Navy) Northwest Training and Testing (NWTT) activities located in the offshore areas of northern California, Oregon, and Washington, the inland waters of Puget Sound, portions of the Olympic Peninsula, as well as part of Western Behm Canal in southeast Alaska. The Opinion also includes the analysis for the U.S. Forest Service's (Forest Service) Special Use Permit for the Navy's Pacific Northwest Electronic Warfare Range activities within the Olympic National Forest (ONF). We evaluated the effects of the proposed action on the bull trout (*Salvelinus confluentus*), designated bull trout critical habitat, the marbled murrelet (*Brachyramphus marmoratus*), the northern spotted owl (spotted owl) (*Strix occidentalis caurina*) and the short-tailed albatross (*Phoebastria albatrus*) in accordance with section 7 of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.) (ESA).

On January 20, 2015, the Service received the Navy's request for formal consultation on effects to the bull trout and the marbled murrelet and for informal consultation on effects to the spotted owl and the short-tailed albatross. The Service initiated consultation on June 4, 2015. On October 30, 2015, the Service informed the Navy, via email, that we did not concur with your "may affect, not likely to adversely affect" determination for the spotted owl and the short-tailed albatross. The Navy then requested formal consultation on the spotted owl and the short-tailed albatross on November 3, 2015. In our final analysis of the effects to the northern spotted owl, we concurred with the Navy's original "not likely to adversely affect" determination for this species.

This Opinion is based on information from: the January 2015 Biological Evaluation (BE), the January 2014 Draft Environmental Impact Statement (DEIS), the December 2014 Supplement to the DEIS, the October 2015, Final Environmental Impact Statement (FEIS), the September 2014 Final Environmental Assessment for the Pacific Northwest Electronic Warfare Range, numerous meetings, telephone conversations and emails, as well as from other sources of information as detailed below. A complete record of this consultation is on file at the Service's Washington Fish and Wildlife Office in Lacey, Washington.

2 CONSULTATION HISTORY

In 2010, the Service issued Opinions on the Keyport Range Complex Extension and the U.S. Pacific Fleet Northwest Training Range Complex. Both of these Opinions covered the Navy's training and testing activities for a period of 5 years. The current proposed action consolidates these training and testing activities into a single federal action, and includes additional activities, projected changes in activities, and additional geographic areas.

- On January 20, 2015, the Service received the Navy's request for consultation and a BE for the Northwest Training and Testing Activities.

- From January 2015 through February 2016, the Navy and the Service coordinated extensively through meetings, conference calls, and emails, to compile the information necessary to complete the consultation.

- February 17, 2015: The Service requested that the Navy include the Electronic Warfare Range activities in the NWTT consultation, define “foreseeable future”, and provide an analysis of the impacts to designated bull trout critical habitat.

- April 1, 2015: At the Service’s recommendation, the Navy requested including the Electronic Warfare Range signal emitter activities occurring in the Olympic Military Operations Area (MOA) in the current NWTT consultation and that the term of the action was the “foreseeable future.” The Navy also provided an analysis of effects to designated bull trout critical habitat.

- May through September, 2015: The Navy, National Marine Fisheries Service (NMFS), and the Service coordinated on the subject of the Service’s acoustic thresholds for fish and birds.

- June 4, 2015: The Service initiated formal consultation.

- June 16, 2015: The Navy provided a presentation on acoustics and their analysis on effects to marine mammals, birds, and fish to Service staff.

- July 22, 2015: The Navy provided the Service and NMFS its proposed acoustic criteria for affects to fishes.

- July 30, 2015: The Navy, NMFS, and the Service met to discuss the Navy’s proposed acoustic criteria for fishes.

- September 25, 2015: The Service sent a letter to the Navy extending the duration of the incidental take exemption for ongoing activities addressed in the Northwest Training Range Complex Opinion through November 30, 2015, or until the current consultation has been completed.

- September 30, 2015: The Navy submitted their final proposal for acoustic criteria and range to effects for fishes and birds.

- October 21, 2015: The Navy provided the methodology they used to estimate the range to effects for sonar and explosives to the Service.

- November 12, 2015: The Service sent the Navy a draft of the Project Description from the draft Opinion, and the Navy returned comments on November 24, 2015.

- December 4, 2015: The Service sent the Navy a portion of the draft Opinion and the Navy returned comments on December 14, 2015.

- December 16 and 17, 2015: The Navy and Service met to discuss the Service's modeling analysis and the information needed to complete the analysis of explosives and sonar.

- January 6, 2016: The Navy, in response to comments from the Service, submitted revised range to effects tables for fishes and birds.

- January 19, 2016: The Navy sent the Service a "Memo to Record" regarding high frequency sonar and marbled murrelet hearing.

- February 23, 2015: The Service sent a letter to the Navy extending the duration of the incidental take exemption for ongoing activities addressed in the Northwest Training Range Complex Opinion through March 31, 2016.

- March 1, 2016: The Service sent the Navy a draft of the Project Description from the Opinion and the description of the Action Area. The Navy returned comments on March 4, 2016.

- March 28, 2016: The Service sent the Navy a final draft of the Opinion, and the Navy returned comments on April 1, 2016

- April 13, 2016: The Service sent a final draft of the Opinion to the U.S. Forest Service, Olympic National Forest. The Forest Service replied that they had no comments or concerns on April 15, 2016.

- April 20, 2016: The Navy and the Service met to discuss draft Terms and Conditions, exposure and effects analysis for underwater and in-air sound, and underwater detonation conservation measures.

- April 21, 2016: The Navy provided the Service with a list of conservation measures that they could implement to protect marine birds during underwater detonations at the Bangor and Crescent Harbor EOD Range Sites.

- April 27, 2016: The Navy provided ranges to effect for non-explosive practice munitions and bow shock projectile noise.

3 CONCURRENCES

The concurrences below are based on the proposed action as described in the following Opinion.

3.1 Western Snowy Plover

The Pacific coast population of the western snowy plover (*Charadrius nivosus nivosus*) (snowy plover) was federally listed as threatened across the range of the species in California, Oregon and Washington in 1993 (USFWS 1993). The species breeds primarily on coastal beaches from southern Washington to southern Baja California, Mexico. Snowy plovers nest above the high tide line on coastal beaches, sand spits, dune-backed beaches, sparsely-vegetated sandy areas such as dredge deposit sites, beaches at creek and river mouths, and salt pans at lagoons and estuaries (USFWS 2007, p.7). Suitable nesting habitat is distributed throughout the listed range, but may be widely separated by areas of rocky shorelines or narrow coastal areas that are not used by snowy plovers for breeding. In Washington, which is the northern extent of the range of the species, snowy plovers nest on coastal beaches between Damon Point (in Grays Harbor) and the Long Beach Peninsula. The nesting areas are designated critical habitat. Between 2006 and 2009, the population declined significantly, but has remained fairly stable since 2012. In 2014, the mean breeding adult population in Washington was 41 (Pearson et al. 2015, p. 1). All of the current nesting occurs at Leadbetter Point and Midway Beach/Graveyard Spit, approximately 30 miles south of the Naval Facility at Pacific Beach.

There are a few anecdotal reports and sightings of individual snowy plovers (Cornell Lab of Ornithology, 2015) at coastal sites north of their current nesting areas during the non-breeding season and it is possible that they may occasionally be present at Pacific Beach. Based on the information provided in the FEIS, proposed Navy activities at this location include the launching and retrieval of slow-moving unmanned crawler vehicles and testing activities offshore in the surf-zone. The activities conducted at Pacific Beach are infrequent and have stressors that are similar to ongoing recreational activities along this portion of the coast. Most of the beaches along the Washington coast, including Pacific Beach, are open to motorized vehicles and pedestrians. Since this is not a snowy plover breeding or wintering site, any individuals that may be present are not expected to be actively nesting and are more likely to be dispersing young birds. While recently fledged and first-year young snowy plovers often disperse and explore other areas during the non-breeding season, adult snowy plovers generally stay close to the nesting sites and spend the winter in groups near the breeding sites. Since Pacific Beach is 30 miles north of the closest nesting and wintering area and there are very few records of individuals outside of the known breeding areas, it is extremely unlikely that nesting snowy plovers would be adversely affected by project-related activities. None of the stressors associated with the proposed action overlap with habitats used by snowy plovers in Oregon or California.

The Naval testing location at Pacific Beach is a one-mile portion along a 26-mile long stretch of contiguous sandy beach. The facility is in the community of Pacific Beach, which includes residences, stores, hotels and amenities such as coastal camping and recreational facilities and a nearby state park. Launching and retrieval of unmanned crawler vehicles would be conducted in a narrow path, is relatively short in duration (minutes or hours), and infrequent/intermittent (not conducted daily or all day long). Permitted public access and recreational activities occur year-round on this beach and include operation of motor vehicles, pedestrians, as well as seasonal festivals and special events. Any shorebirds that forage or use this beach are likely accustomed or habituated to human activities and vehicles being driven on the beach on a daily basis. The intermittent launching and retrieval of unmanned vehicles would be very similar to regular daily recreational activities conducted on this stretch of beach. Any individuals that may be temporarily displaced or flushed by people or slow-moving vehicles do not have to move far up or down the beach to avoid the launch zone and can continue foraging a short distance away. Because the stressors associated with infrequent testing-related activities are similar to background recreational activities that occur on that beach, and there is ample foraging habitat nearby, we do not expect non-breeding foraging or resting individuals to be measurably affected or experience a significant disruption of their normal behaviors.

3.1.1 Concurrence

Considering the project location and the project effects, we concur that the proposed action is not likely to adversely affect the western snowy plover.

3.2 Streaked Horned Lark

The streaked horned lark (*Eremophila alpestris strigata*)is a passerine endemic to the Pacific Northwest, and is a subspecies of the wide-ranging horned lark. Historically, the breeding range of this species extended from southern British Columbia, Canada, south through the Puget lowlands and outer coast of Washington, along the lower Columbia River, through the Willamette Valley, the Oregon coast and into southwest Oregon. The streaked horned lark was listed as a threatened species on October 3, 2013 (78 FR 61452). The current range of the species includes the Puget lowlands in Washington, the southern Washington coast, islands on the lower Columbia River, and the Willamette Valley. Although there is a historic record of potential nesting near Pacific Beach on the Washington coast, the species currently nests in the same areas as snowy plovers from Grays Harbor south to the Long Beach Peninsula (WDFW 2013, p. 69).

In 1999 to 2000, extensive surveys were conducted across the historic range of the species and potentially suitable habitat in Washington, but did not include coastal beaches north of Copalis Spit (Stinson 2005, p. 62). There are no records or reports of horned larks near Pacific Beach or the Quinault Range Site Area. All of the currently occupied sites are surveyed annually during the breeding season to monitor population status and trends. Because the breeding range of the streaked horned lark is fairly well defined and continues to contract as populations decline, the number of pairs nesting on the coastal beaches is very small, and there are no records or reports of the species at any sites where activities will be conducted, it is extremely unlikely that streaked horned larks will be exposed to or adversely affected by the proposed training activities. Therefore, effects to streaked horned larks are considered discountable.

3.2.1 Concurrence

Considering the project location and the project effects, we concur that the proposed action is not likely to adversely affect the streaked horned lark.

3.3 Northern Spotted Owl

Based on our review of the Navy's proposed training activities, the northern spotted owl (spotted owl) may be exposed to the following stressors:

- The presence of low-flying aircraft causing above ambient noise levels and the potential for direct collisions with aircraft.

- Above ambient, ground-based noise levels and/or visual disturbance caused by mobile emitters for electronic warfare training.

- Electromagnetic radiation (EMR) caused by mobile emitters for electronic warfare training.

3.3.1 Potential Disturbance to Nesting Spotted Owls from Aircraft Overflights

Jet aircraft flights over the Olympic MOAs will cause increased levels of aircraft sound throughout the year, inclusive of the spotted owl nesting season. The sound level emitted by jet aircraft can be extremely loud at close distances. Because jet aircraft fly at high rates of speed (≥ 250 km/hr), the onset of exposure to loud noise from a jet overflight can be rapid –i.e., in some situations a jet can be flying so fast that a person or animal on the ground will not hear the jet approaching until the jet is passing directly overhead. The rapid onset of the sound can be startling, and the combined auditory and visual stimuli of a low altitude jet overflight have the potential to disturb or disrupt spotted owl nesting behaviors. Navy jets flying over land areas within the Olympic MOAs will potentially expose spotted owls on the Olympic Peninsula to various levels of aircraft noise, ranging from low-intensity, ambient-level sounds from distant overflights to high amplitude sounds associated with low altitude flights.

3.3.1.1 Best Available Information Regarding the Effects of Aircraft Overflights to Spotted Owls

3.3.1.1.1 Background

No published studies have evaluated the effects of aircraft overflights on the spotted owl. However, a number of aircraft disturbance studies (cited below) have examined both sound exposure levels and stimulus distance in an effort to determine the relationship between exposure to sound, stimulus distance, and behavioral responses in the Mexican spotted owl (*Strix occidentalis lucida*). The Mexican spotted owl is a closely-related subspecies to the northern spotted owl with broadly similar habitat associations. For purposes of this analysis, the research on the effects of aircraft overflights on the Mexican spotted owl is considered the best available source of information for evaluating such effects to the spotted owl.

In the following discussion, reference is made to sound levels measured in decibels (dB) in the "A" weighted scale (dBA), which is a commonly-used metric representing sound energy that is filtered based on human hearing range and sensitivity. Sound exposure level (SEL), which is the total sound energy over a specific time interval (e.g., 1 sec), is a metric that is often used to characterize brief sound events (Pater et al. 2009, p. 790). Equivalent sound level (LEQ), the average sound pressure level in dB measured over a specific time, is another common metric used to measure continuous sounds, such as traffic noise (Pater et al. 2009, p. 790).

3.3.1.1.2 Military Helicopter Overflights

Delaney et al. (1999) evaluated the behavioral responses of both nesting and non-nesting Mexican spotted owls exposed to military helicopter overflights on the Lincoln National Forest in south central New Mexico over a period of two nesting seasons. Helicopter overflights during the nesting season elicited alert responses (i.e., head turning towards the noise source) when helicopters were an average of 0.25 mile (400 m) away, but owls did not flush from their roosts until the aircraft passed within a distance of less than 344 ft (105 m) and aircraft sound exceeded 92 dBA SEL (Delaney et al. 1999, p. 68). In total, there were 58 overflight samples. Of these, flush responses by owls were documented for 7 overflights (12 percent). Owl flush frequency increased with decreasing distance, with 50 percent of overflights within a distances of less than 100 ft (30 m) resulting in a flush response by a spotted owl (Delaney et al. 1999, p. 67).

Regression analysis indicated that spotted owl prey delivery rates were potentially reduced at a threshold distance of 96 m, which is consistent with the 105-m threshold for flush response cited above (Delaney et al. 1999, p. 70). At comparable distances, helicopter overflights were less disturbing to spotted owls than ground-based chainsaw activities (Delaney et al. 1999, p. 68). The authors suggest that "spotted owls may have perceived helicopters [overflights] as less threatening than chainsaws because of their shorter duration, gradual crescendo in noise levels, minimal visibility, and lack of association with human activity" (Delaney et al. 1999, p. 72). All spotted owl flushes recorded during the nesting season occurred after fledging of nestlings; no flushes occurred during the incubation and nestling phases (Delaney et al. 1999, p. 67).

Spotted owls that were previously exposed to helicopter overflights did not flush during subsequent exposures, suggesting some spotted owls have the ability to tolerate or habituate to helicopter noise (Delaney et al. 1999, p. 69). Distance was a better predictor of spotted owl response to helicopter flights than noise levels, because even when controlled for distance, noise levels from helicopters were variable (Delaney et al. 1999, p.72). The authors note that short duration, single pass, single aircraft overflights had little effect on spotted owls, and concluded that a 105-m (344-ft) radius protection zone should eliminate all spotted owl flush responses to helicopter overflights (Delaney et al. 1999, p. 74). Although the samples sizes in this study were small, there was no difference in the reproductive success or the number of young fledged for spotted owls exposed to experimental disturbance when compared with non-manipulated spotted owls (Delaney et al. 1999 p. 66).

3.3.1.1.3 Military Jet Aircraft Overflights

Johnson and Reynolds (2002) investigated the effects of military fixed-wing aircraft (F-16 jets) overflights on the behavior of Mexican spotted owls in Colorado. This study provides some insight into the behavioral responses of roosting spotted owls exposed to aircraft overflights that passed at > 1,500 ft (> 460 m) above ground level. Behaviors of spotted owls during 25-second fly-by periods ranged from "no response" (no body movements) to "intermediate response" (sudden movement of head, wing, or body). The sound levels that spotted owls were exposed to during this study were reported as ranging from 78 to 95 dBA (Johnson and Reynolds 2002, p. 2), but the authors did not specify if these measurements represented peak or average sound levels over the 25-second intervals. No spotted owls flushed from their day roosts in response to the aircraft overflights.

The U.S. Air Force (2012) evaluated the effects of military jet aircraft noise on the occupancy and nesting success of Mexican spotted owls on the Gila National Forest in New Mexico. This was a 6-year study commissioned by the Air Force to determine whether exposure to noise produced by military jet aircraft (F-16 and Tornado jets) affects spotted owl territory occupancy or reproductive success and to establish thresholds below which no detrimental impact to spotted owls is expected. Behavioral responses by spotted owls to military jet aircraft overflights were used to identify whether aircraft could stimulate flight by affected owls, particularly from the nest. Overflights were used as experimental treatments, with spotted owl behavior observed before, during, and after the overflights. Aircraft sound levels were reported using several metrics including the A-weighted sound exposure level (ASEL) and maximum average sound levels (LEQ) measured over two-second intervals (U.S. Air Force 2012, Appendix F, p. 2-20). The study also included a series of ground-based playback experiments where the researchers exposed spotted owls to simulated aircraft noise to quantify the relative influence of sound exposure levels as opposed to source distance on spotted owl behavior (U.S. Air Force 2012, Appendix F, p. 2-57). This is an unpublished study representing research that has not been reported in peer-reviewed publications. However, this study presents substantial new information that we have not considered in previous analyses of spotted owl response to aircraft overflights.

A total of 282 military jet aircraft overflight experiments were conducted during the course of the study. Aircraft during these experiments were estimated to approach as closely as 253 ft (77 m), including 33 jet aircraft overflights that passed within a distance of $\leq$ 500 ft (152 m) and exposed spotted owls to maximum sound levels up to 109 dBA (maximum 2-s LEQ) (U.S. Air Force 2012, Appendix F, p. 3-73). The average of the highest 2-s LEQ in each overflight was 81 dBA to 96 dBA (average ASEL 92 dBA to 108 dBA) (U.S. Air Force 2012, Appendix F, p. 3-2). Data on behavioral responses were collected on 340 adult and 164 owlet (i.e., a nestling or juvenile) spotted owls. Forty-eight playback experiments were completed with 127 observations of spotted owl responses at ranges from 66 ft (20 m) to 262 ft (80 m). Of these, 72 involved adult spotted owls and 55 involved owlets (U.S. Air Force 2012, Appendix F, p. 3-82).

Eight types of spotted owl behaviors were recorded as immediate responses to acoustic disturbances (both aircraft overflights and playback experiments); 1) orienting, 2) alerting, 3) vocalizing, 4) moving, 5) hopping, 6) freezing, 7) flying, and 8) flushing (U.S. Air Force 2012, Appendix F, p. 3-69). Spotted owls frequently did not react visibly (no response) to acoustic stimuli, particularly when they were inactive before the onset of the disturbance event. The least intense detectable response was orienting, in which the owl rotated its head after a disturbance, usually in the direction of the sound. If acoustic disturbances were unfamiliar, unexpected, or especially intense, the owl alerted, a behavior with attributes of ‘startle’ responses described in other studies. In those cases, the owl’s head was sharply rotated in the direction of the sound source. No response, orienting, and alerting were the most common responses by spotted owls to acoustic disturbances, accounting for 96 percent of adult responses and 92 percent of owlet responses (U.S. Air Force 2012, Appendix F, p. 5-3).

During the most intense acoustic disturbances, spotted owls sometimes vocalized, particularly while guarding owlets. In these cases, the owls waited until the noise had declined close to background levels before initiating vocalizations. Observers interpreted this behavior as an effort to contact other members of a family group after the disturbance. Males used a four-note hoot and brief single hoots, while females and owlets typically used contact calls and whistles. In some cases, the noise levels induced by the experiment appeared to arouse owlets, after which they began to beg persistently for food (U.S. Air Force 2012, Appendix F, p. 3-70). The possibility that spotted owl vocalizations made in response to acoustic disturbance could expose owlets to predation was considered in detail. There was no evidence that Mexican spotted owl predators were attracted to calling adults or young, although spotted owls were occasionally mobbed by smaller predators (sharp-shinned hawks) and other birds after vocalizing (U.S. Air Force 2012, Appendix F, p. 5-3). Spotted owls vocalized frequently in the absence of aircraft disturbance, particularly at night and early in the morning when adults maintained their territories and young begged for food. Observers noted an increase in feeding by adult spotted owls after overflights. When owlets were aroused by aircraft noise, they begged more, which stimulated adults to feed them (U.S. Air Force 2012, Appendix F, p. 4-21).

Other spotted owl responses documented in the U.S. Air Force study included owls moving or hopping out of the nest onto a branch, hopping from one branch to another, moving closer to a partner on a branch, or moving closer to the bole of the roost tree. In each case, the behavior appeared to be defensive, either to bring parents and young closer together or to place an adult in a better defensive position. Hopping from the nest was only observed in adult females while incubating and brooding; owlets on nests crouched or froze when disturbed by noise (U.S. Air Force 2012, Appendix F, p. 3-70). Hopping from a nest was only observed during ground-based playback experiments at close range; it was never observed during aircraft overflights (U.S. Air Force 2012, Appendix F, p. 3-83). Nestling owlets were never observed to move in response to aircraft overflights, while fledged owlets were observed moving in response to aircraft on 3 occasions representing 2 percent of the recorded responses (U.S. Air Force 2012, Appendix F, p. 8-34). Movements were observed in both adults and owlets when the maximum 2-s LEQ sound level ranged from 78 to 101 dBA (2-s SEL: 85 – 101 dBA), and aircraft overflights were less than 984 ft (300 m) above ground level. Slant distance (the actual distance from the aircraft to the owl) varied from 764 ft to 6,055 ft (233 m to 1,847 m) (U.S. Air Force 2012, Appendix F, pp. F-3 to F-21).

Freezing was observed in all age-sex classes of the Mexican spotted owl, but rarely. In those cases, the owl typically alerted quickly before freezing, but the rest of the body might remain in an unusual position, such as with a foot raised in the process of preening. It occurred in the same context as moving and vocalizations, i.e., when acoustic disturbances were unusually close or intense (U.S. Air Force 2012, Appendix F, p. 3-70).

Flight by nesting spotted owls in response to an aircraft overflight was never observed (n = 213 experiments) (U.S. Air Force 2012, Appendix F, p. 8-34). The single flight response documented was a for a non-nesting female spotted owl that alerted to the aircraft, waited until it passed, and after just under 2 minutes, flew approximately 75 ft to roost next to its mate. This flight was observed during a period when adult owls were likely to fly from tree to tree within the roost stand under normal conditions. The observers scored the behavior as a flight in response to the aircraft, but the authors recognize it was possible that it was spontaneous or facilitated both by the owls' active state and the presence of moving observers (U.S. Air Force 2012, Appendix F, p. 3-74). Fledged owlets never flew from roost or nest trees in response to aircraft overflights (U.S. Air Force 2012, Appendix F, p. 3-75).

Flushing was defined as an event in which the spotted owl left the nest or branch in an abrupt and uncontrolled manner (U.S. Air Force 2012, Appendix F, p. 3-70). Flushing by spotted owls was never observed in response to aircraft overflights, but was observed during ground-based playback experiments at very close range (e.g., within a distance of 132 ft (40 m) (U.S. Air Force 2012, Appendix F, p. 4-17). The only spotted owl flushing responses observed during the study were to unexpected playback of simulated aircraft noise at 26 to 33 ft (8-10 m; n=2) and to tree climbers within 50 ft (15 m) at the level of the nest (U.S. Air Force 2012, Appendix F, p. 4-17). In the former case, the estimated sound levels at the nest were a maximum 2-s LEQ of 65 dBA in one instance, and a maximum 2-s LEQ of 53 dBA in another instance (U.S. Air Force 2012, Appendix F, p. 3-81).

Female spotted owls that were incubating or brooding young were never observed flushing in response to low-flying aircraft, including military jets and low-flying helicopters (U.S. Air Force 2012, Appendix F, p. 5-2). Owlets in nests never hopped in response to overflights, even when they were close to the age of fledging. Instead, they remained in the nest, occasionally freezing (4 percent of responses) (U.S. Air Force 2012, Appendix F, p. 3-83). While some individual spotted owls exhibited short-term behavioral responses to overflights, there was no evidence to indicate that military aircraft noise affected spotted owl habitat use, habitat selection, nest site selection, or nesting success (U.S. Air Force 2012, Appendix F, p. 3-83).

At close range, distance to the noise source and the sound exposure level were significant predictors of a spotted owl response, but distance was the most important factor based on the result of the ground-based playback experiments. The probability of a startle response (vocalizations or movements) by spotted owls was highest within a distance of 260 ft (80 m) for both adults and young. This range was so close that aircraft could not be expected to approach it except under unusual conditions. Flushing, flights, and female hopping from the nest were nearly always seen at 132 ft (40 m) or closer for ground-based experiments. None of these behaviors were caused by aircraft overflights (U.S. Air Force 2012, Appendix F, p. 3-99). At greater distances, maximum noise level was the most important determinant of response intensity, but in owlets only. In adults, no significant relationship between sound level and spotted owl behavior was found. Owlets responded with vocalizations or slight movements when exposed to a maximum 2-second equivalent average sound level in excess of 84 dBA and an aircraft approach within 984 ft (300 m) (U.S. Air Force 2012, Appendix F, p. 3-99). However, none of the responses of owlets (slight movements, vocalizations) resulted in injury to the owlets.

The behavioral responses of Mexican spotted owls to aircraft overflights were primarily of low intensity (no response, orienting, alerting); such responses accounted for 96 percent of adult and 92 percent of owlet responses. Higher intensity responses, such as moving or vocalizing, were rare, and increased with increasing sound level and decreasing approach distance. The increase in intensity of defensive behaviors occurred when ground-based sources came within 260 ft (80 m). Both adults and owlets vocalized increasingly as source distance decreased, particularly at 132 ft (40 m) and closer. The probability of strong defensive behaviors (movements, flights, vocalizations and freezing) was high at 66 ft (20 m). However, owls appeared to cope well with such disturbances, as neither aircraft nor ground-level human disturbance could be associated with losses of adults or owlets, prolonged absences of adults from the nest, or spotted owl abandonment of favored habitat, including the choice of nesting sites from one year to the next (U.S. Air Force 2012, Appendix F, p. 5-3).

The authors of this study concluded that military aircraft do not affect spotted owl use of habitat or nesting success; there is no change in the rate of spotted owl flight behaviors observed during aircraft overflights versus non-overflight periods; and spotted owl flight responses were only elicited after exposure to ground-based noise (simulating aircraft overflight) within 66 ft (20 m) of roosting adults and 131 ft (40 m) of brooding females and owlets (U.S. Air Force 2012, Appendix F, p. 5-1). Based on these findings, the authors recommended a threshold distance of 260 ft (80 m) for spotted owl response to aircraft overflights because owl flight response became increasingly likely at this distance (p. 5-4).

3.3.1.2 Evaluation Criteria for Assessing the Effects of Aircraft Overflights on Spotted Owls

In previous analyses of potential disturbance effects to spotted owls (USFWS 2003, pp. 265-285; USFWS 2006, entire; USFWS 2013, pp. 74-89), we concluded that exposure to above-ambient sounds or human activity can disrupt spotted owl nesting behaviors in some situations. In these analyses, we relied on the sound and distance thresholds suggested by Delaney et al. (1999, p. 74) as evaluation criteria for assessing aircraft disturbance:

> Spotted owls did not flush when helicopter SEL noise levels were less 92 dBA, or when helicopter overflights were greater than 344 ft (105 m) from owls.

In these analyses, we assumed that spotted owls exposed to aircraft sound levels that exceeded 92 dBA SEL or exposed to aircraft that approached within a distance of less than 344 ft (105 m) could be subject to disruption of their nesting behaviors. We identified specific spotted owl behavioral responses as indicators of the severity of the disturbance on the spotted owl. Behavioral responses indicating a significant disruption of normal nesting behaviors include:

- A flush response (flight) of an adult spotted owl during incubation of eggs or brooding of newly hatched chicks.
- A flush response of a nestling spotted owl prior to fledging.
- A flush response of an adult spotted owl that results in aborted feedings of nestlings.
- Avoidance or delay of nest establishment by adult spotted owls.

These behavioral responses are considered significant because they create a likelihood of injury to exposed individuals due to the potential for reduced hatching success, fitness, or survival of nestlings (e.g., injury from a nestling falling out of nest, or predation of nestlings).

In the studies reviewed above, no aircraft overflights resulted in these severe behavioral responses. Nesting spotted owls did not flush during incubation or brooding in response to military jet aircraft overflights. Nestlings did not flush or move out of nest trees prior to fledging. The only flush and or flight responses that were observed from aircraft occurred after nestlings had fledged, and these responses occurred as a result of helicopter overflights at close range (less than 344 ft [105 m]).

Given the range of responses observed in individual spotted owls to aircraft discussed above, low altitude jet flights pose a risk of minor disturbance to spotted owls by eliciting sub-flight defensive behaviors (i.e., vocalizing, moving). However, best available information indicates there is no consistent relationship between aircraft sound levels or aircraft distance and spotted owl response behaviors. Based on the information presented above, we expect spotted owl behaviors are likely to be affected by military jet aircraft overflights when:

- Jet aircraft fly at altitudes of less than 1000 ft (~300 m) above ground level.

This is not a threshold distance below which we assume spotted owls are likely to be adversely affected by aircraft overflights. It represents a threshold distance where intermediate behavioral responses by spotted owls are more likely to occur. In the U.S. Air Force study, while few spotted owls exhibited responses beyond alerting to aircraft regardless of sound level or distance to aircraft, most movements (non-flight) and vocalizations were observed in both adults and owlets when jet aircraft overflights were less than 984 ft (300 m) above ground level (U.S. Air Force 2012, p. 3-99, pp. F-3 to F-21). With the exception of one observation, all spotted owl movement responses occurred when aircraft sound levels exceeded 90 dBA (max 2-s LEQ) (U.S. Air Force 2012, pp. F-3 to F-21). Sound levels measured for jet flights (F-16s and Tornado jets) within distances of less than 984 ft (300 m) from the aircraft ranged from 86.1 to 102 dBA (max 2-s LEQ; 90.2 – 108.5 SEL).

While precise sound metrics are useful, caution must be used in interpreting sound-only metrics because, as discussed above, there is no consistent relationship between sound level exposure and spotted owl response to that exposure. Distance appears to be a better predictor for spotted owl response to aircraft overflights. While none of the spotted owls in the experimental studies of aircraft exhibited any of the severe behavioral responses that the Service uses as indicators of significant disturbance, we are cautious in our interpretation of these data. For analysis purposes, we will assume that military jet aircraft overflights that occur at less than 1,000 ft (~300 m) above ground level are likely to elicit sub-flight defensive behaviors (vocalizing, moving) by some individual spotted owls, regardless of the sound level.

Jet aircraft flights that occur at less than 500 ft (~150 m) above ground level are expected to have a higher likelihood for causing spotted owl sub-flight behaviors, with a potential for disrupting their nesting behaviors if the flights occur during early nesting periods for the spotted owl. Early nesting season behavior includes nest-site selection, egg-laying, incubation, and brooding of nestlings to the point of fledging (Forsman et al. 1984, pp. 32-38). In Washington, we define the critical nesting period, inclusive of the early nesting period, for the spotted owl as March 1 to July 15.

3.3.1.3 Exposure of Spotted Owl Nesting/Roosting/Foraging Habitat to Aircraft Noise in the Olympic MOAs

Under the proposed action, Navy aircraft operating over land within the Olympic MOAs will fly at an altitude of 6,000 ft above mean sea level or higher. Spotted owl nesting, roosting, and foraging (NRF) habitat in the action area ranges in elevation from 0 to 4,000 ft. Therefore, the closest approach of an aircraft over spotted owl NRF habitat would be 2,000 ft above ground level. The exposure to high-level sound from a jet overflight is a brief event at any single location. Johnson and Reynolds (2002, p. 2) described military jet fly-by events as having a duration of 25 seconds (i.e., at a fixed point on the ground, the exposure to high-level aircraft sound lasted about 25 seconds).

Because the sound level of the jets used in the proposed training activities have a 92 dBA SEL sound contour with a radius of 2,000 to 6,000 ft (depending on the power level), the area exposed to high-level noise by even a minute of low elevation flight can encompass thousands of acres. As described in the following Biological Opinion (under the discussion of Aircraft Noise), we have determined that all available spotted owl NRF habitat, and therefore, all spotted owls nesting within the Olympic MOAs are likely to be intermittently exposed to high-level aircraft noise, multiple times each year.

Although spotted owl NRF habitat includes forests up to approximately 4,000 ft above sea level on the Olympic Peninsula, spotted owl nest sites on the western Olympic Peninsula have only been documented up to 2,400 ft elevation, while non-nesting pairs have been detected up to 2,800 ft elevation (Gremel, pers. comm. 2015). If Navy aircraft adhere to the proposed flight altitudes of 6,000 ft above mean sea level, the closest approach of an aircraft to a potential spotted owl pair would be 3,200 ft. At this distance, spotted owls are likely to be intermittently exposed to high-amplitude aircraft noise (e.g., in excess of 90 dBA SEL).

3.3.1.4 Effects of Proposed Military Aircraft Overflights on Spotted Owls in the Olympic MOAs

At the altitudes that Navy jets are proposed to fly within the Olympic MOAs as referenced above, we expect exposure of spotted owls to aircraft noise is likely to result in only minor behavioral responses such as head-turning, orienting or alerting because these overflights will be at altitudes of 3,000 ft or higher above locations where spotted owls are likely to nest. Some owls may exhibit sub-flight defensive behaviors (vocalizations, movements) in response to these overflights. As discussed above, we expect these types of responses are more likely to occur when aircraft approach within a distance of 1,000 ft or less above ground level.

Best available information supports the conclusion that spotted owls are not likely to respond to aircraft overflights by flying or by exhibiting other behaviors that are indicative of significant stress unless they are approached very closely. In the U.S. Air Force (2012) study, flight responses by spotted owls were not elevated above normal rates in response to military aircraft overflights. Flushing or other high intensity responses (e.g., hopping from a nest) by spotted owls were only likely to be elicited at distances much closer to spotted owls than military jet aircraft are expected to be. Based on this finding, any exposure of spotted owls to sound from the proposed aircraft overflights is likely to result in only minor behavioral responses that are considered to be insignificant (i.e., would never reach a magnitude where take of the spotted owl is likely to occur). These results are consistent with the results of studies on other noise sources (Delaney et al. 1999; Swarthout and Steidl 2001; Tempel and Gutiérrez 2003).

Spotted owls that do not visibly react or only exhibit minor behavioral responses to sound or visual disturbance may produce increased levels of stress-related hormones including glucocorticoids (GCs) and corticosterone (Hayward et al. 2011; Wasser et al. 1997). While there is evidence that acute exposure to motorcycle noise can result in short-term increased levels of GCs in spotted owls, the response of individuals varied by sex, breeding status, and time of year (Hayward et al. 2011, p. 7). While there was no consistent relationship between proximity to roads, road noise and elevated GCs in spotted owls, correlation analysis did reveal a pattern that spotted owls nesting within a distance of 100 m (328 ft) of "loud roads" fledged fewer young compared to spotted owls nesting further from loud roads (Hayward et al. 2011, p. 11).

While the Hayward et al. (2011) study found a correlation between proximity to "loud roads" and reduced spotted owl nest success, an analysis of various factors that may have resulted in this finding were not analyzed (Hayward et al. 2011, p. 11). Spotted owl reproduction is a complex interaction between factors related to age, prey abundance, weather, individual variation, and territory quality (Forsman et al. 2011, p. 59). All of these various factors have been demonstrated to influence spotted owl productivity. There is relatively little that can be concluded from this research other than the fact that spotted owls exposed to motorcycle noise have elevated levels of GCs which reflect a potential disturbance or stress response. Whether this response is indicative of a significant physiological effect is unknown, as the authors did not find that spotted owls with elevated GCs had reduced nesting success, and noted (Hayward et al. 2011, p. 12) that "elevated baseline GCs can be positively, negatively, or not associated with survival and/or reproduction."

Although increased GCs can indicate stress, the interpretation of these studies is complicated by the fact there are no consistent relationships between elevated GCs and survival or reproductive success of affected individuals (Busch and Hayward 2009, p. 2844). Due to the lack of data for any avian species showing a clear correlation between elevated corticosterone levels and effects to breeding, feeding, or sheltering, we are unable to determine the significance of elevated GCs to spotted owls, and continue to rely on behavioral responses as indicators of the severity of potential disturbance effects.

In summary, the proposed aircraft overflights are likely to affect spotted owls through intermittent exposures to aircraft noise throughout the year, including during the nesting season. However, because Navy aircraft will maintain minimum flight altitudes well above the distances at which any significant behavioral responses by affected spotted owls are likely to occur, the effects to spotted owls by these aircraft overflights are considered insignificant.

3.3.2 Potential for Spotted Owl – Aircraft Collisions

Under the proposed action, Navy aircraft operating over land within the Olympic MOAs will fly at an altitude of 6,000 ft above mean sea level or higher. Spotted owl habitat in the action area ranges from 0 to 4,000 ft in elevation. Therefore, the closest approach of an aircraft over spotted owl NRF habitat would be 2,000 ft above ground level. Spotted owl are closely associated with the forest canopy and most spotted owl flights are sub-canopy flights (Gutierrez et al. 1995, p. 9). Because Navy overflights will be located 2,000 ft or greater above spotted owl NRF habitat, we consider the risk of an aircraft striking a spotted owl in flight to be discountable.

3.3.3 Potential for Spotted Owl Exposure to Ground-Based Disturbance

The use of ground-based equipment (mobile emitters) in the Olympic MOAs poses the potential for adverse effects to spotted owls caused by noise and visual disturbance. The Service considers the use of vehicles on open forest roads to be a low-intensity activity that poses a low risk of disturbance to spotted owls. We evaluated the proposed training sites within the Olympic MOAs for proximity to known spotted owl activity centers, and potential NRF habitat for spotted owls. Of the 15 proposed emitter sites identified by the Navy under the proposed action, 3 sites are located within close proximity to potential spotted owl NRF habitat. A cumulative total of approximately 6 acres of potential spotted owl NRF habitat are located within close proximity (defined as a 100-meter radius) from these three emitter sites, indicating the ground-based activities (i.e., noise from vehicles, generators, and presence of people) associated with the use of these emitter sites “may affect” spotted owls. However, none of these proposed emitter sites are located in close proximity to known historic spotted owl activity centers. Given that finding and the small area of potential NRF habitat (6 acres) associated with the proposed emitter sites, the Service considers the likelihood of nesting spotted owls being exposed to noise or visual disturbance from mobile emitter operations to be discountable.

Under the proposed action, upon arrival at a training site, the mobile emitter crew will determine the need for establishing a safety zone. Sites requiring a safety zone will be posted with an electromagnetic radiation hazard sign and the crew will mark the perimeter of the hazard zone with removable warning tape. While conducting training operations, the crew will use a small generator to power the equipment. The generators selected to power the mobile emitters have specifications that meet National Park Service sound level requirements (60 dBA at 50 ft) for National Park use. The generators will be encased in steel and have mufflers on the exhaust, both of which offer an increased level of sound attenuation to create a corresponding drop in noise levels to approximately 42 dBA at 50 ft (Navy 2014, p. 3.2-24), indicating low-level generator noise will be associated with the mobile emitter sites. This level of generator noise is not expected to be disruptive to spotted owls. Low-level mechanical sounds that are detectable to spotted owls may result in minor behavioral responses, such as scanning or head-turning behaviors, or increased vigilance for short periods. Such minor behavioral responses are considered to have insignificant effects to spotted owls.

Short-term disturbance or temporary displacement of non-nesting spotted owls that may be dispersing or roosting in close proximity to a mobile emitter site may occur. If an owl is perched in a tree along the edge of the road at an emitter site, it may flush in response to the vehicle stopping at the site, or people stepping out of the vehicle. Such flush responses that occur away from an active nest site are considered to be an insignificant effect because the affected spotted owls are simply moving away from a source of disturbance, rather than being forced to flush away from an active nest site, and are likely to resume normal behavior.

3.3.4 Potential for Spotted Owl Exposure to Electromagnetic Radiation

There are several aspects of the proposed electronic warfare training that will limit the exposure of wildlife to EMR. The emitter antennas will be extended 14 ft above the mobile emitter vehicles and the directional beams produced by the emitters will be aimed to allow unobstructed signal transmission (taking advantage of clear lines of sight to the west) so that there is little or no potential for wildlife on the ground or in the tree canopy to be exposed to the signal (Mosher, pers. comm. 2015). Therefore, only birds in flight over the forest canopy have the potential to intersect beams and become exposed to EMR from the training.

Spotted owls are not likely to be exposed to EMR due to their close affinity to closed-canopy forest cover. Although spotted owls do occasionally disperse across open areas, they usually avoid crossing such areas by traveling through corridors of forested habitat (Forsman et al. 1984). The typical flight behavior of the spotted owls is described in the Birds of North America (Gutierrez et al. 1995, p. 9):

> "Quick wingbeats interspersed with gliding flight. Not a fast flier. Long flights unusual except during dispersal… Flight labored when attempting to fly to a higher perch or up to nest sites. When gaining altitude in the forest canopy, makes a series of short climbing flights rather than continuous flight. Flights above the forest canopy probably rare except during dispersal."

During dispersal, spotted owls will occasionally cross open areas, and as noted above, may occasionally fly above the level of the forest canopy. Considering spotted owl flight behavior, above canopy flights are likely rare events. The proposed EMR sites are generally located on forested ridgelines. Spotted owls dispersing across a ridge are much more likely to disperse through forested areas at the subcanopy level. If a spotted owl were to fly near an active emitter site, it would most likely pass by the site at an altitude that is at or below the level of the adjacent forest canopy where exposure to EMR is less likely due to the directional nature of the EMR signal. Based on the flight behavior of spotted owls, the risk of direct exposure to an EMR signal is low, but not entirely discountable. It is possible that a non-nesting spotted owl could be perched in a tree near an emitter site, or, a spotted owl that is flying through the area could pass near the emitter site and be briefly exposed to an EMR signal.

3.3.4.1 Effects of Spotted Owl Exposure to EMR

Biological responses to EMR depend on many factors including the density and duration of the exposure, the species and conditions of affected individuals, and the nature of the EM waves. EM waves can "cause different, and even contrary effects, depending on their frequency, intensity, modulation, pulses or time of exposure" (Balmori 2005, p. 110; Redlarski et al. 2015, p. 2). The physical effect of acute exposure to high frequency EMR (100 kHz to 300 GHz) is tissue heating (Health Canada 2015, p. 3). This heating effect varies with the power and frequency of the EM energy. The mobile emitters proposed for use by the Navy will be emitting EMR signals in the range of 4 to 8 GHz, at 90 to 300 watts. For frequencies ranging from 100 kHZ to 300 GHz, tissue heating (burns) can occur at high energy levels. For frequencies above 6 GHz, radiofrequency absorption occurs predominantly in the upper layers of the skin (Health

Canada 2015, p. 3). These effects are not necessarily instantaneous, but can occur over a period of minutes. The Navy has established safety zones around emitter sites to avoid exposing people or wildlife to high energy EMR. These safety zones range in size from a 29 to 101-foot radius around the mobile emitter (Navy 2014, p. 3.1-4). The safety zone is established by the crew placing warning tape around the vehicle. If a spotted owl was perched in close proximity to an emitter site, the owl would likely to move away from the site in response to the vehicle stopping and the movements of the crew setting up the safety perimeter. Moving away from the emitter site would further reduce the likelihood of spotted owl exposure to EMR.

The effect to birds from potential exposure to EMR from mobile emitters is described in detail in the Biological Opinion in the section titled Effects of the Proposed Action – Energy Stressors. In summary, the risk of spotted owl exposure to EMR from the proposed action is very low. No spotted owl nest sites are likely to be exposed to EMR. Potential exposure could occur if a spotted owl flew through the energy field from the emitter. Bruderer et al. (1999, pp. 1016-1017) aimed an ex-military tracking radar emitter (approximately 9 GHz) at birds in flight and observed if the birds altered their behavior related to when the emitter was energized and when it was not. The researchers found that the radar provoked no measurable changes in the behavior of the birds in terms of flight direction or vertical speed (Bruderer et al. 1999, pp. 1018-1019). Although the likelihood of spotted owl exposure to EMR is very low, if a spotted owl was exposed to EMR, the exposure would be brief (duration of seconds). Best available information indicates that the effects of brief EMR exposure to birds in flight in the range of frequencies proposed for use by the Navy are likely to be insignificant (i.e., not measurable or detectable). Physical effects, such as tissue heating, are also considered insignificant because an exposure of 1 or 2 seconds during flight would be too brief to manifest a measureable effect.

3.3.5 Concurrence

Considering the project location and the project effects, we concur that the proposed action is not likely to adversely affect the spotted owl.

3.4 Designated Bull Trout Critical Habitat

The Service designated critical habitat for bull trout on October 18, 2010 (75 FR 63898). In designating critical habitat, certain lands were exempt from final critical habitat designation. These lands included military installations that have developed and are implementing Integrated Natural Resource Management Plans, lands with National Security impacts, and Tribal Lands. Navy NWTT activities that occur at the following locations may impact bull trout designated critical habitat that overlaps or is adjacent to these training and testing locations (Commander, Pacific Fleet and Naval Sea Systems Command 2015):

1. Pacific Beach – One mile of nearshore area of the Quinault Range Site is located in designated bull trout critical habitat.

2. Dabob Bay Range Complex (DBRC) – The DBRC overlaps with designated bull trout critical habitat at two locations; the deltas of Duckabush River and the Hamma Hamma River. The western boundary of the DBRC runs parallel to designated critical habitat.

3. Strait of Juan de Fuca – Multiple nearshore areas along the southern shores of the Strait of Juan de Fuca.

4. Possession Sound – The areas adjacent to the boundaries of the Naval Station Everett installation.

5. Carr Inlet – Areas outside and east of the Carr Inlet Operation Area.

6. Crescent Harbor – The areas adjacent to and across from the Crescent Harbor EOD Range Site.

The designated bull trout critical habitat final rule identified nine Primary Constituent Elements (PCEs) essential for the conservation of bull trout. Five of the nine PCEs are found in the marine waters of the action area:

- PCE 2: Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and foraging habitats including but not limited to permanent, partial, intermittent, or seasonal barriers.

- PCE 3: An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.

- PCE 4: Complex river, stream, lake, reservoir, and marine shoreline aquatic environments and processes with features such as large wood, side channels, pools, undercut banks and substrates, to provide a variety of depths, gradients, velocities, and structure.

- PCE 5: Water temperatures ranging from 2 to 15 °C (36 to 59 °F), with adequate thermal refugia available for temperatures that exceed the upper end of this range. Specific temperatures within this range will depend on bull trout life-history stage and form, geography, elevation, diurnal and seasonal variation, shading, such as that provided by riparian habitat, streamflow, and local groundwater influence.

- PCE 8: Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.

The proposed Navy activities are not expected to have measurable short- or long-term effects to any of the bull trout PCEs. The Navy activities will have no effect on PCEs 4 and 5. The Navy activities will not result in any temporary or permanent changes or alterations to marine shoreline habitat or impact water temperatures. The Navy training and testing activities may affect the following PCEs, however, these impacts will be short in duration, limited in extent, and will not alter the function of the PCE, so effects to these PCEs are expected to be insignificant:

PCE 2: Navy activities conducted within the DBRC, Possession Sound at Naval Station Everett, Carr Inlet, and Crescent Harbor include the use of sonar or underwater detonations that result in increased sound pressure levels that can temporarily act as an impediment within the migratory corridor. However, the area in which potential behavioral responses to sonar are expected is less than 14 meters from the source (see Effects of the Action Section below) and therefore the migratory corridor will not be significantly impeded. At Crescent Harbor, the detonation of 2.5 pound (lb) charges will result in increased sound pressure levels that will extend into critical habitat and could affect bull trout use of the area near the shoreline. Similarly, because underwater detonations are of short duration and intermittent, we do not expect bull trout movement through the area to be precluded by underwater sound levels resulting from detonations. The proposed use of surface ships, submarine, unmanned vessels, torpedoes, sonar, or other acoustic devices will also result in increased noise levels that could extend into designated critical habitat. However, these increased sound levels are intermittent or are at frequencies that are not expected to impede bull trout migration or degrade the function of critical habitat.

PCE 3: Navy activities within or adjacent to bull trout critical habitat that could affect bull trout prey include use of seafloor devices, use of anchors, sonar emissions, and underwater detonations. The use of seafloor devices, except at Pacific Beach, and anchors all occur in deep water and will result in minimal impacts to the seafloor and benthic invertebrate abundance. At Pacific Beach, seafloor devices include remote control "crawlers" that move slowly along the bottom and will have little to no impacts to forage fish or bull trout prey abundance. The use of sonar at DBRC, Possession Sound at Naval Station Everett, and Carr Inlet may result in injury (TTS) to forage fish, and underwater detonations at Crescent Harbor will kill or injure forage fish. However, we do not expect these impacts to result in a long-term reduction in forage fish abundance.

PCE 8: Navy activities will result in temporary impacts to water quality due to increases in turbidity, suspended solids, and contaminants associated with the operation of combustion engines and training and testing activities that disturb the seafloor. Turbidity and suspended solids will increase during the operation of devices on the seafloor, but the effects will be temporary and limited in extent. Increases in contaminants associated with the operation of combustion engines will rapidly diffuse to background levels and will not result in a long-term degradation of water quality.

3.4.1 Concurrence

Considering the project location and the project effects, we concur that the proposed action is not likely to adversely affect designated critical habitat for the bull trout.

4 BIOLOGICAL OPINION

5 DESCRIPTION OF THE PROPOSED ACTION

A federal action means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by federal agencies in the United States or upon the high seas (50 CFR 402.02). The proposed action involves two inter-related federal actions; the Navy's training and testing activities in the Pacific Northwest and the issuance of the Forest Service's Special Use Permit for Electronic Warfare (EW) Range activities on the ONF. The following information sources were relied upon to characterize the description of the proposed action: January 2014, DEIS; December 2014, Supplement to the DEIS; January 2015, BE; October 2015, FEIS, September 2014, and the Final Environmental Assessment for the Pacific Northwest Electronic Warfare Range. Additional clarification to the proposed action was provided in numerous emails, phone calls, and meetings as described above in the Consultation History.

5.1 Navy's Northwest Training and Testing Activities

The Navy's proposed action includes a variety of low intensity in-water testing activities, including high-fidelity passive acoustic signature measurements of submarines and ships, at the Navy's Southeast Alaska Acoustic Measurement Facility in the western Behm Channel in southeast Alaska. However, there are no listed species or critical habitat under the jurisdiction of the Service which will be exposed to Navy activities conducted at this location. Therefore, the Service will not be analyzing the effects of these activities, and they are not further addressed in this Opinion.

The purpose of the proposed action is to conduct training and testing activities to ensure that the Navy meets its mission, which is to maintain, train, and equip combat-ready naval forces capable of winning wars, deterring aggression, and maintaining freedom of the seas. In its request for consultation, the Navy characterized the term of the proposed action as the "foreseeable future." For purposes of this biological opinion, we are defining "reasonably foreseeable future" based on climate-change modeling horizons that are likely to occur. It is our best professional judgment, based on a review of that science, that an analysis period of 20 years is the maximum duration for which we can provide a reasoned analysis. We used information provided by the Intergovernmental Panel on Climate Change (IPCC) to establish a "reasonable foreseeable future" timeframe (Collins et al. 2013; Kirtman et al. 2013). Over the next 20 years, most models of climate change give relatively similar projections of the geographic pattern and magnitude of changes in environmental conditions that will directly influence the condition of species and critical habitat status, but after approximately 2035, model projections diverge depending on initial assumptions about greenhouse gas emissions (Collins et al. 2013, p. 1093; Kirtman et al. 2013, pp. 978-980, 1004-1012). For variables such as sea surface temperature, ocean heat content, and frequency of non-tropical storms over the North Pacific, these differences between projections become more pronounced over time into the future (Collins et al. 2013, pp. 1075, 1093). Any attempt to assess impacts beyond a 20-year horizon would be too speculative to allow for a scientifically meaningful assessment of effects to listed species or critical habitat caused by the proposed action.

The location, frequency, and duration of the proposed training activities are based on:

- Frequency of out-of-area training deployments to other Navy range complexes;
- Overseas deployments of ships and aircraft to the western Pacific and Middle East;
- Lifecycle maintenance and repair work that precludes completing some training within the NWTT; and,
- Certification and training needs for a given ship, submarine, or aircraft crew (e.g., some units could require a certain amount of one kind of training versus another).

Given the inherent uncertainty and potential variation within the training spectrum due to unforeseen world events, the Navy cannot predict exactly what actions it will take under the proposed action on an annual basis. Instead, the Navy provided the suite of activities, a maximum number of events, and the pertinent information associated with each event (e.g., the number and size of ordnance, vehicles and aircraft used, number of hours of sonar used, etc.).

The Navy categorizes the proposed training and testing activities into functional warfare areas called primary mission areas. Most of the proposed training and testing activities analyzed in the NWTT FEIS fall into the following six primary mission areas:

- Anti-Air Warfare
- Anti-Surface Warfare
- Anti-Submarine Warfare (ASW)
- Electronic Warfare
- Mine Warfare
- Naval Special Warfare

Additionally, some miscellaneous activities are grouped under “Other Activities.”

The following four sections provide a description of each training and testing activity, where they occur, number of events per year, and the number and type of ordnances and sonar used. Each activity and stressor may have been further sub-divided to assist in the effects analysis and is described in Appendix A.

5.2 Proposed Training Activities

The Navy’s proposed training activities are briefly described in Table 1. The table is organized according to primary mission areas and includes the activity name and a short description. A full description of each activity, as provided in the FEIS, can be found in Appendix B.

Table 1. Representative Training Activities Occurring in the NWTT Study Area.

Activity Name	Activity Description
Anti-Air Warfare	
Air Combat Maneuver	Aircrews engage in flight maneuvers designed to gain a tactical advantage during combat.
Missile Exercise (Air-to-Air)	Aircrews defend against aircraft threats with missiles.
Gunnery Exercise (Surface-to-Air)	Surface ship crews defend against aircraft or missile threats with guns.
Missile Exercise (Surface-to-Air)	Surface ship crews defend against aircraft or missile threats with missiles.
Anti-Surface Warfare	
Gunnery Exercise (Surface-to-Surface) – Ship	Ship crews engage surface targets with ship's small, medium-, and large-caliber guns.
Missile Exercise (Air-to-Surface)	Fixed-wing aircrews simulate firing precision-guided missiles using captive air training missiles against surface targets. Some activities include firing a missile with a high explosive (HE) warhead.
High-Speed Anti-Radiation Missile Exercise (Non-firing)	Fixed-wing aircrews simulate firing high-speed anti-radiation missiles, using captive air training missiles against surface targets. All missile firings are simulated; no actual missiles are fired.
Bombing Exercise (Air-to-Surface)	Fixed-wing aircrews deliver bombs against surface targets.
Anti-Submarine Warfare	
Submarine-based Tracking Exercises (TRACKEX – Submarine)	Submarine crews search for, detect, and track submarines and surface ships.
Surface-ship-based Tracking Exercises (TRACKEX – Surface)	Surface ship crews search for, detect, and track submarines.
Helicopterbased Tracking Exercises (TRACKEX – Helo)	Helicopter crews search for, detect, and track submarines.
Maritime Patrol Aircraft-based Tracking Exercises (TRACKEX – MPA)	Maritime patrol aircraft crews employ sonobuoys to search for, detect, and track submarines.
Maritime Patrol Aircraft-based Tracking Exercises using extended echo- ranging sonobuoys	Maritime patrol aircraft crews search for, detect, and track submarines using a multi-static active coherent system.
Electronic Warfare	
Electronic Warfare Operations	Aircraft, surface ship, and submarine crews attempt to deny the enemy the ability to control the electromagnetic spectrum, which in turn degrades or denies the enemy the ability to take offensive or defensive actions.

Table 1. Representative Training Activities Occurring in the NWTT Study Area.	
Activity Name	**Activity Description**
Mine Warfare	
Mine Neutralization – Explosive Ordnance Disposal (EOD)	Personnel disable threat mines. Explosive charges may be used.
Submarine Mine Exercise	Submarine crews practice detecting non-explosive training mine shapes in a designated area.
Maritime Homeland Defense/Security Mine Countermeasures Integrated Exercises	Naval mine warfare activities conducted at various ports and harbors in support of maritime homeland defense and security.
Naval Special Warfare	
Personnel Insertion and Extraction – Submersible	Military personnel train for covert insertion and extraction into target areas using submersibles.
Personnel Insertion and Extraction – Non-Submersible	Military personnel train for covert insertion and extraction into target areas using rotary wing aircraft, fixed-wing aircraft (insertion only), or small boats.
Other Training Activities	
Maritime Security Operations	Surface ship and small boat crews conduct a suite of Maritime Security Operations events, including maritime security escorts for Navy vessels such as submarines and aircraft carriers; Visit, Board, Search, and Seizure; Maritime Interdiction Operations; Force Protection; and Anti-Piracy Operations.
Precision Anchoring	Anchors are released in designated locations.
Small Boat Attack	Small boat crews engage pierside surface targets with small-caliber weapons. Only blank rounds are fired.
Intelligence, Surveillance, and Reconnaissance	Aircraft crews and unmanned aircraft systems conduct searches and gather intelligence using visual, optical, acoustic, and electronic systems.
Search and Rescue	Helicopter crews conduct helicopter insertion and extraction.
Surface Ship Sonar Maintenance	Maintenance of sonar systems occurs while the ships are moored and at sea.
Submarine Sonar Maintenance	Maintenance of sonar systems occurs while the submarines are moored and at sea.

5.3 Training Activity Levels

Table 2 provides a summary of training activities (as described in the previous Section) including location, number of events, quantities of non-explosive practice munition (NEPM) and high explosive (HE) munitions, hours or count of sonar used, and other information pertinent to the activity that the Navy proposes to expend during training activities.

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Table 2. Proposed Training Activities.

Range Activity	Location	No. of events (per year)	Ordnance (Number per year)	Sonar - Hours and Source Bin*	Additional Items Used	Additional Information Provided During Consultation
Anti-Air Warfare						
Air Combat Maneuver	Offshore Area (Warning Area 237 [W-237]), Olympic MOA	550	None	None	Chaff, flares	Conducted 95 percent daytime, 5 percent nighttime. Typically 2 but up to 4 aircraft per event. 110 events per year use chaff/flares. For flights over land in the Olympic MOAs, the minimum flight altitude is typically greater than 4,000 ft above ground level for 90 percent of the airspace. When flying in the MOAs, Navy aircraft do not fly at the outer edges of the MOAs, to prevent spilling out of the airspace. Navy aircraft will not be lower than 2000 ft above ground level. Seventy percent of all Navy flights in the MOAs are above 20,000 ft and 95 percent of all flights are above 10,000 ft.
Missile Exercise (Air-to-Air)	Offshore Area (W-237)	24	30 (AIM-7/9/120) 15 HE warheads 15 NEPM	None	Targets: unmanned aerial drone, tactical air-launched decoy, illumination flare	Conducted day only, 50 nautical miles (nm) or greater from shore. Events all occur at high altitudes.
Gunnery Exercise (Surface-to-Air)	Offshore Area (W-237)	160	310 large-caliber rounds (230 HE) 16,000 medium-caliber rounds (6,320 HE 9,680 NEPM)	None	Targets: towed banners	Conducted day only, 20 nm or greater from shore. Target is towed 500 ft or greater above the ocean surface.
Missile Exercise (Surface-to-Air)	Offshore Area (W-237)	4	RIM-7/116 (8 HE warheads)	None	Targets: unmanned drones	Conducted day only, 50 nm or greater from shore.
Anti-Surface Warfare						
Gunnery Exercise (Surface-to-Surface) – Ship	Offshore Area	200	Small-caliber rounds (121,200 NEPM) Medium-caliber rounds (48 HE, 33,492 NEPM) Large-caliber rounds (80 HE, 2,720 NEPM)	None	Targets: floating and remote controlled high speed targets	Conducted day only, 20 nm or greater from shore.

Table 2. Proposed Training Activities.

Range Activity	Location	No. of events (per year)	Ordnance (Number per year)	Sonar - Hours and Source Bin*	Additional Items Used	Additional Information Provided During Consultation
Missile Exercise (Air-to-Surface)	Offshore Area (W-237)	4	AGM-84 (4 HE Missiles)	None	Targets: floating and remote controlled targets	Conducted day only, 50 nm or greater from shore. Target is towed on the ocean surface.
High-Speed Anti-Radiation Missile Exercise (Non-firing)	Offshore Area (W-237)	1,740	All non-firing Captive Air Training Missiles	None	None	No munitions are released. Air to air activities occur at 10,000 ft Mean Sea Level (MSL) or higher.
Bombing Exercise (Air-to-Surface)	Offshore Area (W-237)	30	BDU-45, MK-84 Bombs (10 HE, 110 NEPM)	None	Targets: floating target	Conducted day only, 50 nm or greater from shore when using explosives, not in Olympic Coast National Marine Sanctuary (OCNMS), 20 nm or greater if using NEPM. Thirty smoke buoys per year as targets.
Anti-Submarine Warfare						
Tracking Exercise – Submarine	Offshore Area	100	None	48 MF3 16 HF1 112 HF6	Targets: submarine, expendable mobile anti-submarine warfare training target, or recoverable training target	Conducted day and night, 12 nm or greater from shore in at least 600 ft water depth.
Tracking Exercise – Surface (TRACKEX – Surface)	Offshore Area	65	None	140 MF1 16 MF11 78 ASW3 80 HF6	Targets: submarine, expendable mobile anti-submarine warfare training target, or recoverable training target	Conducted day and night, 12 nm or greater from shore in at least 600 ft water depth.
Tracking Exercise – Helicopter (TRACKEX – Helo)	Offshore Area	4	None	4 MF4 16 MF5	Targets: submarine, expendable mobile anti-submarine warfare training target, or recoverable training target	Conducted day and night, 12 nm or greater from shore in at least 600 ft water depth.
Tracking Exercise – Maritime Patrol Aircraft (TRACKEX – MPA)	Offshore Area	300	None	880 MF5	Targets: submarine, expendable mobile anti-submarine warfare training target, or recoverable training target	Conducted day and night, 12 nm or greater from shore in at least 600 ft water depth.

Table 2. Proposed Training Activities.

Range Activity	Location	No. of events (per year)	Ordnance (Number per year)	Sonar - Hours and Source Bin*	Additional Items Used	Additional Information Provided During Consultation
Tracking Exercise – Maritime Patrol Aircraft Multistatic Active Coherent (MAC) (TRACKEX MPA MAC)	Offshore Area	24	None	720 ASW2	Targets: submarine, expendable mobile anti-submarine warfare training target, or recoverable training target	Conducted day and night, 12 nm or greater from shore in at least 600 ft water depth.
Electronic Warfare						
Electronic Warfare Operations	Offshore Area (W-237), Olympic MOAs	5,000 (aircraft) 275 (ship)	None	None	Chaff, flares	Conducted 99 percent daytime, 1 percent nighttime. Typically 1 to 4 aircraft per event. For Electronic Warfare flights over land in the Olympic MOAs, the flights are conducted more than 10,000 ft above ground level. When flying in the MOAs, Navy aircraft do not fly at the outer edges of the MOAs, to prevent spilling out of the airspace. Navy aircraft will not be lower than 2,000 ft above ground level. Seventy percent of all Navy flights in the MOAs are above 20,000 ft and 95 percent of all flights are above 10,000 ft.
Electronic Warfare Land-Based	Olympic MOA	780	None	None	Mobile Electronic Emitters (2 hrs/event)	Conducted 99 percent daytime, 1 percent nighttime.
Mine Warfare						
Mine Neutralization – Explosive Ordnance Disposal	Inland Waters (Crescent Harbor EOD Training Range)	3	Three 2.5 lb HE charges	None	None	Conducted day only.
		3	18 shock wave action generator (SWAG)	None	None	
	Inland Waters (Hood Canal EOD Training Range)	3	Three 2.5 lb HE charges	None	None	
		3	18 SWAG	None	None	
Submarine Mine Exercise	Offshore Area	8	None	32HF1	24 batho-thermograph buoys	Conducted day and night.

Table 2. Proposed Training Activities.

Range Activity	Location	No. of events (per year)	Ordnance (Number per year)	Sonar - Hours and Source Bin*	Additional Items Used	Additional Information Provided During Consultation
Maritime Homeland Defense/ Security Mine Countermeasures Integrated Exercise	Inland Waters	Three in 5 years	None	384 HF4	Magnetic mine sweeping, 24 hours	Conducted day and night. Twenty-four hours of helicopter flight time over several days. 24 hours of Navy combatant underway time, 24 hours of small boat activity per event, 4 hours of diving time per day, 24 hours of submersible unmanned vehicles time over several days, and 24 hours of magnetic mine sweeping equipment over several days.
Naval Special Warfare						
Personnel Insertion/Extraction – Submersible	Inland Waters (Keyport)	8	None	None	None	Conducted day and night.
	Inland Waters (Indian Island)	5	None	None	None	
	Inland Waters (DBRC Site)	20	None	None	None	
	Inland Waters (Crescent Harbor)	1	None	None	None	
	Inland Waters (Navy 7)	1	None	None	None	
Personnel Insertion/Extraction – Non-Submersible	Inland Waters (Crescent Harbor)	0 to 10, 10 total at both sites	None	None	None	Conducted day and night.
	Inland Waters (R6701)	0 to 10, 10 total at both sites	None	None	None	

Table 2. Proposed Training Activities.

Range Activity	Location	No. of events (per year)	Ordnance (Number per year)	Sonar - Hours and Source Bin*	Additional Items Used	Additional Information Provided During Consultation
Other Activities						
Maritime Security Operations	Inland Waters (Naval Base [NAVBASE] Kitsap Bangor, Hood Canal, Dabob Bay, Puget Sound, Strait of Juan de Fuca)	286	1,320 small caliber rounds (all blanks)	None	None	Conducted day only.
Precision Anchoring	Inland Waters (Naval Station Everett)	7	None	None	None	Conducted day only.
	Inland Waters (Indian Island)	3	None	None	None	
Small Boat Attack	Inland Waters (Naval Station Everett)	1 event per year at one of the three sites	3,000 small-caliber rounds (all blanks)	None	None	Conducted day only.
	Inland Waters (NAVBASE Kitsap Bangor)	1 event per year at one of the three sites	3,000 small-caliber rounds (all blanks)	None	None	
	Inland Waters (NAVBASE Kitsap Bremerton)	1 event per year at one of the three sites	3,000 small-caliber rounds (all blanks)	None	None	
Intelligence, Surveillance, Reconnaissance	Offshore Area	200	None	None	None	Conducted day and night.
Search and Rescue	Inland Waters (Crescent Harbor)	95	None	None	Flares	Conducted day and night.
	Inland Waters (Navy 7)	5	None	None	Flares	

Table 2. Proposed Training Activities.

Range Activity	Location	No. of events (per year)	Ordnance (Number per year)	Sonar - Hours and Source Bin*	Additional Items Used	Additional Information Provided During Consultation
Surface Ship Sonar Maintenance	Offshore Area	7	None	14 MH1	None	Conducted day and night
	Inland Waters (Pierside Naval Station Everett)	6	None	12 MF1	None	
Submarine Sonar Maintenance	Offshore Area	11	None	11 MF3	None	Conducted day and night
	Inland Waters (Pierside NAVBASE Kitsap Bangor)	4	None	4 MF3	None	
	Inland Waters (Pierside NAVBASE Kitsap Bremerton)	7	None	7 MF3	None	

5.4 Proposed Testing Activities

The Navy's research and acquisition community engages (i.e. testing community) in a broad spectrum of testing activities in support of the fleet. These activities include, but are not limited to, basic and applied scientific research and technology development; testing, evaluation, and maintenance of systems (missiles, radar, and sonar), and platforms (surface ships, submarines, and aircraft); and acquisition of systems and platforms to support Navy missions and give a technological edge over adversaries.

The individual commands within the research and acquisition community are:

- Naval Sea Systems Command. Within Naval Sea Systems Command are the following field activities:
    - Naval Undersea Warfare Center Division, Keyport
    - Naval Surface Warfare Center, Carderock Division, Detachment Puget Sound
    - Naval Surface Warfare Center, Carderock Division, Southeast Alaska Acoustic Measurement Facility
    - Puget Sound Naval Shipyard and Intermediate Maintenance Facility
    - Various Naval Sea Systems Command program office-sponsored testing activities
- Naval Air Systems Command

The Navy's proposed testing activities are briefly described in Table 3. The table is organized according to testing category conducted by each technical organization and includes the activity name and a short description. A full description of each activity, as provided in the FEIS, can be found in Appendix B.

Table 3. Representative Testing Activities Occurring in the NWTT Study Area.

Activity Name		Activity Description
Naval Undersea Warfare Center Division, Keyport		
Torpedo Testing	Torpedo Non-Explosive Testing	Test of a non-explosive torpedo against a target.
Autonomous and Non-Autonomous Vehicles	Unmanned Underwater Vehicle Testing	Unmanned underwater vehicles (UUVs) are autonomous or remotely operated vehicles with a variety of different payloads used for various purposes.
	Unmanned Aircraft System	Unmanned Aircraft Systems are remotely piloted or self-piloted (i.e., preprogrammed flight pattern) aircraft that include fixed-wing, rotary-wing, and other vertical takeoff vehicles. They can carry cameras, sensors, communications equipment, or other payloads.
	Unmanned Surface Vehicle Testing	Unmanned surface vehicles are primarily autonomous systems designed to augment current and future platforms to help deter maritime threats. They employ a variety of sensors designed to extend the reach of manned ships.
Fleet Training Support	Cold Water Training	Fleet training for divers in a cold water environment and other diver training related to Navy divers supporting range operations.
	Post-Refit Sea Trial	Following periodic maintenance or repairs, sea trials are conducted to evaluate submarine propulsion, sonar systems, and other mechanical tests.
	Anti-Submarine Warfare Testing	Ships and their supporting platforms (e.g., helicopters, unmanned aerial vehicles) detect, localize, and prosecute submarines or other training targets.
Maintenance and Miscellaneous	Side Scan/ Multi-beam Sonar	Side Scan/Multi-beam Sonar systems associated with a vessel or UUV are tested to ensure they can detect, classify, and localize targets in a real world environment.
	Non-Acoustic Tests	These tests involve non-acoustic sensors. Non-acoustic sensors may also gather other forms of environmental data.
Acoustic Component Test	Countermeasures Testing	Includes testing of two types of countermeasures: those that emit active acoustic energy of varying frequencies into the water to mimic the characteristics of a target so that the actual threat or target remains undetected; and those that would detect, localize, track, and attack incoming weapons.
	Acoustic Test Facility	Various acoustic component testing and calibration is conducted in a controlled experimental environment based on periodicity and is also conducted on modified, upgraded, and experimental devices.
	Pierside Integrated Swimmer Defense	Swimmer defense testing ensures that systems can effectively detect, characterize, verify, and engage swimmer and diver threats in harbor environments.

Table 3. Representative Testing Activities Occurring in the NWTT Study Area.

Activity Name		Activity Description
Naval Surface Warfare Center, Carderock Division Detachment Puget Sound		
System, Subsystem and Component Testing	Pierside Acoustic Testing	Operating autonomous underwater vehicle (AUV), remotely operated vehicle (ROV), UUV, submersibles/Concepts and Prototypes (including experimental vehicles, systems, equipment, tools and hardware) underwater in a static or dynamic condition within 500 yd. of an instrumented platform moored pierside.
	Performance Testing At-Sea	Operating AUV, ROV, UUV, submersibles/Concepts and Prototypes underwater at sea. Systems will be exercised to obtain operational performance measurements of all subsystems and components used for navigation and mission objectives.
	Development Training and Testing	Operating AUV, ROV, UUV, submersibles/Concepts and Prototypes underwater at Sea. Systems will be exercised to validate development and to provide operator familiarization and training with all subsystems and components used for navigation and mission objectives.
Proof of Concept Testing		Design, fabrication and installation of unique hardware and towing configurations in support of various surface and underwater demonstrations as proof-of-concept.
Additional Naval Sea Systems Command Testing Activities		
Life Cycle Activities	Pierside Sonar Testing	Pierside testing of submarine and surface ship sonar systems occurs periodically following major maintenance periods and for routine maintenance.
Shipboard Protection Systems and Swimmer Defense Testing	Pierside Integrated Swimmer Defense	Swimmer defense testing ensures that systems can effectively detect, characterize, verify, and engage swimmer and diver threats in harbor environments.
Unmanned Vehicle Testing	Unmanned Vehicle Development and Payload Testing	Vehicle development involves the production and upgrade of new unmanned platforms on which to attach various payloads used for different purposes.
Anti-Surface Warfare/Anti-Submarine Warfare Testing	Torpedo Testing	Air, surface, or submarine crews employ explosive torpedoes against artificial targets.
	Torpedo Non-Explosive Testing	Air, surface, or submarine crews employ non-explosive torpedoes against submarines or surface vessels.
	Countermeasure Testing	Countermeasure testing involves the testing of systems that would detect, localize, track, and attack incoming weapons.
New Ship Construction	Anti-Submarine Warfare Mission Package Testing	Ships and their supporting platforms (e.g., helicopters, unmanned aerial vehicles) detect, localize, and prosecute submarines.

Table 3. Representative Testing Activities Occurring in the NWTT Study Area.

Activity Name	Activity Description
Naval Air Systems Command Testing Activities **Anti-Submarine Warfare**	
Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft (ASW TRACKEX – MPA) (Directional Command Activated Sonobuoy System [DICASS])	All Naval Air Systems Command ASW testing activities are similar to the training event ASW TRACKEX – MPA. This test evaluates the sensors and systems used by maritime patrol aircraft to detect and track submarines using the DICASS.
ASW TRACKEX – MPA MAC	This test evaluates the sensors and systems used by maritime patrol aircraft to detect and track submarines using the MAC sonobuoy system.
ASW TRACKEX – MPA (Sound Underwater Signal [SUS])	This test evaluates the sensors and systems used by maritime patrol aircraft to communicate with submarines using any of the family of SUS systems.
ASW TRACKEX – MPA (Improved Extended Echo Ranging [IEER])	This test evaluates the sensors and systems used by maritime patrol aircraft to detect and track submarines using the IEER sonobuoy system.
ASW TRACKEX – MPA (High Duty Cycle [HDC])	This test evaluates the sensors and systems used by maritime patrol aircraft to detect and track submarines using the HDC sonobuoy system.
Electronic Warfare	
Flare Test	Flare tests evaluate newly developed or enhanced flares, flare dispensing equipment, or modified aircraft systems against flare deployment. Tests may also train pilots and aircrew in the use of newly developed or modified flare deployment systems. Flare tests are often conducted with other test events, and are not typically conducted as standalone tests.

5.5 Testing Activity Levels

Table 4 provides a summary of testing activities (as described in the previous Section) including location, number of events, quantities of NEPM and HE munitions, hours or count of sonar used, and other information pertinent to the activity that the Navy plans to expend during testing activities.

Table 4. Proposed Testing Activities.

Range Activity		Location	No. of events (per year)	Ordnance (Number per year)	Sonar - Hours and Source Bin* (Counts are italicized)**	Additional Items Used	Additional Information Provided During Consultation
Naval Undersea Warfare Center Division, Keyport Testing Activities							
Torpedo Testing	Torpedo Non-Explosive Testing	Offshore Area (Quinault Range Site [QRS])	20	101 NEPM torpedoes	21 MF10 *134 ASW4* 4.2 ASW3 *63 MF5* *34 TORP1* *67 TORP2*	Targets: submarine, expendable mobile anti-submarine warfare training target, or recoverable training target	Conducted in the warm season, primarily during the day; rarely at night. Typical event is conducted more than 3 nm from shore in water more than 600 ft deep, lasts about 8 hours and averages 5 torpedo runs. An average run lasts approximately 10 minutes. Between runs, sonar is not in use; vessels may maneuver or hold station (maneuvering vessels use navigational acoustic sources considered de minimis by the Navy). Target may be a submarine or a target device. Torpedo may be launched from a submarine, a support craft or a fixed-wing aircraft.
		Inland Waters (DBRC)	41	189 NEPM torpedoes	*42 TORP1* *147 TORP2*	Targets: submarine, expendable mobile anti-submarine warfare training target, or recoverable training target	Same as for QRS, except testing is year-round, and no aircraft used.
Autonomous and Non-Autonomous Vehicles	Unmanned Underwater Vehicle Testing	Offshore Area (QRS)	20	None	None	None	Test conducted year-round, primarily during the day; rarely at night. Crawlers are autonomous devices which propel themselves by pushing off the sea floor (crawling), as opposed to swimming through the water column. They tend to be tracked devices. Up to 10 percent of UUV testing could be crawlers. Support craft may be used during tests.
		Inland Waters (DBRC Site)	30	134 NEPM torpedoes	434 SAS2 *67 TORP1* *67 TORP2* 210 M3	None	
		Inland Waters (Keyport Range Site)	101	None	220 M3 220 SAS2	None	

Table 4. Proposed Testing Activities.

Range Activity		Location	No. of events (per year)	Ordnance (Number per year)	Sonar - Hours and Source Bin* (Counts are italicized)**	Additional Items Used	Additional Information Provided During Consultation
Autonomous and Non-Autonomous Vehicles (Continued)	Unmanned Aircraft System	Offshore Area (QRS)	20	None	None	None	Conducted year-round, day only. Unmanned aircraft tested at less than 3,000 75 percent of time, 3,000 and greater for 25 percent of time.
		Inland Waters (DBRC Site)	20	None	None	None	
	Unmanned Surface Vehicle	Offshore Area (QRS)	20	None	None	None	Test conducted year-round, primarily during the day; rarely at night.
		Inland Waters (DBRC Site)	5	None	None	None	
		Inland Waters (Keyport Range Site)	15	None	None	None	
Fleet Training/ Support	Cold Water Training	Offshore Area (QRS)	20	None	HF	None	Test conducted year-round, 80 percent day, 20 percent night. Divers sometimes use hand-held or man-operated acoustic systems that are de minimis and not quantified.
		Inland Waters (DBRC Site)	33	None	HF	None	
		Inland Waters (Keyport Range Site)	33	None	HF	None	
	Post-Refit Sea Trial	Inland Waters (DBRC Site)	32	None	32 M3 79 MF10	None	Test conducted year-round, 80 percent day, 20 percent night.
	Anti-Submarine Warfare Testing	Offshore Area (QRS)	5	None	4.2 MF10 34 MF11	None	Test conducted year-round, day and night. Helicopters used on 30 percent of tests.

Table 4. Proposed Testing Activities.

Range Activity		Location	No. of events (per year)	Ordnance (Number per year)	Sonar - Hours and Source Bin* (Counts are italicized)**	Additional Items Used	Additional Information Provided During Consultation
Maintenance and Miscellaneous	Side Scan/Multi-beam Sonar	Inland Waters (DBRC Site)	27	None	HF	None	Test conducted year-round, primarily during the day; rarely at night. Assume half the annual events occur at DBRC and half at Keyport. About 14 events per location, tests would use either a towed device or a UUV. Assume 7 events per location include a towed device, 7 include UUV-mounted system.
		Inland Waters (Keyport Range Site)	27	None	HF	None	
	Non-Acoustic Tests	Offshore Area (QRS)	6	None	None	None	Test conducted year-round, systems deployed primarily during day, may be monitored at night.
		Inland Waters (DBRC Site)	23	None	None	None	Same as QRS above. Assume 23 events at DBRC, 51 at Keyport Range Site. System would be deployed from small crafts 30 percent (towed device platform) and from pier 70 percent (UUV/ Unmanned surface vehicles platform).
		Inland Waters (Keyport Range Site)	51	None	None	None	
Acoustic Component Test	Countermeasures Testing	Offshore Area (QRS)	6	None	*84 ASW4*	None	Test conducted year-round, systems deployed primarily during day. Submarine target used in 70 percent of tests, other target used 30 percent.
		Inland Waters (DBRC Site)	18	None	*84 ASW4*	None	Same as QRS above. Assume 18 events at DBRC, 43 at Keyport Range Site.
		Inland Waters (Keyport Range Site)	43	None	*880 ASW4*	None	
	Acoustic Test Facility	Inland Waters (DBRC Site)	9	None	22 HF6 3 LF4 7 MF9 2 VHF2	None	Year-round, deployed primarily day. May monitor overnight. At DBRC, test conducted from a moored vessel, at Keyport the test is conducted from the pier
		Inland Waters (Pierside Keyport Range Site)	167	None	435 HF6 67 LF4 134 MF9 33 VHF2	None	

Table 4. Proposed Testing Activities.

Range Activity		Location	No. of events (per year)	Ordnance (Number per year)	Sonar - Hours and Source Bin* (Counts are italicized)**	Additional Items Used	Additional Information Provided During Consultation
Acoustic Component Test (Continued)	Pierside Integrated Swimmer Defense	Inland Waters (Pierside Keyport Range Site)	38	None	16 LF4 16 MF8 301 SD1	None	Test conducted only at Keyport Range Site, not at DBRC as listed in Draft EIS/OEIS. Test conducted year-round, primarily during day, may be monitored at night.
Naval Surface Warfare Center, Carderock Division Detachment Puget Sound							
System, Subsystem and Component Testing	Pierside Acoustic Testing	Inland Waters (NAVBASE Kitsap Bangor)	30	None	30 LF5 30 MF10	None	Test conducted year-round. Event is typically 8 hours duration with some activity at night. Work divided evenly between the two locations. Targets may be used 10 percent of the activities.
		Inland Waters (NAVBASE Kitsap Bremerton)	30	None	30 LF5 30 MF10	None	
	Performance Testing At Sea	Inland Waters (DBRC Site)	48	None	115 M3 58 SAS2	None	Test conducted year-round. Event is typically 8 hours duration with some activity at night. 48 events at DBRC, 12 in Carr Inlet.
		Inland Waters (Carr Inlet)	12	None	29 M3 14 SAS2	None	
	Development Training and Testing	Inland Waters (DBRC Site)	29	None	230 HF6 461 M3	None	Test conducted year-round. Event is typically 8 hours duration with some activity at night. 36 events total per year, with 80 percent occurring in DBRC and 20 percent occurring in Carr Inlet.
		Inland Waters (Carr Inlet)	7	None	58 HF6 115 M3	None	
Proof of Concept Testing		Inland Waters (DBRC Site)	24	None	77 HF6 269 M3 58 SAS2	None	Test conducted year-round. Event is typically 8 hours duration with some activity at night. 30 events total per year, with 80 percent occurring in DBRC and 20 percent occurring in Carr Inlet.
		Inland Waters (Carr Inlet)	6	None	19 HF6 67 M3 14 SAS2	None	

Table 4. Proposed Testing Activities.

Range Activity		Location	No. of events (per year)	Ordnance (Number per year)	Sonar - Hours and Source Bin* (Counts are italicized)**	Additional Items Used	Additional Information Provided During Consultation
Additional Naval Sea Systems Command Testing Activities							
Life Cycle Activities	Pierside Sonar Testing	Inland Waters (Pierside Naval Station Everett)	8	None	32 MF1	None	Test conducted year-round. Event is typically 8 hours duration with some activity at night.
		Inland Waters (Pierside NAVBASE Kitsap Bangor)	29	None	121 HF1 6 HF3 41 MF3 80 MF9 1 MF3	None	
		Inland Waters (Pierside NAVBASE Kitsap Bremerton)	30		40 HF1 2.5 HF3 104 MF3 120 MF9	None	
Shipboard Protection Systems and Swimmer Defense Testing	Pierside Integrated Swimmer Defense	Inland Waters (Pierside NAVBASE Kitsap Bangor)	1 event per year at one of the two sites	None	12 LF4 12 MF8 228 SD1	None	Test conducted year-round. 1 event can last up to 14 days with intermittent activities throughout the time period. Diver safety procedures typically require 8 hours duration - some activities may occur at night.
		Inland Waters (Pierside Keyport Range Site)	1 event per year at one of the two sites	None	12 LF4 12 MF8 228 SD1	None	
Unmanned Vehicle Testing	Unmanned Vehicle Development and Payload Testing	Inland Waters (DBRC Site)	2	None	240 MF9	None	Test conducted year-round, day and night, 50 percent at DBRC Site, 50 percent at Keyport Range Site.
		Inland Waters (Keyport Range Site)	2	None	240 MF9	None	

Table 4. Proposed Testing Activities.

Range Activity		Location	No. of events (per year)	Ordnance (Number per year)	Sonar - Hours and Source Bin* (Counts are italicized)**	Additional Items Used	Additional Information Provided During Consultation
Anti-Surface Warfare/Anti-Submarine Warfare Testing	Torpedo (Explosive) Testing	Offshore Area	3	6 HE torpedoes 6 NEPM torpedoes	*6 TORP1* *6 TORP2*	None	Test conducted in warm season only, daylight hours, greater than 50 nm from shore.
	Torpedo (Non-explosive) Testing	Offshore Area (QRS)	3	18 NEPM torpedoes	*6 TORP1* *12 TORP2*	None	Test conducted year-round during daylight hours, greater than 12 nm from shore.
	Countermeasure Testing	Inland Waters (DBRC Range Site)	13	21 NEPM torpedoes	*21 TORP1*	None	Test conducted year-round, day and night.
		Offshore Area (QRS)	8	123 NEPM torpedoes	360 HF5 123 TORP1 360 ASW3	None	Test conducted year-round during daylight hours, greater than 12 nm from shore.
New Ship Construction	ASW Mission Package Testing	Offshore Area (QRS)	8	16 NEPM torpedoes	16 ASW1 80 ASW3 24 MF12 10 MF4 *4 MF5* *16 TORP1*	None	Test conducted year-round during daylight hours, greater than 12 nm from shore.

Table 4. Proposed Testing Activities.

Range Activity		Location	No. of events (per year)	Ordnance (Number per year)	Sonar - Hours and Source Bin* (Counts are italicized)**	Additional Items Used	Additional Information Provided During Consultation
Naval Air Systems Command Testing Activities							
Anti-Submarine Warfare Tracking Test	Maritime Patrol Aircraft (DICASS)	Offshore Area	28	None	*170 MF5*	None	Test conducted year-round, day and night, greater than 12 nm from shore, outside OCNMS.
	Maritime Patrol Aircraft (MAC)	Offshore Area	14	None	170 ASW2	None	Test conducted year-round, day and night, greater than 12 nm from shore, outside OCNMS.
	Maritime Patrol Aircraft (SUS)	Offshore Area	5	72 Impulsive SUS buoys (HE) (e.g., MK-61, MK-64, MK-82)	12 MF6	None	Test conducted year-round, day and night, greater than 12 nm from shore, outside OCNMS.
	Maritime Patrol Aircraft (IEER)	Offshore Area	6	70 IEER (HE) sonobuoys	None	None	Test conducted year-round, day and night, greater than 12 nm from shore, outside OCNMS.
	Maritime Patrol Aircraft (HDC)	Offshore Area	1	None	64 ASW2H	None	Test conducted year-round, day and night, greater than 12 nm from shore, outside OCNMS.
Electronic Warfare							
Electronic Warfare	Flare Test	Offshore Area	10	None	None	Flares, chaff	Test conducted year-round, day and night, greater than 3 nm from shore.

* Source bin as identified in Table 16.
** Counts are the number of units (i.e., sonobuoys) used in the testing activity, not hours of use.

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5.6 U.S. Forest Service's Special Use Permit

The Forest Service has received and accepted a special use application by the Navy under authority of the Organic Administration Act of June 4, 1897, to use or occupy National Forest System lands within the Olympic National Forest, Pacific Ranger District. The Forest Service is proposing to issue a 5-year permit for the activities. The activities authorized are in support of the EW training activities described above in Tables 1 and 2.

For EW training the Navy proposes to use three Mobile Electronic Warfare Training System (MEWTS) which are utility trucks modified with two vehicle-mounted mobile emitters. The mobile emitters with which MEWTS will be outfitted are summarized in Table 5. The Navy proposes to operate the MEWTS from 15 sites within the Olympic MOAs; 11 sites on Forest Service lands and four on Washington Department of Natural Resource (WDNR) lands. However, the Navy has not applied to WDNR for a land use or lease application to use the MEWTS on their land as the State of Washington notified the Navy they prefer not to partner with them on this project (Washington State Department of Natural Resources, in litt. 2015). The Navy may apply to WDNR in the future and will consult with the Service, if necessary, at that time. The WDNR sites are not included in this consultation.

Table 5. Summary of mobile electromagnetic emitters in electronic warfare training.

Emitter type	Range of Electromagnetic (EM) wave frequencies (Gigahertz [GHz])	Shape of EM signal	Dimensions of EM Signal	Radiation Hazard Minimum Safe Separation Distance
Traveling Wave Tube Amplifier	4 - 8	Cone	8.1 degrees	30.8 m / 101.1 ft
Magnetron	6.7 – 7.4	Wedge	9 degrees horizontal 27 degrees vertical	8.9 m / 29.3 ft

(Mosher, pers. comm. 2015; Navy 2014)

Specific locations for the 11 sites on Forest Service lands are provided in Table 6 and shown in Figure 1. Each site consists of an existing pull-outs or turnarounds which have already been cleared or have natural features (e.g., a cliff or ridgeline) that provide an unobstructed line of sight to the west. The MEWTS will not be parked at training sites overnight, but travel to sites each day from Naval Station Everett Annex Pacific Beach using existing roads. Once on sites, MEWTS will operate between 8 and 16 hours each day for 260 days each year (Navy 2014). Emitters are expected to be energized, emitting signals at 90-300 watts, about 45 minutes of every hour that the MEWTS are on sites (Mosher, pers. comm. 2015; Navy 2014).

Table 6. Location of proposed MEWTS Emitter Sites (Navy 2014, p. 1-5).

MEWTS Emitter Site No.	Latitude/Longitude	Specific Location
Olympic A MOA		
1	N 47°32'13.56" / W 123°56'51.18"	NFS Rd NF-2140
2	N 47°31'40.80" / W 123°52'47.50"	NFS Rd NF-2190
4	N 47°35'49.80" / W 124°02'39.80"	NFS Rd NF-011
5	N 47°22'32.81" / W 123°53'12.87"	NFS Rd NF-2258
6	N 47°24'20.50" / W 123°50'27.08"	NFS Rd NF-2258
7	N 47°23'47.40" / W 123°54'52.80"	NFS Rd 2257
8	N 47°21'30.10" / W 123°51'56.40"	NFS Rd 042
15	N 47°30'44.80" / W 123°53'20.20"	NFS Rd NF-2190
Olympic B MOA		
9	N 47°57'58.00" / W 124°11'41.70"	Intersection of NFS Rd 2923 and NFS Rd 025
10	N 47°59'26.11" / W 124°09'59.78"	NFS Rd 2923
11	N 48°00'57.54" / W 124°13'26.13"	Intersection of NFS Rd 060 and NFS Rd 065

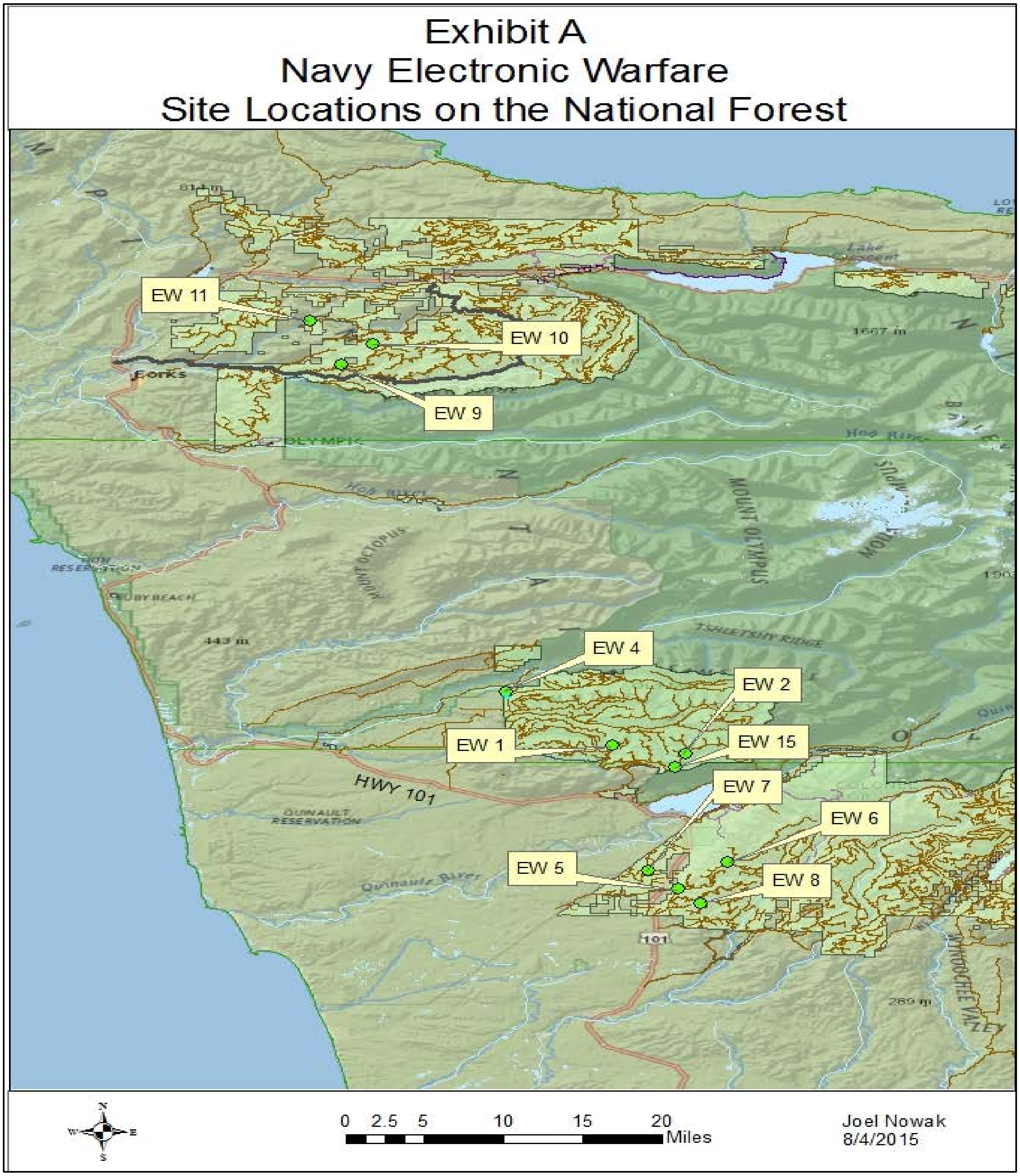

Figure 1. Site Locations on Forest Service lands within MOAs A and B.
(Forest Service 2016)

5.7 Conservation Measures

The following conservation measures have been incorporated into the project design to avoid or minimize potential effects to listed species. Conservation measures include:

1. In inland waters, marine bird monitoring will be conducted for all Mine Neutralization, Explosive Ordnance Disposal activities at both the Hood Canal and Crescent Harbor EOD Training Ranges. Monitoring will take place within the exclusion zone. If any marine bird is observed within this zone, training activities will be paused until the bird(s) have voluntarily left the exclusion zone. Monitoring inclusion zone will be:

    a. SWAGs – 100 yards.

    b. Detonations of E3 Explosive Source Bin – 400 yards.

2. At the Hood Canal EOD Range Site, no E3 detonations will be discharged between February and April. Only SWAG charges (< E1) will be detonated during this time.

3. At the Hood Canal EOD Range Site, the Navy will avoid E3 detonations to the maximum extent practicable between August 1 and October 31 (unless necessitated by readiness requirements). Only SWAG charges (< E1) will be detonated during this time.

4. A mitigation zone with a radius of 200 yd. (183 m) shall be established for small- and medium-caliber gunnery exercises with a surface target. Vessels will observe the mitigation zone from the firing position. The exercise will not commence if seabirds are sighted within the mitigation zone.

5. A mitigation zone with a radius of 70 yd. (46 m) within 30 degrees on either side of the gun target line on the firing side shall be established for weapons firing noise and muzzle blast during large caliber gunnery exercises. Mitigation shall include visual observation immediately before and during the exercise. The exercise will not commence if seabirds are sighted within the mitigation zone.

The Navy plans to implement standard operating procedures, mitigation, and monitoring measures to minimize or avoid impacts to listed species (Navy 2015 – Chapter 5). Most of these activities are related to Lookout Procedures that require the reporting of all objects observed in the water (e.g. trash, periscopes, marine mammals, sea turtles, floating vegetation, etc.) to the Officer of the Deck, as well as all disturbances (e.g., surface disturbance, discoloration) that may be indicative of a threat to the vessel and its crew. The Service reviewed Chapter 5 of the FEIS and determined that, in the Offshore Area, these procedures would not eliminate risk to marbled murrelets and short-tailed albatross. Effective detection of these birds, especially the marbled murrelet, requires a qualified and highly experienced biologist. The Lookouts do not typically have these qualifications. Therefore, we do not expect that these standard procedures will eliminate or measurably reduce the risks to listed seabirds in the Offshore Area.

On April 21, 2016, the Navy provided the following measures that they could implement during EOD activities at the Hood Canal and Crescent Harbor EOD Training Range sites:

1. Procedures and monitoring for all events:

    a. To minimize potential effects, each underwater detonation event will utilize the smallest practicable net explosive weight charge necessary to accomplish the required training objective (e.g. a 1.5 lb charge may be used if a 2.5 lb charge is not required).

    b. Underwater detonation events will only utilize command detonated charges (positive control); none will use time delayed firing devices.

    c. Underwater detonation events will take place only during sea state conditions of Beaufort 0 to 2 to support good visibility of the exclusion area by monitoring teams. Events will not be conducted during conditions of low visibility.

    d. One Navy biologist will be included in the monitoring team onboard the monitoring boat(s) and will be the lead for the monitoring evolution. This person will give the final approval that the exclusion area is clear of all marine birds prior to the underwater detonation charge being initiated. The monitoring team lead will have radio communication with the unit conducting the event and all other monitoring boats.

    e. A pre-event boat survey of the exclusion area will commence 30 minutes prior to the planned detonation event. During the survey, each observer will cover a transect area that is no more than 50 meters wide. Observers will scan without binoculars. Boat speed during the survey will be between 5 to 10 knots.

    f. Units conducting the underwater detonation event will assist in observing the exclusion area, as practicable, during completion of the entire training evolution, and will immediately notify the monitoring team lead of any observed marine species (the unit conducting the underwater detonation is generally 4 to 5 people).

    g. After the charge has been initiated, and the unit conducting the underwater detonation has determined that the exclusion area is safe to reenter, a post-event survey will occur with the monitoring boat(s) resurveying the exclusion area, to observe for effected marine birds as well as fish. Observations will be recorded and any observed injury or mortality of protected species will be documented and reported to the appropriate regulatory agency as soon as is practical.

2. Procedures for different charge sizes:

    a. E3 charge size (charges > 0.5 to 2.5 pounds net explosive weight):

        i. 400 yard exclusion zone will be established for all marine birds (charges will not be initiated if any marine birds are observed within this area).

        ii. Two monitoring boats with two observers onboard each boat will be utilized; observers will be in addition to the boat driver, who also assists in observing the general area.

    b. < E1 charge size (charges 1 ounce net explosive weight or less):

        i. 100 yard exclusion zone will be established for all marine birds (charges will not be initiated if any marine birds are observed within this area).

        ii. One monitoring boat with two observers onboard will be utilized; observers will be in addition to the boat driver, who also assists in observing the general area.

3. Protective measure specific to the Crescent Harbor training site: The training site for underwater detonations in Crescent Harbor has been located 1,000 meters from the closest point of land to avoid nearshore fish habitat areas.

5.7.1 <u>NMFS Final Biological Opinion Terms and Conditions</u>

NMFS finalized their Opinion on the proposed action on November 9, 2015. The following Terms and Conditions (T&Cs) from the NMFS may also minimize adverse effects to bull trout, marbled murrelets, or short-tailed albatross to varying degrees:

1. The Navy shall accomplish the following monitoring for take of fish during underwater detonations (EOD activities) in the inshore areas:

    a. To the extent practicable, minimize potential effects of underwater detonations by scheduling training and testing events during periods of the year when salmonid abundance is lowest.

    b. Survey underwater detonation areas prior to each event to inform “go”, “no go” decisions and to minimize the potential for interactions with ESA-listed species. Surveys should attempt to confirm the absence of salmonids and/or indicators of the presence of salmonids in the mitigation zone. The Navy should employ visual observations from boats, and other available technology to detect fish and other indicators consistent with standard operating procedures and as deemed practicable.

c. After each explosion or at the conclusion of multiple explosion events, survey the impact area and areas immediately downstream to detect possible injured or killed salmonids. If injured or killed fish are detected, consistent with standard operating procedures and safety, try to determine the species affected and estimate the number of adult and juvenile fish.

d. Prepare a report of compliance after each EOD event.

e. Compile and provide hydrophone data from underwater detonation events to verify assumptions used in the derivation of ranges to effects to fish from explosives. If there is sufficient data to make conclusions on ranges to effect from all source classes (NEW) this condition will be met. If not, continue to collect measurements of received sound levels at various distances from the source using hydrophones and other appropriate devices as needed.

The Service determined that the conservation measures in the NMFS Opinion would not be very effective in reducing adverse effects to Service-listed species for the following reasons:

Regarding T&C 1.a – In previous Navy consultations on NWTT activities, the Navy has stated that the schedule of EOD training is based on vessel and personnel deployment. Since deployment schedules can change at any time, training must occur when personnel are at installations in Washington. While this T&C may avoid and minimize adverse effects to bull trout if EOD training occurs during the time of year when juvenile salmon, bull trout prey, are found along the nearshore, bull trout are in the marine waters year-round, and the Service analyzed effects of underwater detonations as they would occur at any time. There is no guarantee or assurance that the EOD training would not occur during the time of year when salmon abundance is the lowest.

Regarding T&C 1.b – The Service was unable to attribute any effectiveness or efficiency to this T&C to minimize adverse effects to bull trout. The T&C did not provide any information on how surveys would be conducted or the size of the mitigation zones surveyed. Under the assumption that divers will be used, there is a high probability that listed species could enter the mitigation zone once the divers stopped surveying to exit the water to conduct the underwater detonation. This T&C will provide avoidance and minimization measures when new technology allows for better fish identification.

Regarding T&C 1.e – This T&C will help determine the accuracy of the Service's analysis. The Navy provided the distances to effects thresholds based off of past acoustic monitoring and published documents. This T&C will verify that these distances were accurate and therefore, the exposure analysis to both bull trout and marbled murrelets.

6 ACTION AREA

The action area is defined as all areas to be affected directly or indirectly by the federal action and not merely the immediate area involved in the action (50 CFR 402.02). In delineating that action area, we evaluated the farthest reaching physical, chemical, and biotic effects of the action on the environment. The action area for this proposed federal action is based on the geographic extent of underwater and in-air sound and the distance that floating debris (specifically plastics) will travel. The vast majority of floating debris from the Navy activities is expected to travel north on the Alaska Current and become part of the North Pacific Subartic Gyre, and to a lesser degree, travel south to the Eastern Garbage Patch off the coast of California. Sound from some sources may travel beyond the immediate area in all directions from the Offshore Area in the Navy's project area.

The Navy's training and testing activities occur in three subunits of the action area: 1) the offshore component (Offshore Area Subunit); 2) the inland waters of Puget Sound (Inland Waters Subunit), and 3) the Olympic MOA Subunit on the Olympic Peninsula. These are described below. The Navy used these three subunits as their National Environmental Policy Act (NEPA) action area and analyzed the effects of the NWTT activities within these areas. However, for the purposes of Section 7 consultation under the ESA, the action area is based on the maximum extent of the direct and indirect effects of the action on the environment, which is an area larger than that identified by the Navy for their NEPA documentation.

6.1 Offshore Area Subunit

The Offshore Area includes, in part, the air, surface, and subsurface operating areas of the Navy's offshore activities extending west from the coastline of Washington, Oregon, and Northern California for a distance until increased sound levels attenuate to background levels off the coastline, including southern Washington, Oregon, and Northern California (Figure 2). The Offshore Area Subunit includes the coastline along the Washington coast beneath the airspace of Warning Area 237 (W-237) and the Washington coastline north of the Olympic MOAs. There is no ceiling to the airspace of the Offshore Area Subunit except for that described below for the Special Use Airspace.

The Offshore Area Subunit also includes the northern Pacific Ocean extending from the coast of Washington to the south shores of the Aleutian Islands of Alaska. This part of the Subunit is also defined by the distance that floating debris will travel. Main Pacific Ocean currents travel east and split along the western coast of North America. The northern Alaska current could carry material to the Subartic Gyre and the southern California Current carries material to the North Pacific Gyre. Military debris from the Navy training and testing activities can travel both north and south.

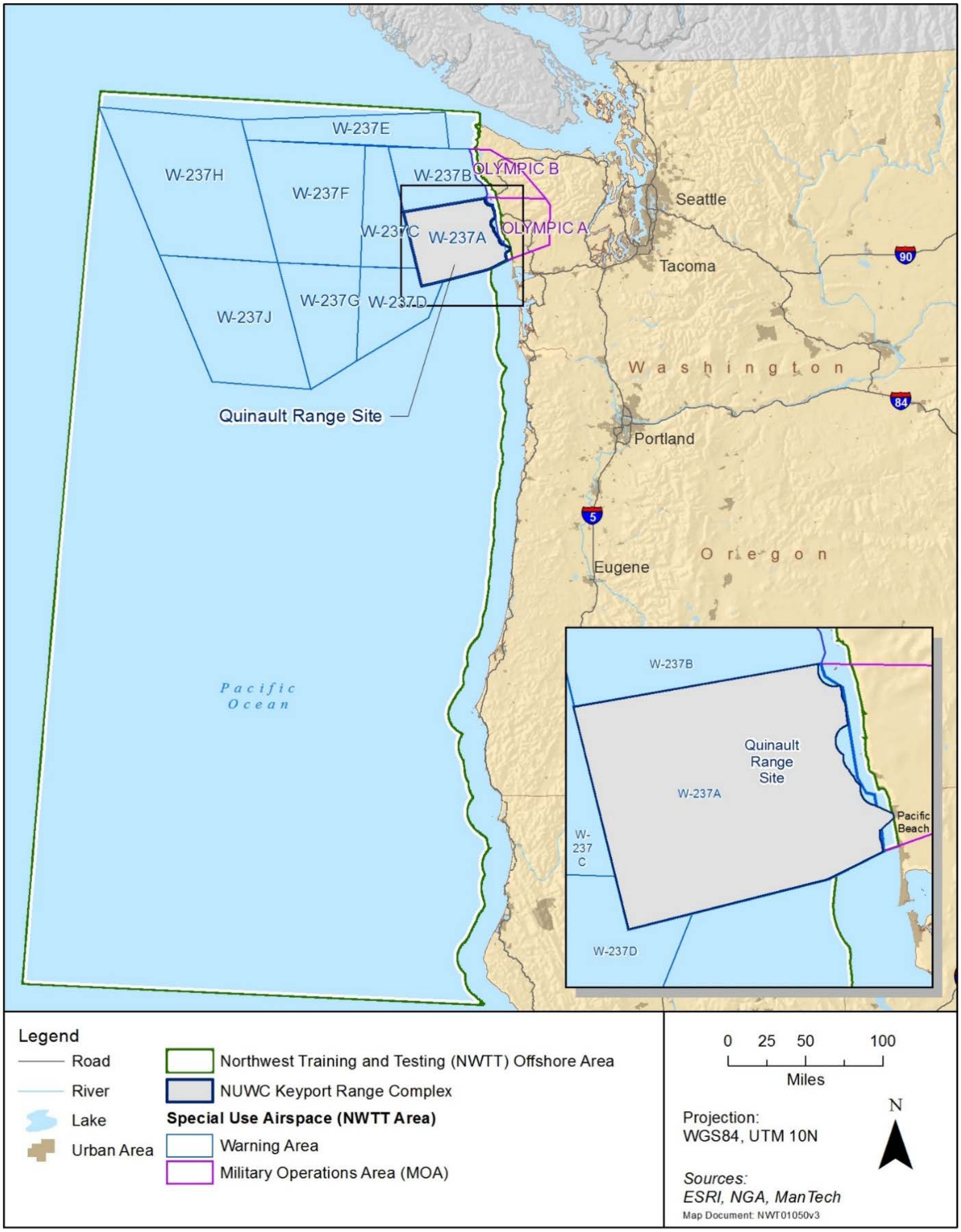

Figure 2. The Navy's Northwest Training and Testing Offshore Area, part of the action area that includes the northern Pacific Ocean from the Washington coast to the Aleutian Islands of Alaska.

6.1.1 Special Use Airspace

The Special Use Airspace in the Offshore Area (Figure 2) is comprised of W-237, which extends westward off the coast of northern Washington State and is divided into nine sub-areas (A–H and J). The eastern boundary of W-237 lies 3 nm (3.5 miles) off the coast of Washington. The Special Use Airspace of W-237 extends from the ocean surface to the ceiling of the airspace, which varies between 27,000 ft (8,200 m) above Mean Sea Level (MSL) in areas E, H, and J; 50,000 ft (15,200 m) above MSL in areas A and B; and unlimited in areas C, D, F, and G.

The Olympic MOAs Subunit overlays both land (the Olympic Peninsula) and sea (extending to 3 nm off the coast of Washington over the Pacific Ocean). The MOAs lower limit is 6,000 ft (1,800 m) above MSL but not below 1,200 ft above ground level, and the upper limit is up to, but not including, 18,000 ft (5,500 m) above MSL, with a total area of 1,614 square nautical miles (nm^2). Above the Olympic MOAs is the Olympic Air Traffic Control Assigned Airspace, which is under the control of the Federal Aviation Administration. This airspace has a floor coinciding with the Olympic MOAs ceiling. The controlled airspace has an upper limit of 35,000 ft (10,700 m) above MSL.

6.1.2 Sea and Undersea Space

The Offshore Area includes sea and undersea space approximately 510 nm (586.9 miles) in length from the northern boundary at the mouth of the Strait of Juan de Fuca to the southern boundary at the northern boundary of Mendocino County in northern California, and 250 nm (287.7 miles) in length from the coastline of northern California, Oregon, and Washington. Total surface area of the Offshore Area is approximately 121,000 nm^2 (160,500 $miles^2$). The Offshore Area extends to the shoreline only along the northern portion of the Washington coast, and is 12 nm (13.8 miles) from the coastline from the southern boundary of the Olympic MOAs to Northern California. The size of the area and its extension south off the coast of Northern California provides valuable training and testing space for ships and submarines transiting between the Pacific Northwest and Southern California.

Within the boundaries of the Offshore Area lies the QRS (Figure 2), a defined area of sea space where training and testing is conducted. The QRS coincides with the boundaries of W-237A and also includes a surf zone component. The surf zone component extends north to south for 5 nm (5.7 miles) along the eastern boundary of W-237A, approximately 3 nm (3.5 miles) to shore along the mean lower low water line, and encompasses 1 mile (1.6 km) of shoreline at Pacific Beach, Washington. Surf-zone activities would be conducted from an area on the shore and seaward.

6.2 Inland Waters Subunit

The Inland Waters Subunit includes air, sea, and undersea space inland of the Pacific coastline, from buoy "J" at 48° 29.6 N, 125° W eastward, including the Strait of Juan de Fuca and Puget Sound. Within the Inland Waters are specific geographic components in which most Inland Waters training and testing occur. Some training activities could occur within Puget Sound, outside the separate component areas described below and depicted in Figure 3.

6.2.1 Air Space

Restricted Area 6701 (R-6701, Admiralty Bay) is a restricted area over Admiralty Bay, Washington, with a lower limit at the ocean surface and an upper limit of 5,000 ft MSL. This airspace covers a total area of 56 nm^2. Chinook A and B MOAs are 56 nm^2 of airspace south and west of Admiralty Bay. The Chinook MOAs extend from 300 ft to 5,000 ft MSL. The sea and undersea area below R-6701 is categorized as Navy 7 (Figure 3).

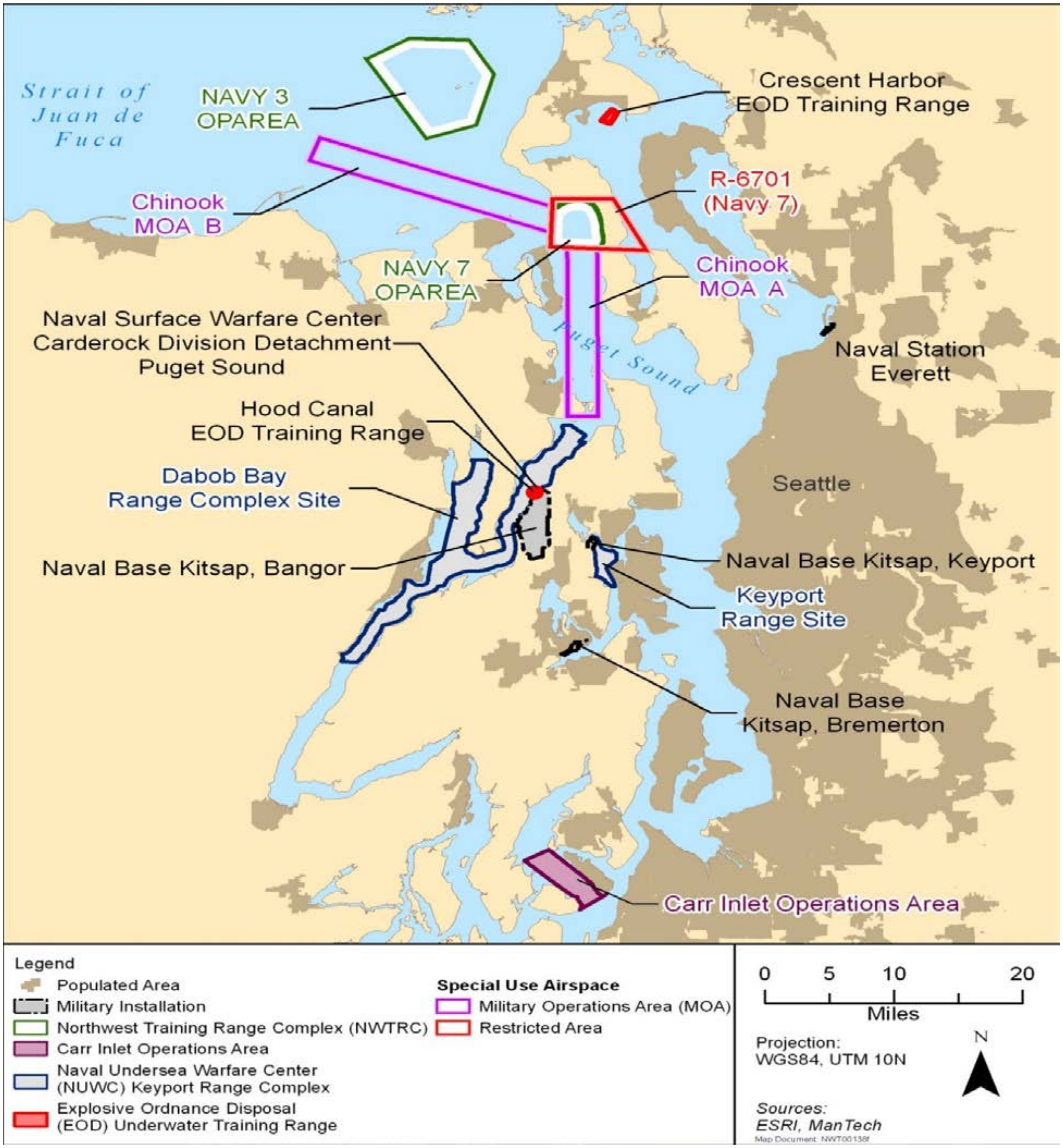

Figure 3. Northwest Training and Testing Inland Waters Areas. These areas are part of the Inland Waters Subunit, and include Puget Sound, Hood Canal, and the Strait of Juan de Fuca.

6.2.2 Sea and Undersea Space

The sea and undersea space of the Inland Waters Subunit includes 1) Explosive Ordnance Disposal Ranges; 2) Surface and Subsurface Testing Sites; 3) Pierside Facilities and Installations; and 4) Surface Operations Areas. These portions of the action area are described below.

6.2.2.1 Explosive Ordnance Disposal Training Ranges

Two active EOD ranges, also used for swimmer training in Mine Countermeasures, are located in the Inland Waters at the following locations (Figure 3):

- NAVBASE Kitsap Bangor – Hood Canal EOD Training Range
- Naval Air Station (NAS) Whidbey Island – Crescent Harbor EOD Training Range

6.2.2.2 Surface and Subsurface Testing Sites

There are three geographically distinct range sites in the Inland Waters where the Navy conducts surface and subsurface testing and some limited training.

1. Keyport Range Site - Located in Kitsap County and includes portions of Liberty Bay and Port Orchard Reach (also known as Port Orchard Narrows). The Keyport Range Site is located adjacent to NAVBASE Kitsap Keyport, providing approximately 3.2 nm^2 (4.2 $miles^2$) for underwater testing, including in-shore shallow water sites and a shallow lagoon to support integrated undersea warfare systems and vehicle maintenance and engineering activities. Water depth at the Keyport Range Site is less than 100 ft (30 m).

2. Dabob Bay Range Complex Site - Located in Hood Canal, in Jefferson, Kitsap, and Mason counties. The DBRC Site includes Dabob Bay and Hood Canal from 1 mile (1.6 km) south of the Hood Canal Bridge to the Hamma Hamma River, a total area of approximately 45.7 nm^2 (60.6 $miles^2$).

    a. Dabob Bay Tracking Range – Dabob Bay is a deep-water area approximately 14.5 nm^2 (19.2 $miles^2$) in size. The Dabob Bay acoustic tracking space is approximately 7.3 nm (8.4 miles) by 1.3 nm (1.5 miles) (9 nm^2, 11.9 $mile^2$) with a maximum depth of 600 ft (182.9 m). The Dabob Bay tracking range, the only component of the DBRC Site with extensive acoustic monitoring instrumentation installed on the seafloor, provides for object tracking, communications, passive sensing, and target simulation. Many activities conducted within Dabob Bay are supported by land-based facilities at Zelatched Point.

3. Carr Inlet Operating Area (OPAREA) - Located in southern Puget Sound. The Carr Inlet OPAREA is a quiet, deep-water inland range approximately 12 nm^2 (15.9 $miles^2$) in size. It is located in an arm of water between Key Peninsula and Gig Harbor Peninsula. Its southern end is connected to the southern basin of Puget Sound. Northward, Carr Inlet OPAREA separates McNeil Island and Fox Island as well as the Key and Gig Harbor peninsulas. The acoustic tracking space within the range is approximately 6 nm (6.9 miles) by 2 nm (2.3 miles) with a maximum depth of 545 ft (166 m). While no permanently installed structures are present in the Carr Inlet OPAREA, the waterway remains a Naval Restricted Area (33 C.F.R. § 334.1250).

6.2.2.3 Pierside Facilities

Most of the NWTT training and testing activities occur in established training and testing ranges; however, the Navy conducts some testing at or near Navy piers. The Navy piers include:

- NAVBASE Kitsap Bremerton in Sinclair Inlet
- NAVBASE Kitsap Bangor Waterfront in Hood Canal, and
- Naval Station Everett.

6.2.2.4 Surface Operations Areas

- Two surface and subsurface areas are located northwest and west of Whidbey Island:
- Navy 3 OPAREA
- Navy 7 OPAREA - Lies beneath R-6701.

6.3 Olympic Military Operations Areas Subunit

The Olympic MOAs Subunit includes the Pacific Northwest EW Range located on Navy, Forest Service, and Washington State Department of Natural Resources lands in the Olympic Peninsula (Figure 2). Activities include the use of mobile signal emitter vehicles at designated sites located along existing logging roads on Forest Service lands within the Olympic MOA. There will also be overflights for Electronic Warfare activities and Air Combat Maneuvers.

7 ANALYTICAL FRAMEWORK FOR THE JEOPARDY DETERMINATIONS

7.1 Jeopardy Determination

The following analysis relies on the following four components: 1) the *Status of the Species*, which evaluates the rangewide condition of the listed species addressed, the factors responsible for that condition, and the species' survival and recovery needs; 2) the *Environmental Baseline*, which evaluates the condition of the species in the action area, the factors responsible for that condition, and the relationship of the action area to the survival and recovery of the species; 3) the *Effects of the Action*, which determines the direct and indirect impacts of the proposed federal action and the effects of any interrelated or interdependent activities on the species; and 4) *Cumulative Effects*, which evaluates the effects of future, non-federal activities in the action area on the species.

In accordance with policy and regulation, the jeopardy determination is made by evaluating the effects of the proposed federal action in the context of the species' current status, taking into account any cumulative effects, to determine if implementation of the proposed action is likely to cause an appreciable reduction in the likelihood of both the survival and recovery of listed species in the wild.

The jeopardy analysis in this Opinion emphasizes the rangewide survival and recovery needs of the listed species and the role of the action area in providing for those needs. It is within this context that we evaluate the significance of the proposed federal action, taken together with cumulative effects, for purposes of making the jeopardy determination.

For species with final Recovery Plans, the Service's consultation handbook (USFWS and NMFS 1998) provides the following additional guidance: "When an action appreciably impairs or precludes the capacity of a recovery unit from providing both the survival and recovery function assigned to it, that action may represent jeopardy to the species." If a Recovery Plan establishes Recovery Units, our analysis considers the relationship of the Recovery Unit to both the survival and recovery of the listed species as a whole.

8 STATUS OF THE SPECIES - RANGEWIDE

8.1 Bull Trout

The bull trout was listed as a threatened species in the coterminous United States in 1999. Throughout its range, the bull trout is threatened by the combined effects of habitat degradation, fragmentation, and alteration (associated with dewatering, road construction and maintenance, mining, grazing, the blockage of migratory corridors by dams or other diversion structures, and poor water quality), incidental angler harvest, entrainment, and introduced non-native species (64 FR 58910 [Nov. 1, 1999]). Since the listing of bull trout, there has been very little change in the general distribution of bull trout in the coterminous United States, and we are not aware that any known, occupied bull trout core areas have been extirpated (USFWS 2015c, p. iii).

The 2015 recovery plan for bull trout identifies six recovery units of bull trout within the listed range of the species (USFWS 2015c, p. 34). Each of the six recovery units are further organized into multiple bull trout core areas, which are mapped as non-overlapping watershed-based polygons, and each core area includes one or more local populations. Within the coterminous United States we currently recognize109 currently occupied bull trout core areas, which comprise 600 or more local populations (USFWS 2015c, p. 34). Core areas are functionally similar to bull trout metapopulations, in that bull trout within a core area are much more likely to interact, both spatially and temporally, than are bull trout from separate core areas.

The Service has also identified a number of marine or mainstem riverine habitat areas outside of bull trout core areas that provide foraging, migration, and overwinter (FMO) habitat that may be shared by bull trout originating from multiple core areas. These shared FMO areas support the viability of bull trout populations by contributing to successful overwintering survival and dispersal among core areas (USFWS 2015c, p. 35).

For a detailed account of bull trout biology, life history, threats, demography, and conservation needs, refer to Appendix C: Status of the Species: Bull Trout.

8.2 Marbled Murrelet

Murrelet populations have declined at an average rate of 1.2 percent per year since 2001. The most recent annual population estimate for the entire NWFP area ranged from about 16,600 to 22,800 murrelets during the 14-year period, with a 2013 estimate of 19,700 murrelets (95 percent confidence interval [CI]: 15,400 to 23,900 birds) (Falxa and Raphael 2015, p.7). While the overall trend estimate was negative (-1.2 percent per year), this trend was not conclusive because the confidence intervals for the estimated trend overlap zero (95 percent CI:-2.9 to 0.5 percent), indicating the murrelet population may be declining, stable, or increasing at the range-wide scale (Falxa and Raphael 2015, pp. 7-8). Annual reports with population estimates have been released since the 2015 report by Falxa and Raphael (2015); however, these reports did not also provide trend information. Therefore, some of the data cited in this Opinion was used to predict current abundance of murrelets based on the most recent population abundance estimates, but the trend information from previous reports (Falxa and Raphael 2015) was used to predict future population estimates over the duration of this Opinion (20 years). Due to funding restrictions, the NWFPEM will only collect a complete sampling data set every other year, meaning rangewide population and trend information will only be available every other year.

Murrelet population size and marine distribution during the summer breeding season is strongly correlated with the amount and pattern (large contiguous patches) of suitable nesting habitat in adjacent terrestrial landscapes (Falxa and Raphael 2015, p. 156). Monitoring of murrelet nesting habitat within the NWFParea indicates nesting habitat has declined from an estimated 2.53 million acres in 1993 to an estimated 2.23 million acres in 2012, a total decline of about 12.1 percent (Falxa and Raphael 2015, p. 89). The largest and most stable murrelet subpopulations now occur off the coast of Oregon and northern California, while subpopulations in Washington have experienced the greatest rates of decline (-5.1 percent per year; 95 percent CI: -7.7 to -2.5 percent) (Falxa and Raphael 2015, p. 8-11). Rates of nesting habitat loss have also been highest in Washington, primarily due to timber harvest on non-Federal lands (Falxa and Raphael 2015, p. 124), which suggests that the loss of nesting habitat continues to be an important limiting factor for the recovery of murrelets.

Factors affecting murrelet fitness and survival in the marine environment include: reductions in the quality and abundance of murrelet forage fish species through overfishing and marine habitat degradation; murrelet by-catch in gillnet fisheries; murrelet entanglement in derelict fishing gear; oil spills; and high levels of underwater sound pressure generated by pile-driving and underwater detonations (USFWS 2009a, pp. 27-67). While all of these factors are recognized as stressors to murrelets in the marine environment, the extent that these stressors affect murrelet populations is unknown (USFWS 2012b). As with nesting habitat loss, marine habitat degradation is most prevalent in the Puget Sound area where anthropogenic activities (e.g., shipping lanes, boat traffic, shoreline development) are an important factor influencing the marine distribution and abundance of murrelets in Conservation Zone 1 (Falxa and Raphael 2015, p. 163).

For a detailed account of marbled murrelet biology, life history, threats, demography, and conservation needs, refer to Appendix D: Status of the Species: Marbled Murrelet.

8.3 Short-tailed Albatross

The range-wide population of the short-tailed albatross has been growing steadily. Based on surveys at the breeding colonies on Torishima, the three-year running average of the population growth rate between 2000 and 2013 ranges from 5.2 to 9.4 percent (USFWS 2014, p. 9). To date, conservation efforts have largely focused on addressing the threats of habitat alteration and loss due to catastrophic events and commercial fishing. Less effort has been invested to alleviate threats to short-tailed albatross from climate change, ocean regime shift, and contaminants including plastics.

Over three-quarters of the breeding population of short-tailed albatross nest on Torishima (USFWS 2014, p. 3). There have been volcanic eruptions on Torishima that have killed large numbers of birds and destroyed nesting habitat (Austin Jr 1949, p. 288). It is estimated that a volcanic eruption on Torishima in the near future could kill as much as 54 percent of the world's population of short-tailed albatross (USFWS 2008b, p. 17). Conservation strategies for short-tailed albatross emphasize the importance of establishing breeding colonies on other islands to hedge against losing a large proportion of short-tailed albatross from a single catastrophic event (USFWS 2008b). By-catch of short-tailed albatross by commercial fisheries continues to be a major conservation concern; efforts to address the threat are primarily focused on raising awareness and use of seabird deterrents in the industry (USFWS 2014, p. 15).

The training and testing area along the west coast of the United States is used by juvenile and sub-adult short-tailed albatross. As birds age they appear to spend more time in other parts of the species range, especially in the marine waters of Alaska and the Aleutian Islands. The action area does not include any current breeding habitat for short-tailed albatross.

For a detailed account of short-tailed albatross biology, life history, threats, demography, and conservation needs, refer to Appendix E: Status of the Species: Short-tailed Albatross.

9 ENVIRONMENTAL BASELINE

Regulations implementing the ESA (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.

As described in the Action Area section above, the Navy proposes to conduct training and testing activities in three areas: Offshore Area, Inland Waters, and the Olympic MOAs. The Environmental Baseline section is organized by species and discusses exposure in the areas where the species presence is anticipated. First, we discuss bull trout within the Offshore Area and Inland Waters Subunit. Second, we discuss the status of marbled murrelets in the Offshore Area, Inland Waters Subunit, and the Olympic MOAs. Lastly, we describe the status of the short-tailed albatross in the Offshore Area.

9.1 Status of Bull Trout in the Action Area

9.1.1 Offshore Area

The marine waters off the western coast of Washington State provides important FMO habitat for anadromous subadult and adult bull trout. The marine habitat provides important FMO habitat located outside of the three core areas of the Olympic Peninsula: Hoh River, Queets River, and Quinault River core areas.

Migratory bull trout use nonnatal watersheds (habitat located outside of their spawning and early rearing habitat) to forage, migrate, and overwinter (Brenkman and Corbett, in litt. 2003a,b in USFWS 2004). Marine waters, including coastal rivers, estuaries, and nearshore waters, provide access to productive foraging areas and to protected overwintering areas. Coastal FMO habitat is important to bull trout along the Olympic Peninsula for maintaining diversity of life history forms and for providing access to productive foraging areas (USFWS 2004).

Bull trout have been documented in tributaries west of, and including, the Satsop River in the lower Chehalis River basin (Mongillo 1993). Bull trout are reported historically from the Satsop, Wynoochee, Wishkah, and Humptulips Rivers, but not from the Hoquiam River; information to describe presence in the Hoquiam River is considered a research need (USFWS 2004). Bull trout were reported from Grays Harbor surveys conducted between 1966 and 1981 (Jeanes et al. 2003), but not from surveys conducted between 1981 and 2001. In 2002, beach seine surveys specifically targeting bull trout succeeded in locating the species in Grays Harbor (Jeanes et al. 2003).

Bull trout foraging and migrating in the action area (surf zone area at Pacific Beach) are most likely from the Quinault, Queets, and/or Hoh River core areas. The Quinault, Queets, and Hoh River core areas support five distinct bull trout local populations. The Quinault, Queets, and Hoh River core areas play a critical role in the conservation and recovery of bull trout, since each core area is vital to maintaining the overall distribution and genetic diversity of bull trout within the Coastal Recovery Unit (USFWS 2004).

Each of the bull trout life history forms are believed to be represented within the Quinault, Queets, and Hoh River core areas. However, current information is inadequate for determining the status of the local populations, the locations of most of the actual spawning sites, and the extent to which bull trout of these core areas use nonnatal watersheds (USFWS 2004). Adult and subadult bull trout may use that surf zone area of the action area at any time of year. However, an estimate of the number of bull trout that forage, migrate, and overwinter in the action area is not available. The Service expects that low numbers of bull trout are likely to forage, migrate, and overwinter in the surf zone area of the action area. The Service does not expect bull trout to use the action area located 3 miles or more off the coast of Washington.

9.1.2 Inland Waters Subunit

The Inland Waters Subunit includes all of Puget Sound, including Hood Canal.

9.1.2.1 Hood Canal

Based on historic observations (1980's) in the Duckabush, Quilcene, and other nearby rivers and estuaries entering Hood Canal from the west, we expect that very few bull trout occur near the Hood Canal EOD Training Range site (Brenkman and Corbett 2007; Brenkman and Corbett 2005; Goetz et al. 2004; Goetz et al. 2007). These rivers are approximately 8 miles west of the Hood Canal EOD Training Range site. The closest population of bull trout in Hood Canal is in the Skokomish River located 33 miles to the south of Hood Canal EOD Training Range site. Hood Canal, especially the western shore, has been identified as an important foraging, migration, and overwintering habitat for bull trout and would likely be used as the Skokomish River core population increases in abundance (FWS 2004 volume II p. 66).

Fluvial and, potentially, anadromous bull trout are present in the South Fork Skokomish River local population. Although there may be a residual expression of anadromy in the South Fork population, there are currently no indications or data that suggests that individuals are entering the marine environment. The North Fork Skokomish River local population has been isolated above Cushman No.1 and No 2 dams for over a century, but as a result of a recent settlement agreement, Tacoma Power is in the process of restoring fish passage to the North Fork. If fish passage efforts are successful, there is a potential that the anadromous life history form of bull trout could become more prevalent in the future. However, habitat degradation of nearshore foraging, migration, and overwintering habitat from natural and human sources (Brennan 2007; Goetz et al. 2004; PSAT (Puget Sound Action Team) 2007; Puget Sound Partnership 2008; Puget Sound Water Quality Action Team 2002) and the distance from the Skokomish River, is still likely to limit bull trout occurrence near the Hood Canal EOD Training Range site.

9.1.2.2 Puget Sound

Bull trout are distributed throughout most of the large rivers within Puget Sound, with the exception of the Nisqually River, where only a few observations have been reported (USFWS 2004, p. 46). Anadromous bull trout require access to marine waters, estuaries, and lower reaches of rivers to forage and overwinter (USFWS 2004, p. 134). It is believed that some level of mixing and interaction within marine waters occurs among anadromous individuals from the various core areas identified in Puget Sound. While bull trout occasionally migrate as far south in Puget Sound as the Nisqually River, the Service's recovery plan indicates the current distribution of listed bull trout extends from the Canadian border to Commencement Bay and the eastern shores of Puget Sound (USFWS 2004, p. 135). Bull trout use of Puget Sound south of the Tacoma Narrows and along the western shore (e.g., Vashon and Bainbridge Islands), is expected to be rare or extremely unlikely.

The Inland Waters Crescent Harbor EOD Training Range and Naval Station Everett include the marine portion of the bull trout Coastal Recovery Unit (RU). Bull trout from three core areas in watersheds that drain into marine waters of Puget Sound are most likely to utilize the action areas. Core areas represent the closest approximation of a biologically functioning unit for bull trout (USFWS 2002, p. 98). Core areas consist of habitat that supplies all the necessary elements for all life stages 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 RU. Bull trout present in the Crescent Harbor action area are expected to be from the Lower Skagit, Stillaguamish, and the Snohomish/Skykomish River Core Areas (Appendix F). Bull trout present at Naval Station Everett would be primarily from the Snohomish/Skykomish River core area. Unique to the Coastal RU, 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, sub-adult, and adult bull trout utilize marine waters of the action area for foraging, migration, and overwintering. In two telemetry studies documenting the extent of anadromy in bull trout within portions of the Coastal RU, approximately 55 percent of the fish tagged in freshwater emigrated to saltwater (Brenkman and Corbett 2005; Goetz et al. 2007). Results from these studies also demonstrate that anadromous bull trout inhabit a diverse range of estuarine, freshwater, and marine habitats.

Marine waters provide important habitat for anadromous bull trout for extended periods of time. Data for bull trout from Puget Sound indicate that the majority of anadromous bull trout tend to migrate into marine waters in the spring and return to rivers in the summer and fall period. Although much less frequent, tagged fish have been detected in Puget Sound nearshore marine waters during December and January, which indicates that some fish remain in marine waters during the winter (Goetz et al. 2007; USGS 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 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; USGS 2008). Upon entering marine waters, bull trout can make extensive, rapid migrations, usually in nearshore marine areas. However, bull trout have also been tracked crossing Puget Sound at depths greater than 183 m (600 ft) (Goetz et al. 2012).

During the majority of their marine residency, anadromous bull trout have been found to occupy territories ranging in size from approximately 10 m to more than 3 km within 100 to 400 m of the shoreline (USGS 2009). Aquatic vegetation and substrate common to bull trout marine habitat include eelgrass, green algae, sand, mud, and mixed fine substrates. Forage fish occurrence is also correlated with these habitat features. Bull trout prey on surf smelt (*Hypomesus pretiosus*), Pacific herring (*Clupea pallasii*), Pacific sand lance (*Ammodytes hexapterus*), and other small schooling fish (Kraemer 1994).

Some level of mixing or interaction within marine waters occurs among anadromous individuals from various core areas and bull trout from several core areas may be present in the action area simultaneously (Brenkman and Corbett 2007; Brenkman and Corbett 2005; Goetz et al. 2004; Goetz et al. 2007). We expect that bull trout from the Stillaguamish, Snohomish/Skykomish, and Lower Skagit Rivers could occur in the action area. The status of each of these core areas are discussed in Appendix F.

Bull trout have been captured in marine waters surrounding the Crescent Harbor EOD Range Site. In Penn Cover and Utsalady Bay, twenty bull trout were caught using beach seines from June 1974 to July 1975 (Goetz et al. 2004). Two bull trout were captured on May 10, 2002, during intertidal beach seining activities at the outlet of the tidegate in Crescent Harbor (Beamer 2003). These bull trout were 505 mm (19.8 inches) and 610 mm (24.0 inches) in length. 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 inches) was caught on April 29, 2002 (Heatwole, pers. comm. 2003). These samples, and the fact that bull trout migrate over deep waters (Goetz et al. 2012), indicate that bull trout may utilize Crescent Harbor, and may be exposed to project-related stressors.

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 Crescent Harbor 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 those bull trout populations are smaller, because of their migratory behavior, bull trout from these rivers may also use the Crescent Harbor action area.

At Naval Station Everett, (approximately 2.5 miles south of the mouth of the Snohomish River), anadromous bull trout would originate primarily from the Snohomish/Skykomish core area. Bull trout migrating out of the Snohomish River may also move through Steamboat and Union Sloughs and may or may not pass by Naval Station Everett. Bull trout abundance within the Snohomish and Skykomish Rivers is estimated to be between 1000 and 2500 individuals (USFWS 2008a, p. 35). The anadromous portion (55 percent) of the bull trout abundance would be approximately 550 to 1,375 individuals.

9.1.2.3 Factors Affecting the Bull Trout Within the Inland Waters Subunit

9.1.2.3.1 Crescent Harbor EOD Training Range Site

The Crescent Harbor portion of the 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 °C in the summer and 7 to

10 °C 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 within the Crescent Harbor portion of the 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 exist along the NAS Whidbey Island shoreline in Crescent and Oak Harbors. Extensive tidelands occur throughout much of the area; however, tidelands in some areas have been modified by dredging, armoring, and the construction of piers, docks, and boat ramps.

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

Most of Crescent Harbor is surrounded by rural areas with low human population densities and agriculture is the predominant land use. 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. Shoreline development as a result of urbanization, residential, and erosion are threats to bull trout within the Crescent Harbor portion of the action area.

The Navy establishes safety zones to exclude 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. These diving operations are conducted for a number of purposes, including proficiency training with diving systems, locating underwater objects, maintaining personnel qualifications, practicing emergency procedures, and placing explosives for the underwater detonation activities.

Forage fish occurring in the Crescent Harbor portion of the action area include surf smelt, Pacific herring, and sand lance. These species spawn in multiple locations in and around Crescent Harbor (Figure 4). Surf smelt spawn in two locations in Crescent Harbor, and throughout Oak Harbor (Harbor west of Crescent Harbor), Penn Cove, and along the north and west shores of Camano Island. Sand lance spawn in the same general locations as surf smelt, but the spawning grounds are much smaller. The nearest Pacific herring spawning location is at Snakelum Point, southwest of Crescent Harbor.

The Skagit Bay herring stock is currently one of the larger stocks in Puget Sound. A pre-spawn holding area is located in a passage just outside of Crescent Harbor (Figure 4) (WDFW 2015). The entire pre-spawn holding area is in the portion of Crescent Harbor that will be affected by the proposed action. Spawning occurs from February to mid-April with peak spawning occurring at the end of February and the beginning of March (Stick et al. 2014, p.38). Spawning biomass is used to estimate overall abundance. From 2008 to 2012, the mean spawning biomass was 738 tons based upon acoustic/trawl surveys. The 2012 stock summary indicates the 2-year stock status is depressed, and data quality is fair (Stick et al. 2014, p. 29).

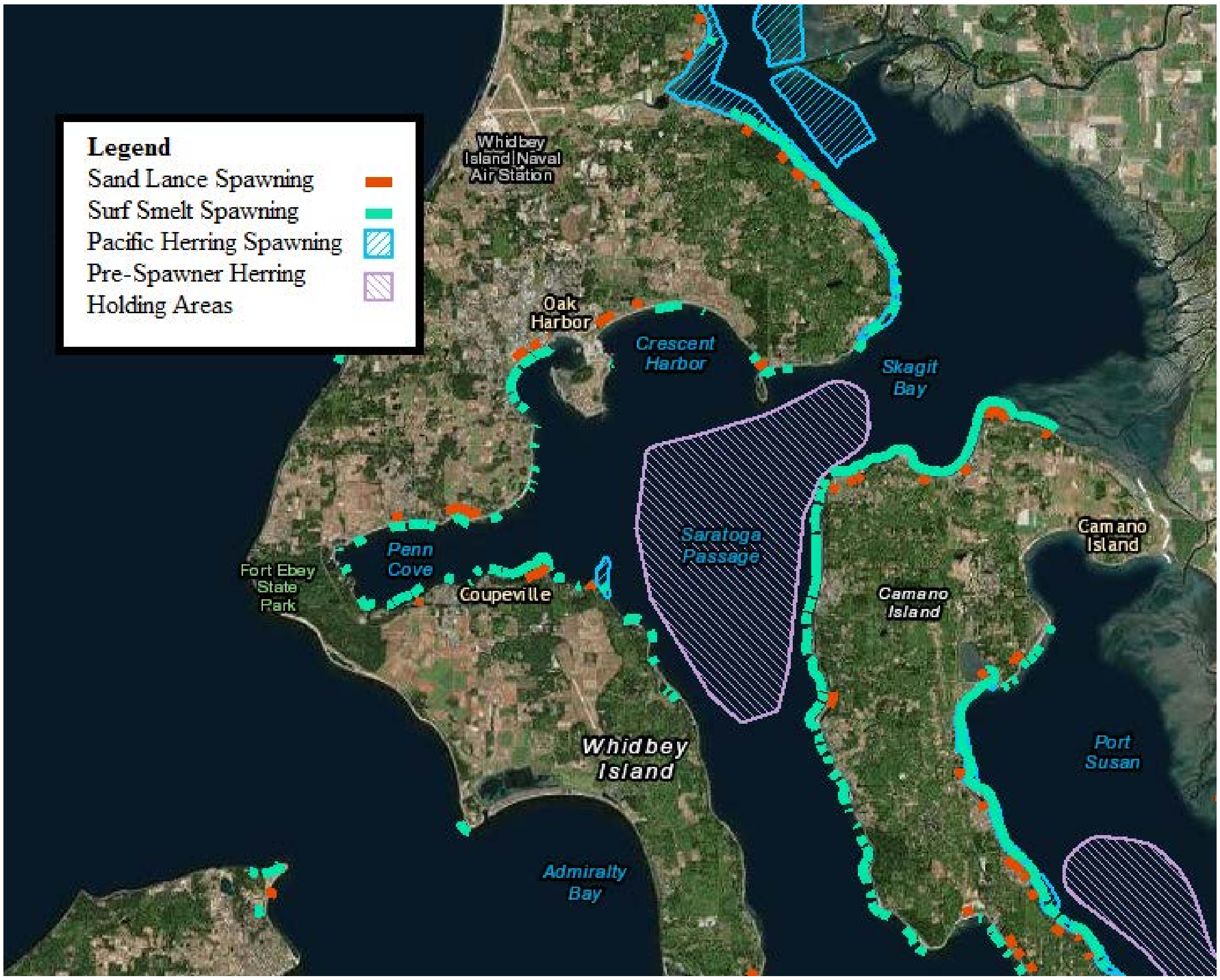

Figure 4. Sand lance, surf smelt and Pacific herring spawning locations and pre-spawn holding area for Pacific Herring within and surrounding Crescent Harbor (WDFW 2015).

Under the Sikes Act, the Navy drafts and implements Integrated Natural Resource Management Plans (INRMPs) to provide for long term planning of natural resources at Navy installations. INRMPs ensure natural resources conservation measures and military operations are integrated and consistent with the military mission. Within the INRMPs, projects are defined to protect, conserve, and manage the waters and improve habitat for listed species at the installation.

Within Crescent Harbor, as part of their INRMP at NAS Whidbey Island, the Navy is studying the presence of ESA-listed species and their habitat through 2022. Ongoing forage fish surveys are occurring to determine presence, location, and timing of forage fish spawning around the installation. At NAS Whidbey Island, eelgrass surveys are conducted as needed to minimize and avoid eelgrass impacts from construction projects.

Under the NAS Whidbey Island INRMP, the Navy has completed two restoration projects to increase habitat for listed salmon species, forage fish, and other prey species. The Crescent Harbor Salt Marsh Restoration Project restored approximately 300 acres and the Maylor Beach Restoration Project restored approximately 2,000 feet of beach area.

9.1.2.3.2 Naval Station Everett

Naval Station Everett has approximately 1.9 miles of shoreline, which is entirely armored with riprap and seawalls (Navy 2015, p. 2-1). Six piers and a marina, totaling 11.5 acres of overwater structure are found at Naval Station Everett. Piers A and B support the bulk of the installation fleet support operations.

The armored shoreline contains habitat that is simplified, with little to no structure for bull trout or their prey species. We expect that bull trout will primarily use the shoreline as a migratory corridor and to forage on prey along the shoreline. The closest documented forage fish spawning area is located approximately 1.1 miles to the south of Naval Station Everett. Jetty Island Park, a 2-mile man-made island located across the Snohomish River for Naval Station Everett, provides habitat for invertebrates and salmonids migrating through the area. Figure 5 indicates the sand lance and surf smelt spawning locations surrounding Naval Station Everett (WDFW 2015). No aquatic vegetation is located in or around Naval Station Everett.

The Navy has conducted fish and forage fish surveys at Naval Station Everett to determine presences of ESA listed species and to document presence and spawning of forage fish.

Water quality in Port Gardner, along Naval Station Everett, is highly influenced by discharge of the Snohomish River, stormwater discharge from the City of Everett, and industrial use of the piers and marinas that exist along the Everett waterfront.

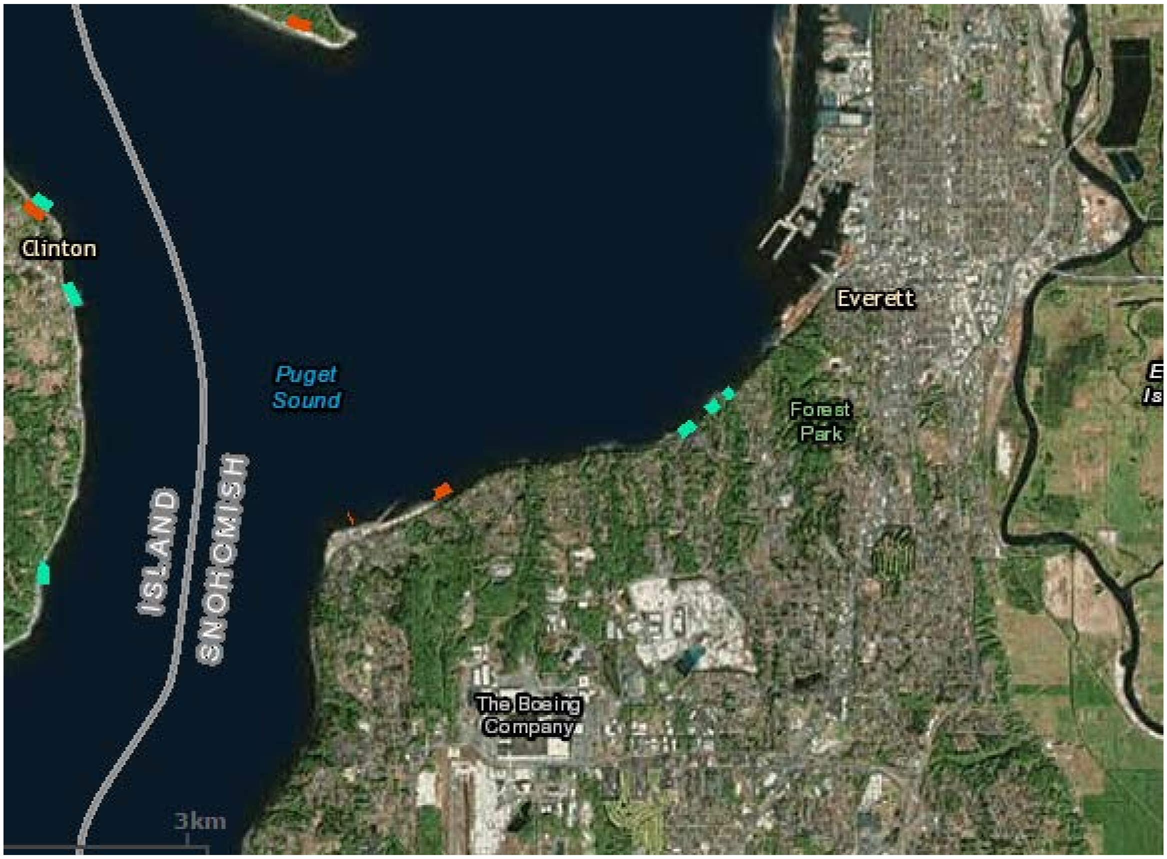

Figure 5. Sand lance and surf smelt spawning locations surrounding Naval Station Everett. (WDFW 2015)

9.1.2.4 Conservation Role of the Crescent Harbor Portion of the Action Area for Bull Trout

The Crescent Harbor EOD Training Range Site and Naval Station Everett are within the Coastal RU. Maintaining viable populations of bull trout is essential to the conservation of species within each of the core areas, the RU, and the conterminous listing. Marine waters of Puget Sound are critical in supporting the bull trout anadromous life history form due to their complex migratory patterns associated with foraging and overwintering (USFWS 2015b, p. A-1, A-4). The marine waters provide important foraging habitat including eelgrass and kelp for prey species such as juvenile salmon, Pacific herring, surf smelt, and sand lance. In addition, the marine environment provides a migratory corridor for bull trout from their natal streams to other locations within Puget Sound or nearby watersheds to forage and overwinter.

In summary, bull trout from three nearby core areas are expected to use the Crescent Harbor and Naval Station Everett portions of the action area year round. Skagit Bay contains shallow water at low tide enabling larger juvenile, sub-adult, and adult bull trout from the Skagit River to migrate to the nearshore of Whidbey Island and Crescent Harbor. The conservation role of the action area will function as foraging, migration, and overwintering habitat necessary for bull trout recovery (USFWS 2004, p. 20). Marine nearshore and estuarine habitats are highly productive due to the complexity of habitats and nutrient inputs (USFWS 2004, p. 43).

The primary threat to the Puget Sound marine area is development and urbanization that degrade or eliminate nearshore marine and estuarine habitats and processes critical to the persistence of the anadromous life history form and their marine prey base. The marine environment, the Crescent Harbor EOD Training Range Site, and Port Gardner are essential to the recovery of bull trout within the three core areas, the Coastal RU, and the coterminous United States.

Similar to NAS Whidbey Island, the Navy at Naval Station Everett, under their INRMP, has conducted fish studies to determine seasonal and resident presence of ESA-listed species and their habitat. The project is ongoing through 2022. Forage fish surveys are ongoing to determine presence, location and timing of forage fish spawning around the installation.

9.2 Status of the Marbled Murrelet in the Action Area

The action area for the proposed action encompasses the marine environment component of the rangewide distribution of the marbled murrelet (Figure 6). As such, please refer to the discussion of the range-wide status of the marbled murrelet presented in Appendix D. The environmental baseline analysis for the marbled murrelet also addresses the relationship of the current condition and conservation role of the action area to marbled murrelet recovery units. The Recovery Plan for the Marbled Murrelet identifies 6 broad “Marbled Murrelet Conservation Zones” across its range. These Conservation zones were assigned recovery goals and objectives (USFWS 1997b, p. 114) and, on that basis, they function as RUs. Their assigned conservation role is to support persistent populations of the murrelet across its range.

Conservation Zones 1 and 2 are within the action area. Conservation Zones 3, 4, and 5 are between the shoreline and the action area, but are not within the action area. However, we expect that activities occurring in the action area offshore of Conservation Zones 3, 4, and 5 could affect marbled murrelets associated with these Zones. Additionally, we expect that individual marbled murrelets from any of the Conservation Zones (1 through 6) could occur in the action area due to the birds’ transient nature.

Murrelets abundance is declining, primarily because of nesting habitat loss and degraded marine habitat conditions, which has led to low reproductive success. The action area includes terrestrial and marine areas that provide both nesting and foraging habitat, and both are considered essential to marbled murrelet survival and recovery.

The information we considered in our exposure analysis is summarized below. This information relates to marbled murrelet occurrence and habitat use in both the marine and terrestrial settings within the action area. The Navy described distances as km and nautical miles (nm). Bird density is typically reported in birds per km^2. Our exposure analysis describes area in marine waters as nm^2. As such, we provide areas in both km^2 and nm^2 to allow easier synthesis of effects and conversion between number of birds present/exposed and the units that describe area of effect.

Telemetry studies indicate that some mixing of marbled murrelet subpopulations between Conservation Zones occurs in Conservation Zones 1 and 2 (Bloxton and Raphael 2006), although further south along the coast, the likelihood of such a mixed population is reduced, but not impossible, during the nesting season. With the possible exception of Zone 6, the Conservation Zones are not necessarily occupied by discrete subpopulations of the marbled murrelet; however, for management and consultation purposes, the Service uses the Conservation Zones as a way to divide and describe marbled murrelet populations into discrete segments that are recognized as Recovery Units for purposes of the jeopardy analyses under section 7(a)(2) of the ESA. We expect there is some movement of individual marbled murrelets between Zones, although there is insufficient telemetry data to quantify the frequency or extent of that movement.

The presence of marbled murrelets at inland sites during the non-nesting season indicates that some birds may stay in the vicinity of a nest site during non-nesting periods. Marbled murrelets within the action area could originate from any of the six Conservation Zones designated for this species in the final recovery plan for the marbled murrelet (USFWS 1997b) (Figure 6).

9.2.1 Marbled Murrelets in the Marine Environment

Much of what we know about marbled murrelet use of the marine environment comes from long-term population trend sampling for to the Northwest Forest Plan's effectiveness monitoring program (NWFPEM). To monitor population trends, the Forest Service conducts an annual census of marbled murrelets at-sea (including the Strait of Juan de Fuca and Puget Sound). The sampling plan subdivides each Conservation Zone into Strata and within each Stratum into smaller Primary Sampling Units (PSUs; Figure 7). Strata are surveyed at the PSU scale. Marbled murrelet densities can then be estimated at the Stratum level, but not at the smaller PSU scale because marbled murrelet occurrence in the marine environment is highly variable. The PSU sampling scheme was carefully designed to provide information about densities at the larger Stratum level, densities that are intended to inform a long-term trend analysis.

The sampling protocol for the NWFPEM is designed to determine long-term marbled murrelet population trends, not to estimate marbled murrelet density. Each PSU is typically sampled only once or twice in a given year, which is inadequate to determine a density estimate at the individual PSU scale unless several years of data are averaged. More appropriate use of the data is to average several years at the stratum level or Conservation Zone level to reduce the amount of error. This results in more accurate estimates of marbled murrelet density. We use density data at the scale of the stratum or Conservation Zone (whichever is most appropriate) to describe the baseline conditions for the marbled murrelet within an action area.

Marbled murrelets are known to consume prey from at least 27 taxa (McShane et al. 2004, p. 5-7). Stomach content analysis is difficult in a threatened seabird, so the most recent studies have relied on at-sea observations of birds holding fish (Day and Nigro 2000; Kuletz 1997, p. 4; McShane et al. 2004; Speckman et al. 2003), and sampling in-situ where foraging occurs (Becker and Beissinger 2003b; Henkel and Harvey 2006; McShane et al. 2004; Ostrand et al. 1998), as well as from use of stable isotopes (Becker 2001). Very little is known about the diet of marbled murrelets south of Alaska and British Columbia. It is believed that their diet north of Washington is dominated by sand lance, herring, and capelin, while in the southern portions of the range it is dominated by northern anchovy, surf/night smelt, and herring (McShane et al. 2004, p. 5-9).

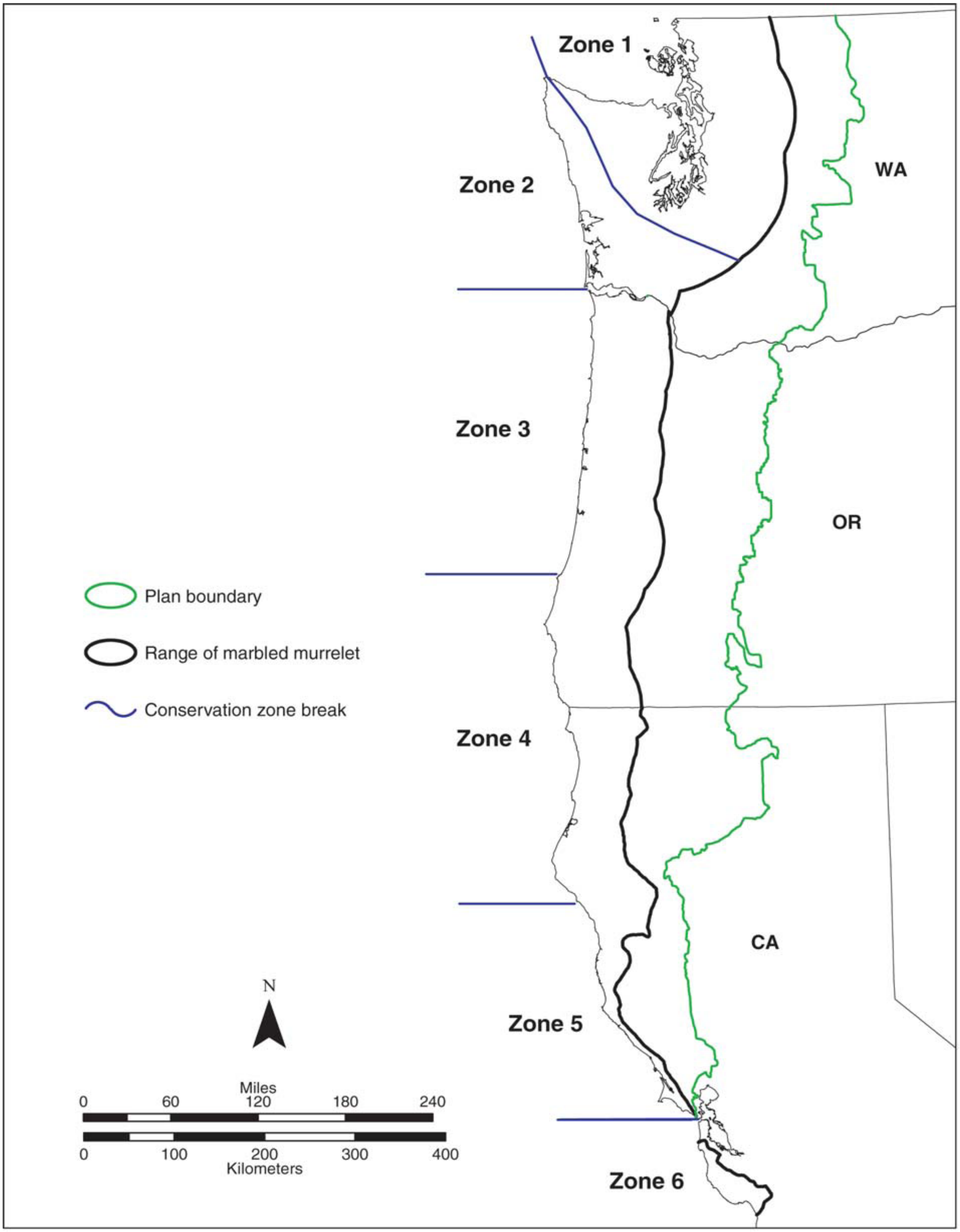

Figure 6. Marbled Murrelet Conservation Zones in the Northwest Forest Plan.
(USFWS 1997b)

We expect marbled murrelet presence in marine waters is driven by prey availability. Prey availability varies depending on a variety of factors, but especially upwelling conditions created by seawater temperature changes and seafloor topography. The foraging habits of marbled murrelets change depending on whether they are nesting and provisioning young. When breeding, they tend to forage closer to shore, primarily on small pelagic fish. This allows them to efficiently provision young. During non-breeding they disperse and can be found much farther offshore foraging on both small fish and crustaceans.

The Navy implements INRMPS both within and outside the action area. These INRMPS may benefit the marbled murrelet. At Naval Air Station Whidbey Island, two restoration projects have increased habitat for forage fish. The Crescent Harbor Salt Marsh Restoration Project restored approximately 300 acres and the Maylor Beach Restoration Project restored approximately 2,000 feet of beach area. Outside the action area, the Jim Creek INRMP protects marbled murrelet nesting habitat and designated critical habitat.

9.2.1.1 Offshore Area Subunit

Outside the early to mid-nesting season, marbled murrelets in the Offshore Area Subunit could be from any of the Conservation Zones. Birds from Zone 5 have been documented moving up into Washington State Conservation Zones towards the end of the breeding season (Hebert and Golightly 2006; Peery et al. 2004). For these reasons, we assume that marbled murrelets in the Offshore Area Subunit portion of the action area could be from any of the Conservation Zones, regardless of the season.

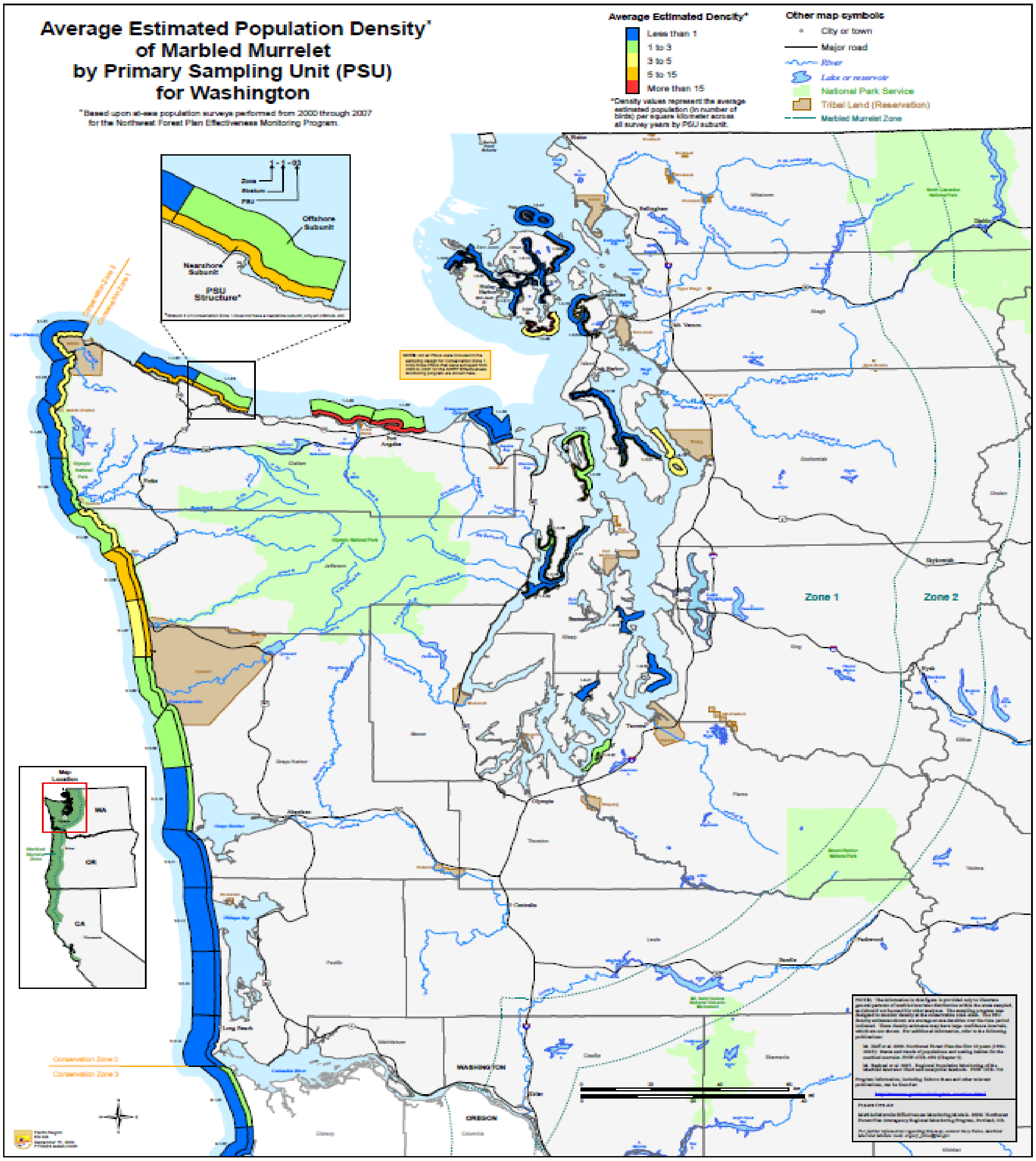

Figure 7. NWFPEM Primary Sampling Units for At-Sea Survey of Marbled Murrelets in Washington.
(Falxa et al. 2009)

Although we have previously assumed that marbled murrelets would not be present farther than five miles from shore (USFWS 2010, p. 87), a recent survey report prepared for the Bureau of Ocean Energy Management (Adams et al. 2014, pp. 32-33, 214-216) and supporting geospatial data (USGS 2015) prompted us to reevaluate this assumption (Figure 8, Figure 9). This dataset includes observations of marbled murrelets at four different locations ranging from 13 to 32 nm from shore during November of 2011 and February of 2012. Given that these data were collected via aerial surveys, and with Beaufort Sea State ranging up to 5 (29-38 km/h wind speed) (Adams et al. 2014, p. 5), it is very likely that the density and distribution of marbled murrelets were underestimated. Aerial surveys have been documented to result in marbled murrelet density estimates less than half of those generated from boat-based surveys, likely due to a variety of factors including marbled murrelet avoidance diving in front of the airplane and high sensitivity to visibility conditions (Strong et al. 1995, pp. 347-348); but see (Henkel et al. 2007, p. 148-149), for a contrasting result). We were unable to find any boat-based survey datasets covering the activity area at these or greater distances from shore during the months of January through April.

To predict the exposure and density of marbled murrelets in the Offshore Area Subunit further than 1.9 km (1.04 nm) offshore, we must use a different approach than in the coastal and inland waters where the NWFPEM provides marbled murrelet density data at the scale of Conservation Zone and/or at the Stratum Level. Although the NWFPEM describes marbled murrelet density at the scale of the Conservation Zone, the information is limited because coastal surveys only extend between 1.6 km and 8 km (0.9 nm to 4.3 nm) from shore. The NWFPEM surveys target the marbled murrelet population defined by an area of navigable waters within 3 km to 8 km (1.6 nm to 4.3 nm) of shore, but the distances vary by Conservation Zone (Falxa and Raphael 2015, p. 10). For density in coastal areas, we applied the density information from NWFPEM summer surveys to a distance of 5.6 km (3 nm) from shore for Washington, Oregon, and California. Marbled murrelet populations are concentrated closer to the shore in summer (April to September) than in winter (October to March) (Piatt et al. 2007a; Piatt et al. 2007b).

To estimate the exposure and density of marbled murrelets further than 1.9 km (1.04 nm) offshore we instead used marbled murrelet density data from Menza et al. (2015), who surveyed for marbled murrelets approximately 92.6 km (50 nm) from the coast of Washington, Oregon, and California. During the summer, the likelihood of a marbled murrelet being beyond the continental shelf is so low that we consider it discountable. We expect that warmer water near the shoreline may push food further from shore, which may cause murrelets to move further from shore; however, we do not expect this effect to persist beyond the continental shelf due to changes in ocean topography and deeper water that are not used by murrelets. Other assumptions the Service made about the presence and density of marbled murrelets in the Offshore Area Subunit, especially during the summer and winter include:

- Most areas where the Navy will perform training and testing activities are farther offshore than the area covered by the NWFPEM surveys.

- Menza et al. (2015) survey methods included transect configurations that were not ideal for detecting marbled murrelets, yet they still documented presence; although they likely predicted lower abundance of marbled murrelets than were actually present.

- It is not clear whether the small number of marbled murrelet observations offshore is due to an actual rarity of marbled murrelets in these areas, or to a lack of survey effort that might be expected to detect them. Therefore, we assume that outside of the warm season, marbled murrelets will be present farther than 12 nm from shore. This assumption was informed by data from Alaskan populations of marbled murrelets showing that approximately 18 percent of marbled murrelets were found between 50 km and 300 km (27 nm to 162 nm) from shore during the non-breeding season (Piatt and Glenn 1993, pp. 664-665).

Given the lack of survey data covering the winter and early spring months in the activity area, we cannot rule out the possibility of similar seasonal patterns of marbled murrelet use of offshore habitats in the activity area, and in a "reasonable worst-case" scenario, marbled murrelets may be exposed to activities taking place anywhere within the offshore activity area.

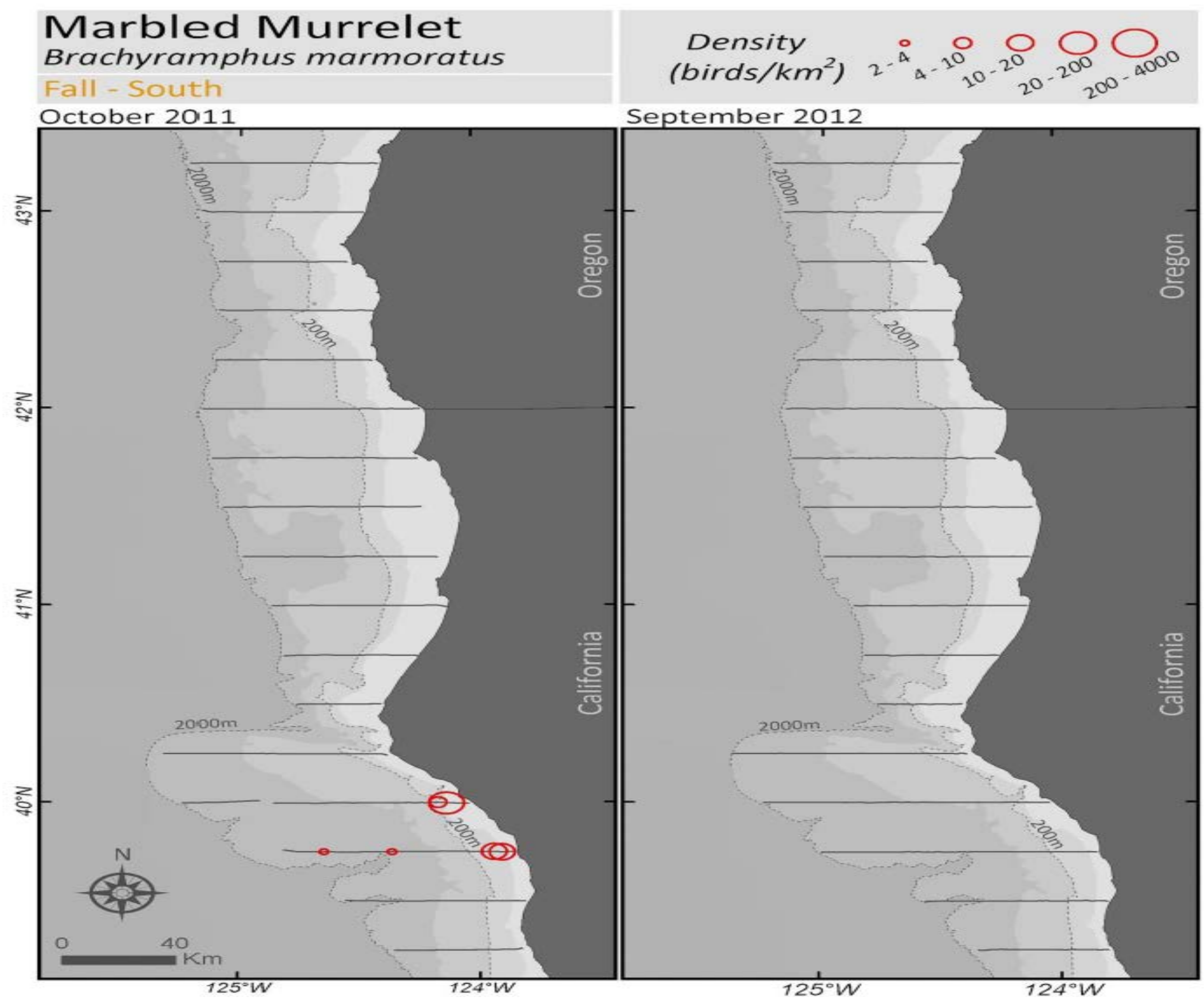

Figure 8. Mean density (birds/km^2) of marbled murrelets in October (non-breeding) and September (breeding).

(Adams et al. 2014)

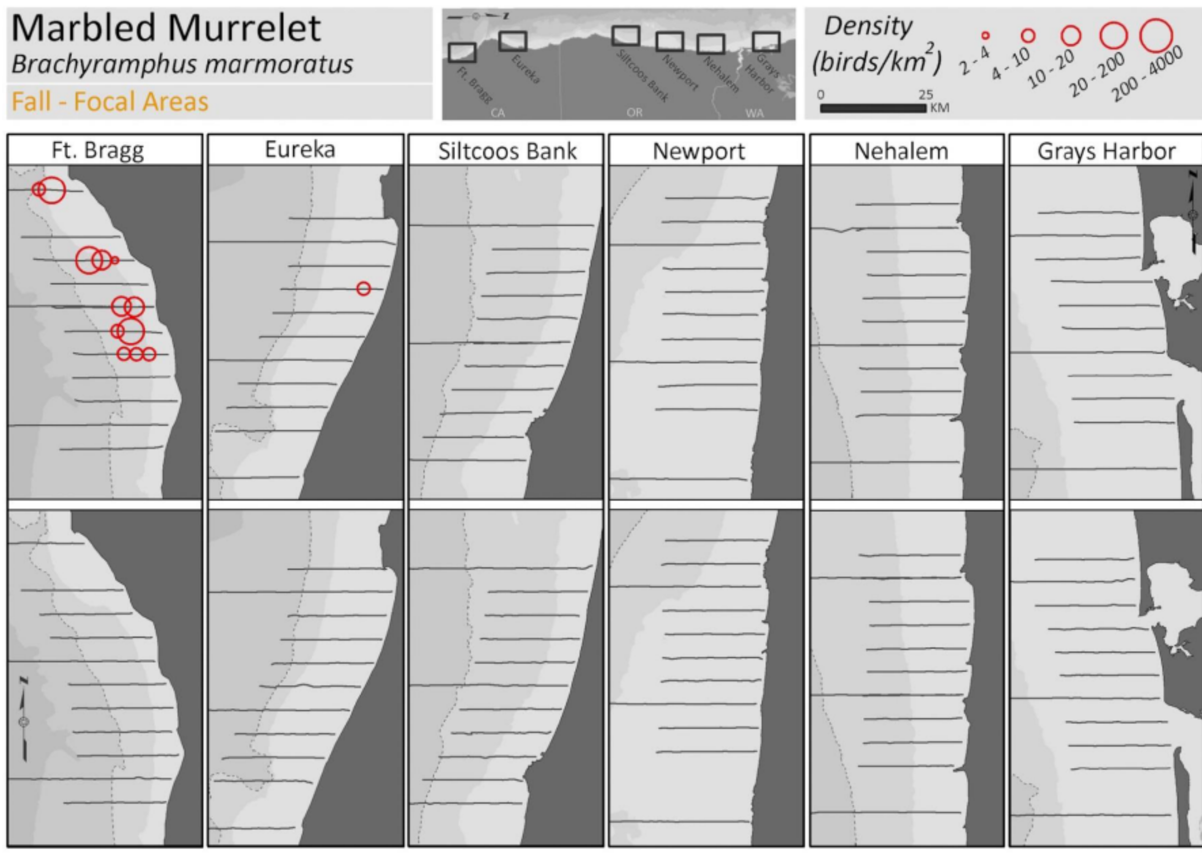

Figure 9. Mean density (birds/km^2) of marbled murrelets in October (non-breeding) and September (breeding).

(Adams et al. 2014)

During the breeding season (April through September), marbled murrelet density in the Offshore Area Subunit (beyond the areas surveyed by the NWFPEM) is expected to be much lower than in the nearshore coastal and inland Waters. During the summer, it is assumed that 5 percent of marbled murrelets detected during NWFPEM are offshore (the NWFPEM effort detects approximately 95 percent of the population, and the remaining 5 percent are assumed to be offshore), but not beyond the continental shelf (37 km, or 20 nm). The following tables (7 through 10) below show the density estimates for marbled murrelets detected by NWFPEM in Conservation Zones 2, 3, 4, and 5 (6 is not included because it is not part of the NWFPEM program).

Table 7. Marbled murrelet population estimates and densities in Conservation Zone 2 from 2001 to 2015

Year	Conservation Zone 2 – Stratum					
	All		1		2	
	Density (birds/km^2)	Population Estimate	Density (birds/km^2)	Population Estimate	Density (birds/km^2)	Population Estimate
2001	0.90	1,518	1.43	1,040	0.50	478
2002	1.23	2,031	2.45	1,774	0.28	258
2003	2.41	3,972	2.64	1,912	2-23	2,061
2004	1.82	3,009	3.37	2,444	0.61	565
2005	1.56	2,576	2.79	2,018	0.60	558
2006	1.46	2,381	2.26	1,638	0.80	743
2007	1.54	2,535	2.85	2,065	0.51	470
2008	1.17	1,929	2.58	1,872	0.06	57
2009	0.77	1,263	1.61	1,166	0.11	97
2010	0.78	1,286	1.34	968	0.34	318
2011	0.72	1,189	1.31	952	0.26	237
2012	0.72	1,186	1.18	853	0.36	333
2013	0.77	1,271	1.61	1,163	0.12	108
2014	1.32	2,176	2.88	2,086	0.10	90
2015	1.94	3,204	2.85	2,064	1.23	1,140

(Lynch et al. 2016, pp. 10-13)

Table 8. Marbled murrelet population estimates and densities in Conservation Zone 3 from 2001 to 2015

Year	Conservation Zone 3 - Stratum					
	All		1		2	
	Density (birds/km^2)	Population Estimate	Density (birds/km^2)	Population Estimate	Density (birds/km^2)	Population Estimate
2001	4.64	7,396	1.72	1,140	6.70	6,257
2002	3.58	5,716	0.70	460	5.62	5,256
2003	3.69	5,881	1.19	788	5.45	5,093
2004	5.05	8,058	1.72	1,137	7.41	6,921
2005	3.67	5,854	0.81	534	5.69	5,320
2006	3.73	5,953	1.03	684	5.64	5,269
2007	2.52	4,018	0.53	348	3.93	3,670
2008	3.86	6,153	0.34	223	6.35	5,930
2009	3.70	5,896	0.65	430	5.85	5,467
2010	4.50	7,184	1.07	708	6.93	6,476
2011	4.66	7,436	0.98	648	7.26	6,788
2012	3.99	6,359	0.90	591	6.17	5,768
2013	4.94	7,880	0.99	655	7.73	7,225
2014	5.54	8,841	1.48	976	8.42	7,864
2015	No data	No data	No data	No data	No data	No data

(Lynch et al. 2016, pp. 10-13)

Table 9. Marbled murrelet population estimates and densities in Conservation Zone 4 from 2001 to 2015

Year	Conservation Zone 4 - Stratum					
	All		1		2	
	Density (birds/km^2)	Population Estimate	Density (birds/km^2)	Population Estimate	Density (birds/km^2)	Population Estimate
2001	3.28	3,807	4.57	3,351	1.07	456
2002	4.11	4,766	5.19	3,805	2.26	961
2003	3.81	4,412	4.96	3,640	1.82	773
2004	4.27	4,952	5.33	3,911	2.45	1,041
2005	3.17	3,673	4.49	3,292	0.90	381
2006	3.41	3,953	4.82	3,538	0.98	416
2007	3.23	3,749	4.73	3,470	0.66	279
2008	4.56	5,285	6.39	4,685	1.41	600
2009	3.79	4,388	5.30	3,892	1.17	497
2010	3.16	3,665	3.77	2,769	2.11	896
2011	5.20	6,023	6.72	4,933	2.56	1,090
2012	4.28	4,960	6.05	4,439	1.23	521
2013	5.22	6,046	7.38	5,418	1.48	629
2014	No data	No data	No data	No data	No data	No data
2015	7.54	8,743	9.90	7,262	3.48	1,481

(Lynch et al. 2016, pp. 10-13)

Table 10. Marbled murrelet population estimates and densities in Conservation Zone 5 from 2001 to 2015

Year	Conservation Zone 5 - Stratum					
	All		1		2	
	Density (birds/km^2)	Population Estimate	Density (birds/km^2)	Population Estimate	Density (birds/km^2)	Population Estimate
2001	0.12	106	0.20	87	0.04	19
2002	0.28	249	0.51	225	0.05	24
2003	0.06	48	0.11	48	0.00	--
2004	0.10	88	0.09	40	0.11	47
2005	0.17	249	0.14	62	0.20	87
2006	Interpolated	89	Interpolated	69	Interpolated	65
2007	0.03	30	0.07	30	0.00	--
2008	0.08	67	0.07	29	0.09	38
2009	Interpolated	90	Interpolated	55	Interpolated	36
2010	Interpolated	114	Interpolated	81	Interpolated	33
2011	0.16	137	0.24	107	0.07	30
2012	Interpolated	104	Interpolated	89	Interpolated	15
2013	0.08	71	0.16	71	0.00	--
2014	No data	No data	No data	No data	No data	No data
2015	No data	No data	No data	No data	No data	No data

(Lynch et al. 2016, pp. 10-13)

Very little survey information is available for marbled murrelets beyond the nearshore coastal areas. However, there are observations of marbled murrelets in offshore areas. For example, marbled murrelets in Alaska were found approximately 298 km (161 nm) during the non-breeding season (October through March) (Piatt et al. 2007a). In March of the early 1980's, low altitude aerial surveys off California found marbled murrelets approximately 26 km (14 nm) offshore just north of Cape Mendocino (OBIS SEAMAP 2015). Surveys by the Bureau of Ocean Energy Management found a number of marbled murrelets approximately 60 km (32 nm) offshore in October of 2011 just south of Cape Mendocino in northern California (Adams et al. 2014). Marbled murrelets were also found off the Oregon coast, west of Newport, approximately 46 km (25 nm) offshore in February 2012 (Adams et al. 2014). Although ocean conditions may be different in Alaska, we believe that the previous studies indicate marbled murrelet presence farther offshore than previously known. We do not know the proportion of the population that occurs offshore during the non-breeding season.

Therefore, based on best available information, it is reasonable to assume that marbled murrelets may be anywhere that training and testing activities are being conducted in the action area during winter. In the summer, we expect that marbled murrelet density beyond 12 nm from shore is so low that the likelihood of exposure to project stressors is discountable (i.e., extremely unlikely).

We expect that the birds are present in offshore areas because prey resources are found there. Marbled murrelet prey density and distribution in offshore areas changes in response to changing ocean conditions. During the non-breeding season we expect that marbled murrelets respond to prey availability by moving further offshore in search of crustaceans and small fish.

Given the lack of survey data covering the winter and early spring months in the activity area, we cannot rule out the possibility of similar seasonal patterns of marbled murrelet use of offshore habitats in the activity area, and in a "reasonable worst-case" scenario, marbled murrelets may be exposed to activities taking place anywhere within the offshore activity area.

9.2.1.1.1 Factors Affecting the Marbled Murrelet Environment within the Offshore Area Subunit

Marbled murrelets spend over 90 percent of their lives at sea (Ballance et al. 2001), and they are entirely dependent on the marine environment for food. At sea, marine birds typically associate with physical processes that enhance productivity and/or aggregate prey (Ballance et al. 2001; Hunt Jr. et al. 1999). In offshore areas, marbled murrelets are generally associated with areas characterized by higher relative tidal speeds, greater depths, steeper ocean floor slopes, less freshwater inflow and proximity to sandy beaches (Barrett 2008; Barrett et al. 2008). We expect that these conditions combined with sea temperature are conducive to providing prey for marbled murrelets. Sea surface temperature patterns may be indicative of areas of enhanced or reduced primary productivity (Becker et al. 2007), and have been associated with seabird, forage fish, and zooplankton distributions (Abookire and Piatt 2005; Raya Rey et al. 2007). Evidence suggests that marbled murrelets change their foraging tactics as their needs and/or local oceanographic conditions change (Barrett 2008; Barrett et al. 2008).

A reliable prey supply is critical during the breeding season when energy demands are highest (Hull et al. 2001) and provisioning parents are traveling approximately 50 miles (80 km) inland to feed chicks, if not further. Because marbled murrelets only deliver a single fish per trip to the nest, and must rely on high-energy flapping flight, they may be especially sensitive to commuting costs (Hull et al. 2001). Due to the energetic costs and risks associated with commuting, a breeding marbled murrelet may be faced with a tradeoff between seeking an optimal inland nesting site, characterized by low predation danger, suitable microhabitat features and close proximity to flyways (Ralph et al. 1995), and remaining within reasonable distance of a profitable marine foraging patch (Barrett 2008, p. 3). Variations in the performance of seabird populations, including reduced productivity (Abraham and Sydeman 2004), increased foraging effort (Ronconi and Burger 2008), and adult mortality (Jones et al. 2002), have been correlated with shifts in oceanographic conditions, particularly during extreme events such as El Nino (Gaston and Smith 2001).

During the breeding season marbled murrelets tend to forage in well-defined areas along the coast in relatively shallow marine waters (Carter and Sealy 1990), mainly eating sand lance (*Ammodytes hexapterus*), smelt (*Hypomesus spp.*), Pacific herring (*Clupea pallasii*), capelin (*Mallotus spp.*), and various other fish (Strachan et al. 1995, p. 247). Other small schooling fishes that marbled murrelet eat include anchovy (*Engraulidae spp.*), osmerids (*Osmeridae spp.*), and sea perch (*Percidae spp.*), with fish being more important in the summer, and coinciding with the nestling and fledgling period (Burkett 1995, p. 223). During the breeding season, marbled murrelets generally forage within 2 km (1.1 nm) of the shore in relatively shallow waters in Washington, Oregon, and California, but disperse during the non-breeding season, and can be found farther from shore (Strachan et al. 1995, p. 247). Off the coast of California, in waters up to 2,000 meter depths, marbled murrelets were found 24 km (13 nm) offshore during the breeding season and were thought to be attracted to recently upwelled waters, where the availability of potential prey species were more abundant (Ainley et al. 1995, p. 361).

During the non-breeding season, marbled murrelets are less concentrated in the immediate nearshore coastal waters (Strachan et al. 1995, p. 247) and are much farther offshore (Menza et al. 2015). Their behavior at sea is poorly known (Strachan et al. 1995, p. 247). However, it is evident that their summer and winter diets differ, with euphausiids and mysids becoming more the more dominant prey items during winter and spring (Burkett 1995, p. 223). An analysis of the availability of potential prey species indicated that marbled murrelets were most abundant when more euphausiids were found in areas that were far offshore (Ainley et al. 1995, p. 361).

In winter and spring, the primary types of invertebrate prey include euphausiids (e.g., krill, such as *Euphausia pacifica, Thysanoessa spinifera*), mysids (e.g., opossum shrimp, *Hemimysis anomala*), and amphipods (*Gammarus roeseli*) (Burkett 1995, p. 223). In spring, the *euphausiid, T. spinifera*, may be more important than sand lance in the diets of adults and subadults. Euphausiids role in murrelet diets diminish greatly after the early part of the breeding season (Burkett 1995, p. 224). However, *T. spinifera* remained important in the diet of adult ancient murrelets (*Synthliboramphus antiquus*) through mid-July (Burkett 1995, p. 224). Sealy (1975) attributed this difference in diet to the offshore movement of *E. pacifica* (affinity for deeper water than *T. spinifera*) and, to some extent, offshore movement of *T. spinifera* as the spring progressed and water temperature rose. Sealy (1975) found that adult ancient murrelets feed further offshore than marbled murrelets or juvenile ancient murrelets because the food supply of the ancient murrelet was spotty and unpredictable. We expect that small crustaceans, like krill, opossum shrimp, and amphipods in offshore areas are important food resources for non-breeding marbled murrelets during winter and spring.

The importance of both sea surface temperature and nearshore environment most likely reflect associations with prey abundance and availability (Barrett et al. 2008, p. 38). At sea, prey can be concentrated in upwellings, currents, and eddies (Kuletz 2005). Haynes et al. (2007) suggests that marbled murrelets forage in shallower waters when feeding young and may target deeper waters when foraging for themselves. Sea surface temperatures were consistently the most important predictor of marbled murrelet marine habitat selection, with nearshore environment features close in importance (Barrett et al. 2008, p. 38). Oceanographic features were generally less important than sea surface temperature, environment, and distance to nest site, in predicting the probability densities of marbled murrelets at-sea (Barrett et al. 2008, p. 39). Oceanic warming is driving a shift from cool productive sub-arctic ocean conditions toward a warm subtropical marine environment that is less productive (Di Lorenzo et al. 2005). We expect a marbled murrelet's ability to locate prey in the marine environment will become increasingly difficult because of climate-change-related effects in the marine environment.

Warm nearshore conditions may inhibit breeding activity and reduced prey availability in warm seas is a likely cause (Burger 2000, p. 723). Becker and Beissinger (2003a, p. 243) predicted that marbled murrelet habitat selection would vary with upwelling intensity and prey availability. Prey-aggregating mechanisms should be more important under low upwelling scenarios when cool, productive water is more limited, and marbled murrelets should forage closer to nesting habitat when prey availability is high. This was generally the case, as marbled murrelets selected cooler locations when upwelling was low and locations closer to nesting habitat when upwelling was high. Marbled murrelets also selected cool water (higher quality habitat) when prey availability was low and were associated with prey schools when prey availability was high (Becker and Beissinger 2003a, p. 243). Marbled murrelets occurred farther from nesting flyways in years when spring upwelling was low and when food webs were depressed and other seabirds failed to reproduce (Becker and Beissinger 2003a, p. 243). Based on the behavior of marbled murrelets and other seabirds when prey availability is poor, we expect that marbled murrelets move further offshore to locate alternative prey resources.

Many threats to adult murrelets tend to occur in the marine environment. Marbled murrelet populations are sensitive to small increases in adult mortality (Piatt and Naslund 1995) and population dynamics are most strongly affected by adult survivorship (Beissinger 1995). Reductions in prey quantity and quality in marine areas, inland and offshore, are expected to affect marbled murrelet fitness because they rely on both areas for sources of prey. We expect that degraded marine habitat reduces the quantity and quality of prey abundance for marbled murrelets.

Anthropogenic threats in the marine environment are posed by oil spills, by-catch in gill nets, fish farms, coastal urbanization, recreation (Burger 2002; Burger and Chatwin 2002; Piatt et al. 2007), pollution, commercial shipping, commercial and recreational fishing, invasive species, benthic structures, and climate change, including ocean acidification, ultraviolet radiation, and changes in sea temperatures (Falxa and Raphael 2015, p. 160). Military training and testing activities are also expected to result in additional anthropogenic stressors that are described in the effects section of this Opinion. Within the terrestrial environment, the trend towards warmer, drier summers along the Pacific coast has favored increased fire frequency and intensity (Littel et al. 2009). This change may be contributing to nesting habitat loss from fire (Falxa and Raphael 2015, p. 167), while drier summers also reduce epiphyte growth on branches, thereby degrading the suitability of platforms for nesting (Falxa and Raphael 2015, p. 167; Malt and Lank 2007).

9.2.1.2 Inland Waters Subunit

The Inland Water Subunit is within Conservation Zone 1, which encompasses all of Puget Sound and the Strait of Juan de Fuca. Within the Inland Water Subunit, marbled murrelets tend to forage in well-defined areas during the breeding season. They are found in the highest densities 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 Puget Sound, with smaller numbers observed during different seasons within the Nisqually Reach, Possession Sound, Skagit Bay, Bellingham Bay, and along the eastern shores of Georgia Strait. In the most southern end of Puget Sound, they occur in extremely low numbers. During the non-breeding season, they typically disperse and are found farther from shore (Strachan et al. 1995).

It appears that marbled murrelets from Vancouver Island, British Columbia move into more sheltered waters in Puget Sound and the Strait of Georgia, which contributes to increased numbers of murrelets in Puget Sound in fall and winter (Burger 1995). Surveys along the southern shore of the Strait of Juan de Fuca conducted by the Washington Department of Fish and Wildlife from 1996-1997 (Thompson 1997) showed an increase in the number and group size of marbled murrelets in August in the eastern Strait of Juan de Fuca, although numbers declined in the western portion of the Strait of Juan de Fuca. Surveys in the near-shore waters of the San Juan Islands (Evans and Asso. Inc. 1999; Ralph et al. 1995) 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 marbled 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).

Marbled murrelet presence in the Inland Water Subunit is documented by several sources. The most accurate information comes from the consistent sampling method used to estimate population size and trends under the NWFPEM (Raphael et al. 2007). Since 2000, the estimated population size for Conservation Zone 1 has ranged from a low of 2,822 marbled murrelets in 2014 to a high of 9,758 in 2002 (Table 11) (Lynch et al. 2016, p. 13). The most recent (2015) estimated population for Conservation Zone 1 is 4,290 marbled murrelets (2,783-6,492, the upper and lower 95 percent confidence intervals, upper and lower confidence intervals are not listed in Table 11, see Lynch et al. 2016 for the data) (Lance and Pearson 2016, p. 4; Lynch et al. 2016, p. 13). Since 2001, the estimated marbled murrelet density in Conservation Zone 1 has ranged from 0.81 to 2.79 marbled murrelets per km^2, with the most recent (2015) density of 1.23 birds per km^2 (Lynch et al. 2016, p. 13).

Table 11. Marbled murrelet population estimates and densities in Conservation Zone 1 from 2001 to 2015

Year	Conservation Zone 1 - Stratum							
	All		1		2		3	
	Density (birds/km^2)	Population Estimate	Density (birds/km^2)	Population Estimate	Density (birds/km^2)	Population Estimate	Density (birds/km^2)	Population Estimate
2001	2.55	8,936	4.51	3,809	1.76	2,111	2.07	3,016
2002	2.79	9,758	7.21	6,092	1.88	2,248	0.97	1,419
2003	2.43	8,495	6.64	5,617	1.44	1,721	0.79	1,156
2004	1.56	5,465	3.83	3,241	1.51	1,807	0.29	417
2005	2.28	7,956	2.50	2,114	2.43	2,895	2.02	2,947
2006	1.69	5,899	2.76	2,333	1.42	1,693	1.28	1,873
2007	2.00	6,985	3.45	2,912	1.22	1,453	1.80	2,620
2008	1.34	4,699	3.57	3,019	0.90	1,073	0.42	607
2009	1.61	5,623	3.81	3,221	0.69	822	1.08	1,580
2010	1.26	4,393	2.00	1,694	1.78	2,128	0.39	571
2011	2.06	7,187	5.58	4,717	1.24	1,484	0.68	986
2012	2.41	8,442	7.17	6,056	1.51	1,799	0.40	587
2013	1.26	4,395	2.38	2,010	0.66	784	1.10	1,600
2014	0.81	2,822	1.26	1,063	1.27	1,521	0.16	238
2015	1.23	4,290	2.22	1,875	1.95	2,321	0.06	94

Sources: (Lance and Pearson 2016, p. 4; Lynch et al. 2016, pp. 10-13)

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

We expect marbled murrelet density to be higher during winter in the nearshore waters of northern and eastern Puget Sound. Many of the Navy's training and testing activities will occur in these areas. Marbled murrelet density is anticipated to be the lowest near the most southern end of Puget Sound. The most recent estimate of the population in Inland Waters (Conservation Zone 1, all Stratums) is 4,290 marbled murrelets, with a density of 1.23 marbled murrelets per km^2 (Table 11, above).

9.2.1.3 Summary of Marbled Murrelet Marine Distribution in the Action Area

Based on the above discussion and referenced information on murrelet use of marine habitats, and the discussion in the Status of the Species section for the murrelet, the Service has made the following findings regarding the distribution of the murrelet population in the action area:

- During the breeding season, murrelets are located primarily in nearshore areas, typically within 5 km (2.7 nm) adjacent to landscapes that provide large areas of nesting habitat. Approximately 95 percent of the population occurs in this nearshore zone during the breeding season, while the remaining 5 percent are assumed to be dispersed in offshore areas farther than 5 km (2.7 nm), but not beyond the continental shelf, the distance of which varies, but is approximately 37 km (20 nm) from the shoreline (Bentivoglio et al. 2002, pp. 22, 29, 34, 40; Menza et al. 2015, p. 49). For the purpose of this analysis, the Service assumes the density of murrelets in offshore waters farther than 22 km (12 nm) is so low that they are unlikely to be observed during the breeding season.

- Seasonal movements and redistribution of marbled murrelets occurs during the fall and winter months. In Puget Sound, there is evidence that marbled murrelet densities increase as marbled murrelets from the outer coasts of Washington and British Columbia move into the protected, inland waters of Puget Sound (Speich and Wahl 1995). For the purpose of this analysis, the Service assumes the density of murrelets in Conservation Zone 1 increases by a factor of 1.83 during the non-breeding season (Appendix G – Risk to Marbled Murrelets in Inland Waters).

- During winter, there is evidence of seasonal movement of murrelets between Conservation Zones and in some cases from nearshore areas to offshore areas. For this analysis, the Service assumes that birds present in the waters off the coasts of Washington, Oregon, and northern California may originate from any Conservation Zone within the listed range of the species, except Conservation Zone 1, which was considered isolated from Zones 2, 3, 4, and 5. We know birds within Conservation Zone 1 exhibit seasonal movements as well, but for the quantitative analysis, we assume the Zone 1 subpopulation remains within Zone 1 year-round.

- During winter on the outer coast of Washington, and south to northern California we assume that the murrelet population is mixed and randomly distributed. Based on observation of murrelets off the coasts of Oregon 46 km (25 nm) and northern California 60 km (32 nm) (Adams et al. 2014), we are reasonably certain that murrelets occur in offshore waters out to a distance of 93 km (50 nm). While there is no direct evidence of murrelet presence beyond this distance off the coasts of Washington, Oregon, or California, there is evidence from Alaska that murrelets can occur up to 300 km (162 nm) offshore. Based on the evidence from Alaska, we assume that some murrelets can occur up to 463 km (250 nm) offshore as a “reasonable worst-case” scenario for our quantitative analysis.

9.2.2 Marbled Murrelets in the Terrestrial Environment

9.2.2.1 Conservation Zone 2

The Olympic MOAs special use airspace is located over the northwestern portion of the Olympic Peninsula (Figure 2). The MOAs encompass a total area of over 1.36 million acres, and extends west of Olympic Peninsula over marine waters out to a distance of approximately 5 miles from the coast. The Olympic MOAs are located in marbled murrelet Conservation Zone 2. Conservation Zone 2 includes marine waters within 1.2 miles of the Pacific Ocean shoreline south of the U.S.-Canadian border off Cape Flattery and extends south to the mouth of the Columbia River, and extends inland to the midpoint of the Olympic Peninsula and 55 miles inland in southwestern Washington (Figure 6). Most of the forested lands in the northwestern portion of Conservation Zone 2 occur on public (Federal and state) lands, while most of the forested lands in the southwestern portion are privately owned. Extensive timber harvest has occurred throughout Conservation Zone 2 in the last century, but the greatest losses of suitable nesting habitat occurred in the southwest portion of Conservation Zone 2 (USFWS 1997, p. 127). Murrelet conservation is largely dependent upon Federal lands in the northern portion of Conservation Zone 2 and on non-Federal lands in the southern portion.

Landscape models of potential murrelet nesting habitat developed for the Northwest Forest Plan (Raphael et al. 2015) indicate approximately 58 percent of the potential nesting habitat in Conservation Zone 2 is located on Federal lands in Olympic National Park and Olympic National Forest, (Table 12). Habitat on non-Federal lands occurs on state lands managed under the Washington Department of Natural Resources Habitat Conservation Plan (HCP) and approximately 25 percent of murrelet habitat in Conservation Zone 2 is located on private or Tribal lands. Approximately 115,000 acres of potential murrelet habitat was lost to timber harvest and windstorms in Conservation Zone 2 during the period from 1993 to 2012, indicating a net loss of approximately 16.1 percent of habitat since 1993 (Raphael et al. 2015, p. 121). Most of this habitat loss has occurred on non-Federal lands.

Table 12. Summary of marbled murrelet nesting habitat distribution in Conservation Zone 2.

Murrelet Conservation Zone	Murrelet habitat on federal lands (acres)	Murrelet habitat on nonfederal lands (acres)	Total murrelet habitat in Conservation Zone
Zone 2 – Washington Coast	353,800	249,977	603,777

Note: Marbled murrelet habitat estimates represent approximate conditions in 2012, as depicted by map data developed for the Northwest Forest Plan monitoring program, moderate (class 3) and highest (class 4) suitability (Raphael et al. 2015, p. 121).

Population estimates for marbled murrelets in Conservation Zone 2 are provided in Table 7. The marbled murrelet population in Conservation Zone 2 declined at an average annual rate of 7.37 percent for the period from 2001 to 2013 (Pearson et al. 2014, p. 5). The declines in Zone 2 may be stabilizing, as surveys over the past two years (2014, 2015) have shown an increase in the number of murrelets observed at sea off Conservation Zone 2. The population estimate in 2015 was 3,204 murrelets (Lance and Pearson 2016, p. 5). With the substantial increase in the estimated murrelet population in Zone 2, the annual rate of population change (since 2001) has decreased to -2.8 percent (2015), and the 95 percent confidence intervals for the trend (-7.6 % to +2.3) now overlap zero, indicating no clear trend for this murrelet subpopulation (Lance and Pearson 2016, p. 5). At a broad landscape scales, there is a strong association between total murrelet populations as indicated by at-sea distribution during the summer breeding season and total suitable habitat area at the scale of Conservation Zones and the stratums within them (Falxa and Raphael 2015, p. 156). This pattern is apparent in Conservation Zone 2, where at-sea surveys indicate most of the murrelets associated with Conservation Zone 2 are located off the coast of the Olympic Peninsula (Lance and Pearson 2016, p. 5), while few murrelets are observed off the coast of southwest Washington where there are relatively low amounts of murrelet nesting habitat.

9.2.2.2 Olympic MOAs Subunit

The total land area located under the special use airspace is 1.19 million acres (Table 13). Most of the land area under the Olympic MOAs special use airspace is comprised of low elevation, non-federal lands under State, tribal, or private ownership. Federal lands within the Olympic MOAs include portions of the Olympic National Forest and Olympic National Park. Landscape models of murrelet nesting habitat developed for the Northwest Forest Plan (Raphael et al. 2015) indicate over 370,000 acres of potential murrelet nesting habitat are located within the boundaries of the Olympic MOAs (Table 13), and most of this potential habitat is located on State lands managed by the Washington Department of Natural Resources within the Olympic Experimental Forest. The potential murrelet nesting habitat within the Olympic MOAs represents about 61 percent of the total available nesting habitat in Conservation Zone 2, and about half of the potential murrelet nesting habitat located on the Olympic Peninsula.

Table 13. Summary of land ownership and distribution of potential marbled murrelet nesting habitat on the Olympic Peninsula and within the Olympic MOAs.

	Olympic Peninsula		**Olympic MOAs**	
Land Ownership	**Total land area (acres)**	**Murrelet nesting habitat (acres)**	**Total land area in MOAs (acres)**	**Total murrelet nesting habitat in MOAs (acres)**
Olympic National Forest	630,746	221,466	179,230	31,901
Olympic National Park	900,072	322,993	209,020	90,554
Other lands: State, Tribal, Private	1,500,106	211,398	805,804	248,540
Totals:	3,030,924	755,857	1,194,054	370,995

Note: Marbled murrelet habitat estimates represent approximate conditions in 2012, as depicted by map data developed for the Northwest Forest Plan monitoring program, moderate (class 3) and highest (class 4) suitability (Raphael et al. 2015, p. 121).

Surveys for marbled murrelets were conducted on the Olympic Peninsula opportunistically by Olympic National Forest, Olympic National Park, and Washington Department of Wildlife personnel in limited areas from 1987 to 1991. More extensive surveys were carried out between 1992 and 1999 using the intensive survey methods described in the Pacific Seabird Group marbled murrelet survey protocol (Evans Mack et al. 2003). Within the Olympic MOAs, most murrelet surveys have occurred on State lands within the Olympic Experimental Forest, where WDNR has delineated over 39,000 acres of murrelet habitat as "occupied" stands. There are an additional 1,663 acres on the Olympic National Forest that are delineated as "occupied" stands. However, large areas of the Olympic National Forest and Olympic National Park remain unsurveyed. Based on the relative distribution of murrelet nesting habitat in Conservation Zone 2, we expect that a relative proportion of the murrelet population in Conservation Zone is associated with potential nesting habitat in the Olympic MOAs.

A radio-telemetry study of 153 tagged marbled murrelets in the Olympic Peninsula documented a nest success rate of 0.20 (2 chicks fledging from 10 nest starts) (Bloxton and Raphael 2009, p. 8). Of the 20 nests monitored, only three were successful and one was presumed to be successful (Bloxton and Raphael 2009, p. 8), indicating that the apparent low nesting rate coupled with low nesting success suggests the murrelet population on the Olympic Peninsula does not produce enough young to support a stable population.

9.2.3 Conservation Role of the Action Area

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

9.2.4 Threats

As described in the marbled murrelet Status of the Species-Rangewide (Appendix D), marbled murrelets were listed as threatened in 1992 due, in large part, to habitat loss and predation in the terrestrial environment, and oil spills and net fisheries entanglement in the marine environment. In 2012, the Service convened the marbled murrelet Recovery Implementation Team which concluded that the primary cause of the continued population decline is sustained low recruitment (USFWS 2012b). Sustained low recruitment can be caused by nest failure, low numbers of nesting attempts, and/or low juvenile survival rates due to 1) terrestrial habitat loss, 2) nest predation, 3) changes in marine forage base which reduce prey resources, and 4) cumulative effects of multiple smaller impacts. The Service's recent 5-year review (USFWS 2009a, p. 27-67) identified the following additional threats in marine waters:

1. Exposure to marine polychlorinated biphenyls in prey.

2. Changes in prey abundance, availability and quality.

3. Harmful algal blooms, biotoxins, and dead zones.

4. Derelict fishing gear that causes entanglement.

5. Energy development projects (wave, tidal, and on-shore wind energy projects) leading to mortality.

6. Disturbance, injury, and mortality in the marine environment from exposures to elevated sound levels caused by pile-driving and underwater detonations, and potential disturbance from vessel traffic.

7. Climate change in the Pacific Northwest that can exacerbate many of the marine-related threats, as described above.

In our previous consultations on Navy activities, we determined that mortality, injury, and disturbance of the murrelet were likely to occur from elevated underwater sounds and detonations.

Threats in the terrestrial environment are all related to habitat loss and quality as it pertains to the availability of marbled murrelet nesting habitat (i.e., fragmentation, tree loss, etc.). More marbled murrelet habitat has been lost historically in the U.S. than in Canada, and in the U.S., marbled murrelet population numbers are lower (less than one-third of the Canadian population), productivity is lower, old-growth forest loss is more severe, and there is less remaining suitable habitat (USFWS 2009a, p. 5). In the Recovery Plan, (USFWS 1997a, pp. 43-76), several anthropogenic threats were identified as having caused the dramatic decline in the species related to the terrestrial environment:

- Habitat destruction and modification in the terrestrial environment from timber harvest and human development caused a severe reduction in the amount of nesting habitat.

- Unnaturally high levels of predation resulting from forest edge effects.

- The existing regulatory mechanisms, such as land management plans (in 1992), were considered inadequate to ensure protection of the remaining nesting habitat and reestablishment of future nesting habitat.

These threats still likely contribute to the continued decline of the population and all these threats, whether marine or terrestrial, are expected to continue into the foreseeable future. As stated in the Service's 5-year review (USFWS 2009a, p. 66), there have been no additional regulations or changes to regulations to reduce these above-mentioned threats. Those that cause direct mortality or reduce individual fitness are likely to contribute to continued marbled murrelet population declines and may lead to the species extirpation in its listed range. Also, we expect that climate change is likely to further exacerbate some existing threats such as the projected potential for increased habitat loss from drought related fire, mortality, insects and disease, and increases in extreme flooding, landslides and windthrow events in the short-term (10 to 30 years) (USFWS 2009a, p. 34).

9.3 Status of the Short-tailed Albatross in the Action Area

Although it is difficult to assess and compare changes or trends in oceanic conditions, the ecosystem conditions throughout the species range seem to have generally remained intact since population pressures from overharvest abated in the early 1900s (USFWS 2014, pp. 11-12). Despite some marine ecosystem changes affecting prey distribution [e.g., in the northern part of this species range (Kuletz et al. 2014)], the current population is still well below historic levels and the very rapid population growth of this species infers that the species is not currently limited by breeding or marine habitat.

Short-tailed albatross use the action area for dispersal and feeding. After fledging, juvenile short-tailed albatross disperse from breeding colonies in the western Pacific. The eastern Pacific along the coast of North America marks the eastern edge of the short-tailed albatross range (Suryan et al. 2008; Suryan, pers. comm. 2015). The action area overlaps with immature short-tailed albatross core-use areas (Figure 10) (O'Connor 2013, p. 33). Young short-tailed albatross predominantly feed where the ocean topography causes upwelling, bringing nutrients from deep water toward the surface and creating areas of high productivity (Guy et al. 2013, p. 230; Suryan et al. 2006, p. 371; Suryan et al. 2012, pp. 218-222). Satellite telemetry shows that tagged short-tailed albatross converge in hot spots of high productivity or prey aggregations. There are hot spots within the boundaries of the Navy's training and testing area along the coast of Washington State (Suryan et al. 2012, p. 222) and throughout the Aleutian Islands (Suryan et al. 2006, pp. 381-383). Accurate population counts of short-tailed albatross in the action area are difficult to obtain due to the extremely large area where the birds could occur. However, satellite telemetry of tagged short-tailed albatross suggests that 66 percent (and perhaps as much as 90 percent) of juvenile short-tailed albatross travel to the portion of the action area along west coast of the United States during their first two years of life (Suryan, pers. comm. 2015). Juveniles are present in the Aleutian Islands throughout the year and along the west coast of the United States during the winter and spring (O'Connor 2013, p. 32). Even though all breeding habitat is outside of the action area, each year up to 25 percent of adults forego returning to breeding habitat and stay within the action area (USFWS 2008b, p. 9).

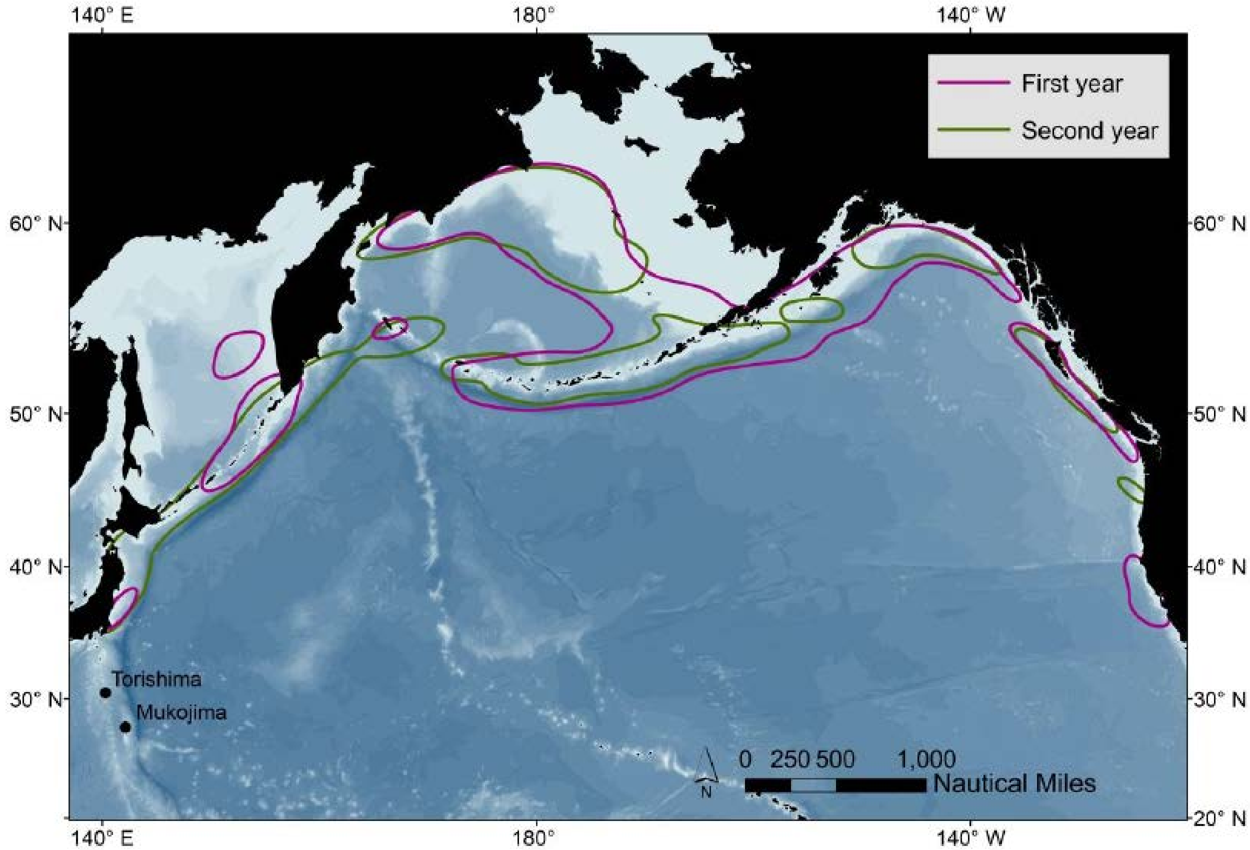

Figure 10. Core habitat (50 percent kernel) for immature short-tailed albatross during the first and second flight years
(O'Connor 2013, p. 33)

Within the action area, the Aleutian Islands may be especially important during molting. Data from short-tailed albatross captured at sea in the Aleutian Islands showed that most birds were undergoing extensive flight feather molt (Suryan, R. and K. Courtot, unpublished data cited in USFWS 2015a, p. 41). Satellite tracking data indicated individuals were spending an average of 19 consecutive days (maximum of 53 days) within a 100 km (54 nm) radius of some Aleutian passes (Suryan, R. and K. Courtot, unpublished data cited in USFWS 2015a, p. 41).

Short-tailed albatross from different breeding colonies may segregate in post-breeding seasons (Suryan et al. 2008, p. 30) and before over-exploitation short-tailed albatross were abundant along the coast of North America from Alaska to California (Hasegawa and DeGange 1982, p. 807). Use of habitat within the Offshore Area Subunit may reach historic levels as the population grows and the number of short-tailed albatross breeding colonies increases (Suryan et al. 2013, p. 64; USFWS 2008b, p. 41), and those colonies differentiate their post-breeding ranges.

Sightings by the NMFS Observer Program with the Pacific Coast Groundfish Fishery have documented short-tailed albatross use down to Monterey Bay, California (Figure 11). Currently, no formal surveys for the species exist for the waters within the Offshore Area, and no estimate of density for the area is available. While the apparent increase in sightings of the species along the west coast correlates to known increases in the species' rangewide population, the increase in trained observers and bird enthusiasts available to document sightings of the species confounds any attempt to extrapolate the available sighting data into a precise estimate of population size or density within the affected area. As the population trajectory increases for the short-tailed albatross, we can also expect the use of the action area by foraging and dispersing sub-adult and adults to increase.

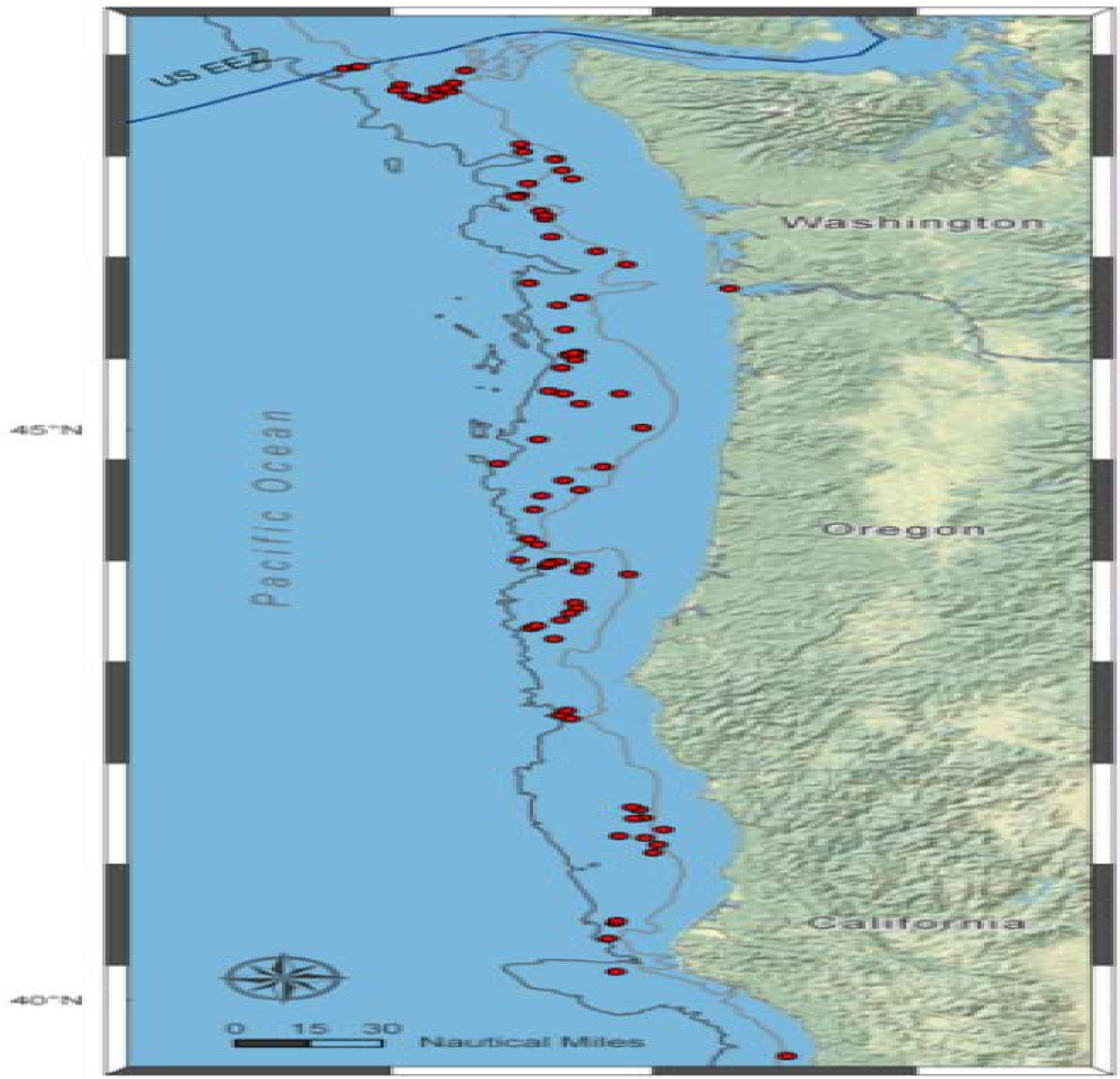

Figure 11. Geographic distribution of opportunistic sightings of short-tailed albatross by the NMFS Observer Program from 2001-July 2011.
(Northwest Fisheries Science Center 2011, p. 145)

9.3.1 Factors Affecting the Short-tailed Albatross within the Action Area

Known threats to the short-tailed albatross within the action area include commercial fisheries, predation, oil pollution, plastics, contaminants, and climate change. Short-tailed albatross also face threats from habitat alteration and loss from catastrophic events and parasites, but these factors occur outside of the action area (USFWS 2008b).

9.3.1.1 Commercial Fishing

Commercial fishing, especially the long-line fishery, has injured and killed short-tailed albatross. Birds dive after baited hooks as they are being set, get hooked, and drown while being dragged below the water's surface with the sinking line. In 2014, approximately 24,000 commercial vessels fished for albacore with hook-and-line (Pacific Fisheries Management Council 2015). Participation in the albacore fishery has increased 62 percent and 130 percent in Oregon and Washington, respectively, in the past 20 years. However, other fisheries with the potential to injure or kill short-tailed albatross, such as the drift gillnet fishery, have had a decline in the number of vessels fishing along the west coast of the United States (Pacific Fisheries Management Council 2015).

The Service, NMFS, and the fishing industry have employed various means of reducing short-tailed albatross mortality. The commercial fishing industry uses seabird deterrent measures such as night setting of lines, using artificial bait, use of bird-scaring tori lines, or acoustic deterrents (Brothers et al. 1999; Food and Agricultural Organization of the United Nations 1999; Gilman et al. 2002; 2005; 2007; 2008; Robertson et al. 2010). Other measures include implementing an observer program to ensure accurate reporting of bycatch, supplying free streamer line kits to commercial longline vessel owners, and conducting a 50 percent cost-share program to reimburse owners of certain longline vessels for half of the costs of purchasing tori line-deployment booms. In addition, NMFS has conducted public awareness and education campaigns to improve use of streamers on smaller vessels.

Controlled and large scale field studies have demonstrated that properly deployed paired streamer lines are effective at reducing seabird bycatch by 88 to 100 percent (Melvin et al. 2001, p. 28). The effectiveness of streamer lines is borne out by bycatch data, which shows continued reduction in bycatch rate since fishermen began using the lines in 1999 (Van Fossen 2007, pp. 19-20). Single streamer lines are slightly less effective than paired lines, reducing seabird bycatch by 96 percent and 71 percent for the sablefish and Pacific cod fisheries respectively (Melvin et al. 2001, pp. 16, 24). The Pacific Coast Groundfish Fishery has killed one known short-tailed albatross due to hooking and drowning on a longline hook. Additionally trawl and cables are a possible hazard to short-tailed albatross, although no known injury or mortality in the action area has occurred due to birds striking these wires.

The Short-tailed Albatross Recovery Plan recommends continued research on fisheries operations and mitigation measures. Great progress has been made in developing seabird bycatch avoidance measures that minimize seabird bycatch in Alaska demersal longline fisheries. This work needs to be continued, and further research needs to be conducted on other aspects of commercial fisheries (e.g. pelagic longline and trawl fisheries (USFWS 2008b, p. 48).

Recreational fishing may result in some risk to short-tailed albatross within the action area, but there is no quantitative estimate of the risk at this time. To date, there have been no documented observations of short-tailed albatross having been wounded or killed by this method.

The Short-tailed Albatross Recovery Plan does mention derelict gear from fisheries as a potential threat to short-tailed albatross (USFWS 2008b, p. 30), although there is no information on the extent of derelict gear in the action area, except for in Puget Sound. There has been no documented harm to short-tailed albatross from derelict gear.

The effects of the Pacific Coast Groundfish Fishery to short-tailed albatross in part of the action area were previously analyzed by the Service in the Oregon Fish and Wildlife Office. It was the Service's opinion that the multiple commercial and recreational fisheries using many different gear types, except purse seines, was reasonably certain to kill short-tailed albatross, but that the impact of the fishery was not likely to jeopardize the continued existence of the species (USFWS 2012a, pp. 32-34).

9.3.1.2 Predation

Although predation by sharks is a known source of mortality for some species of albatross, especially for recently fledged juveniles near breeding islands, the actual occurrence of this in the action area is poorly understood. Sharks may scavenge short-tailed albatross that have been already injured or killed by longline fishing methods within the action area, but the actual magnitude of this predation and its effect at a population level is unknown. Other sources of predation (crows, cats, rats) previously documented for the nesting islands are not expected to be of consequence within the action area.

9.3.1.3 Oil Spills

Within the action area, oiling of short-tailed albatross due to spills occurring in the marine environment remains a risk. Short-tailed albatross that are molting may be less mobile and therefore more at risk from oil spills (USFWS 2015a, p. 42). The number and volume of oil and other hazardous materials spills in the marine waters is highly variable. Between 1995 and 2012, the number of marine spills reported in Alaska annually ranged from 11 to 37, and total annual spill volume ranged from 5,017 to 352,602 gal (USFWS 2015a, p. 42). To date, there have been no documented circumstances of oil contamination of this species in the action area that rose to the level of injury or mortality (USFWS 2012a, p. 20). There are currently multiple proposals to expand marine and rail shipping of oil throughout the Pacific Northwest that would increase the threat of oil spills within the action area.

9.3.1.4 Plastics

Plastics have been identified as a threat to the short-tailed albatross (USFWS 2008b, p. 26; USFWS 2014, p. 25), and there is potential for short-tailed albatross to be exposed to plastics since research has shown that black-footed albatross (*Phoebastria nigripes*) (which have a diet similar to short-tailed albatross) and marine debris concentrate in the same areas (Titmus and

Hyrenbach 2011, p. 2505). Short-tailed albatross may ingest floating plastic either because the debris resembles typical prey, or because the debris is the substrate to which flying fish eggs are attached (Pettit et al. 1981, p. 840).

The rate at which short-tailed albatross ingest plastics in the action area may be a factor affecting the species' survival. The distribution of disposed plastics in the open ocean is presumed to be ubiquitous and has the potential to affect short-tailed albatross throughout the action area. It is estimated that at least 5.25 trillion plastic particles are currently floating in the world's oceans, and that 35.8 percent of that plastic is in the North Pacific Ocean (Eriksen et al. 2014, p. 7). Land based sources of marine debris include stormwater and combined sewer discharges, littering, solid waste disposal, and industrial activities. Ocean-based sources include commercial fishing, recreational boaters, merchant, military and research vessels, and offshore oil and gas platforms and explorations (Allsopp et al. 2006). Marine debris has increased over the past couple decades due to the increase in use of plastics. Williams et al. (2011, p. 1308) estimated that 36,000 pieces of plastic were floating in the coastal waters of British Columbia, Canada; and Titmus and Hyrenbach (2011, p. 2500) estimated that as many as 15,222 pieces of plastic per km^2 were floating in the southern end of the action area. As the population of short-tailed albatross increases in the future, this problem may increase.

9.3.2 Conservation Role of the Action Area

The recovery goals for the short-tailed albatross include criteria for population size and breeding populations (USFWS 2008b, pp. 41-42). Since the Offshore Area Subunit does not include breeding habitat, the action area's role in conserving short-tailed albatross is providing foraging habitat that supports the overall population. The population criteria for downlisting short-tailed albatross from endangered to threatened was estimated to have been met in 2013 and the delisting criteria is forecasted to be achieved in 2017 (USFWS 2014, p. 3). Since the role of the action area is supporting the overall population size and there continues to be short-tailed albatross population growth, the action area appears to be contributing to the conservation of the species.

9.4 Climate Change

Our analyses under the ESA include consideration of ongoing and projected changes in climate. The terms "climate" and "climate change" are defined by the IPCC. The term "climate" refers to the mean and variability of different types of weather conditions over time, with 30 years being a typical period for such measurements, although shorter or longer periods also may be used (IPCC 2014a, pp. 119-120). The term "climate change" thus refers to a change in the mean or variability of one or more measures of climate (e.g., temperature or precipitation) that persists for an extended period, typically decades or longer, whether the change is due to natural variability, human activity, or both (IPCC 2014a, p. 119).

Scientific measurements spanning several decades demonstrate that changes in climate are occurring, and that the rate of change has been faster since the 1950s. Examples include warming of the atmosphere and the oceans, melting of glaciers and sea ice, and substantial increases in precipitation in some regions of the world and decreases in other regions (Solomon et al. 2007, pp. 35-54, 82-85; IPCC 2014b, pp. 40-42).\ Results of scientific analyses presented by the IPCC show that most of the observed increase in global average temperature since the mid-20th century cannot be explained by natural variability in climate, and is “extremely likely” (defined by the IPCC as 95 percent or higher probability) due to the observed increase in greenhouse gas (GHG) concentrations in the atmosphere as a result of human activities, particularly carbon dioxide emissions from use of fossil fuels (Solomon et al. 2007, pp. 21-35; IPCC 2014b, pp. 47-49). Further confirmation of the role of GHGs comes from analyses by Huber and Knutti (2011, p. 4), who concluded it is extremely likely that approximately 75 percent of global warming since 1950 has been caused by human activities.

Scientists use a variety of climate models, which include consideration of natural processes and variability, as well as various scenarios of potential levels and timing of GHG emissions, to evaluate the causes of changes already observed and to project future changes in temperature and other climate conditions (Ganguly et al. 2009, pp. 11555, 15558; Meehl et al. 2007, entire; Prinn et al. 2011, pp. 527, 529). All combinations of models and emissions scenarios yield very similar projections of increases in the most common measure of climate change, average global surface temperature (commonly known as global warming), until about 2035. After 2035, model projections diverge depending on initial assumptions about greenhouse gas emissions (Collins et al. 2013, pp. 978-980; Kirtman et al. 2013, p. 1093). Although projections of the magnitude and rate of warming differ after about 2035, the overall trajectory of all the projections is one of increased global warming through the end of this century, even for the projections based on scenarios that assume that GHG emissions will stabilize or decline. Thus, there is strong scientific support for projections that warming will continue through the 21st century, and that the magnitude and rate of change will be influenced substantially by the extent of GHG emissions (Meehl et al. 2007, pp. 760-764; Ganguly et al. 2009, pp. 15555-15558; Prinn et al. 2011, pp. 527, 529; IPCC 2014b, pp. 56-63). Other changes in the global climate are likely to include longer and more frequent heat waves, extreme precipitation events over mid-latitude land masses, intensified precipitation variability related to El Niño-Southern Oscillation, reductions in spring snow cover and summer sea ice, ocean acidification, and decreases in the dissolved oxygen content of the ocean (IPCC 2014b, pp. 60-62).

Various changes in climate may have direct or indirect effects on listed species. These effects may be positive, neutral, or negative, and they may change over time. Identifying likely effects often involves aspects of climate change vulnerability analysis. Vulnerability refers to the degree to which a species (or system) is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the type, magnitude, and rate of climate change and variation to which a species is exposed, its sensitivity, and its adaptive capacity (Glick et al. 2011, pp. 19-22; IPCC 2007a, p. 89). There is no single method for conducting such analyses that applies to all situations (Glick et al. 2011, p. 3). We use our expert judgment and appropriate analytical approaches to weigh relevant information, including uncertainty, in our consideration of various aspects of climate change. In general, many species are projected to face increased extinction risk as the climate changes in the future, especially when climate changes are combined with other factors like habitat modification; but this risk can be reduced through management actions, including those that reduce the impacts of non-climate change stressors (IPCC 2014a, pp. 14-15).

9.4.1 Bull Trout

Recent observations and modeling for Pacific Northwest aquatic habitats suggest that bull trout and other salmonid populations will be negatively affected by ongoing and future climate change. Rieman and McIntyre (1993, p. 8) listed several studies which predicted substantial declines of salmonid stocks in some regions related to long-term climate change. More recently, Battin et al. (2007) modeled impacts to salmon in the Snohomish River Basin related to predictions of climate change. They suggest that long-term climate impacts on hydrology would be greatest in the highest elevation basins, although site specific landscape characteristics would determine the magnitude and timing of effects. Streams which acquire much of their flows from snowmelt and rain-on-snow events may be particularly vulnerable to the effects of climate change (Battin et al. 2007, p. 6724). In the Pacific Northwest region, warming air temperatures are predicted to result in receding glaciers, which in time would be expected to seasonally impact turbidity levels, timing and volume of flows, stream temperatures, and species responses to shifting seasonal patterns.

Battin et al. (2007, p. 6720) suggest that salmonid populations in streams affected by climate change may have better spawning success rates for individuals that spawn in lower-elevation sites, especially where restoration efforts result in improved habitat. Higher elevation spawners (like bull trout) would be more vulnerable to the impacts of increased peak flows on egg survival. They further note that juvenile salmonids spending less time in freshwater streams before out-migrating to the ocean would be less impacted by the higher temperatures and low flows than juveniles that rear longer in the streams. Bull trout generally spawn in cold headwater streams, and juveniles may spend one to three years rearing in cold streams before moving downstream to large river reaches or estuarine/marine habitats. Therefore, bull trout would be less likely than other salmonids to be able to adjust their spawning habitat needs related to water temperature. Connectivity between lower and upper reaches of a river system and marine waters may become even more critical for the growth and survival of fluvial and anadromous individuals that access the action area for foraging, migrating, and overwintering purposes.

Changes in climate have been identified that are occurring now or will occur over the next 50 to 100 years (Glick et al. 2007, p. iii; Mote et al. 2005, p. 4). The predicted changing precipitation patterns are expected to result in more frequent severe weather events and warmer temperatures (Mote et al. 2005, p. 13). Glaciers in the Cascades and Olympics Mountains have been retreating during the past 50 to 150 years in response to local climate warming. Regional warming can result in reduced winter snowpack, earlier occurrence of peak runoff, and reduced summer flows. If the current climate change models and predictions for Pacific Northwest aquatic habitats are relatively accurate, bull trout from the three core areas, the Lower Skagit, Stillaguamish, and the Snohomish/Skykomish River that are expected to be in the Crescent Harbor portion of the Inland Water Subunit, are likely to be impacted through at least one or more of the following pathways:

- Changes in distribution of bull trout within the core area, such as reduced spawning habitat, and/or seasonal thermal blockage in the migratory corridors associated with increased stream temperatures.

- Disturbance or displacement of eggs, alevins, juveniles, and adults of resident and/or migratory adults during winter flooding events.

- Short-term or long-term changes in habitat and prey species due to stochastic events during winter floods.

- Changes in flow/out-migration timing in the spring for bull trout and their prey species.

- Increased migration stressors from lower stream flows and high stream temperatures during spawning migrations.

9.4.2 Marbled Murrelet

During the next 20 to 40 years, the climate of the Pacific Northwest is projected to change significantly with associated changes to forested ecosystems. Predicted changes include warmer, drier summers and warmer, wetter autumns and winters, resulting in diminished snowpack, earlier snowmelt, and an increase in extreme heat waves and precipitation events (Salathe Jr et al. 2010). Initially, the Pacific Northwest is likely to see increased forest growth region-wide over the next few decades due to increased winter precipitation and longer growing seasons; however, forest growth is expected to decrease as temperatures increase and trees can no longer benefit from the increased winter precipitation and longer growing seasons (Littel et al. 2009, p. 15). Additionally, the changing climate will likely alter forest ecosystems as a result of the frequency, duration, and timing of disturbance factors such as fire, drought, introduced species, insect outbreaks, landslides, and flooding (Littel et al. 2009).

One of the largest projected effects on Pacific Northwest forests is likely to come from an increase in fire frequency, duration, and severity. In general, wet western forests have short dry summers and high fuel moisture levels that result in very low fire frequencies. However, high fuel accumulations and forest densities create the potential for fires of very high intensity and severity when fuels are dry (Mote et al. 2008, p. 23). Westerling et al. (2006) looked at a much larger area in the western United States including the Pacific Northwest, and found that since the mid-1980s, wildfire frequency in western forests has nearly quadrupled compared to the average of the period 1970 to 1986. The total area burned is more than 6.5 times the previous level and the average length of the fire season during 1987 to 2003 was 78 days longer compared to 1978 to 1986 (Westerling et al. 2006, p. 941). Littell et al. (2009, p. 2) project that the area burned by fire in the Pacific Northwest will double by the 2040s and triple by the 2080s.

9.4.3 Short-tailed Albatross

Climate change poses a potential risk to short-tailed albatross. The short-tailed albatross Recovery Plan (USFWS 2008b) states that increased water temperatures in the Arctic, melting glaciers and sea ice, increased freshwater input to the oceans, altered ocean circulation and patterns of upwelling, and altered vegetation and other characteristics of their breeding sites may affect the short-tailed albatross food base and nesting sites (USFWS 2008b, p. 18). In the northern extent of short-tailed albatross range, climate change may delay ice formation and provide more and longer foraging opportunities in the Bering Sea (Kuletz et al. 2014). However, increased foraging opportunities in the north could be offset by declining foraging in the south due to disruption of the upwelling that drives marine productivity (Kuletz et al. 2014, p. 291)

Increasing ocean water temperatures over the past few years have resulted in a warmer than normal "blob" of water off the west coast of North America that extends into the Gulf of Alaska (Peterson et al. 2014). The warmer ocean temperatures shortened the upwelling season in 2013 by 6 weeks (Peterson et al. 2014). Ocean upwelling is related to marine ecosystem productivity. High water temperatures lead to low entrainment of nutrients and therefore, decreasing biological productivity (Peterson et al. 2014). Low biological productivity may impact short-tailed albatross prey abundance.

Hazen et al. (2012, entire) looked at predicted habitat shifts of Pacific top predators in a changing climate. They concluded that within the west coast Exclusive Economic Zone[1], chlorophyll is estimated to increase and the area is expected to remain a high biodiversity area into the future (Hazen et al. 2012, p. 4). They also caution that as offshore habitat decreases or becomes less accessible, there may be increased use in the upwelling-driven California Current Marine Ecosystem leading to greater competition among top predators, and also a higher risk of anthropogenic impacts such as shipping traffic and fisheries bycatch (Hazen et al. 2012, p. 4).

The Recovery Plan mentions possible prey base changes affecting the species due to climate change (USFWS 2008b, p. 19). A recent global analysis of seabird response to forage fish depletion in 16 seabird species found a general pattern of breeding success being fairly stable above a threshold of prey abundance, but was impacted below that threshold (Cury et al. 2011, entire). The threshold approximated one-third of the maximum prey biomass observed in long-term studies. This study suggests that many seabird species are resilient to some level of prey depletion.

9.5 Previously Consulted-on Effects

9.5.1 Offshore Area Subunit

9.5.1.1 Short-tailed Albatross

The Service has only conducted a few consultations addressing potential effects of short-tailed albatross. We have issued Opinions on the longline fishery [bigeye tuna (*Thunnus obesus*) and swordfish (*Xiphias gladius*)]; operation and maintenance of the Midway Atoll National Wildlife Refuge; the Gulf or Alaska, Bering Sea/Aleutian Islands, and State of Alaska Parallel groundfish (approximately 100 species) fisheries; and the Alaska Federal and State Preparedness Plan for response to oil and hazardous substance discharges. The Service has also issued a letter of concurrence on the Makah Noxious Weed Management Plan. Adverse effects to short-tailed

[1] NMFS observer program was established in May 2001 in accordance with the Pacific Fishery Management Plan (50 CFR Part 660) (50 FR 20609). This regulation requires that all vessels that catch groundfish in the U.S. Exclusive Economic Zone from 3 to 200 miles offshore carry an observer when notified to do so by NMFS or its designated agent.

albatross that were addressed by these consultations includes direct mortality or injury from hooking and drowning during fishery interactions, and mortality from exposure to oil and hazardous substance spills.

9.5.2 Offshore Area and Olympic MOA Subunits

9.5.2.1 Marbled Murrelet and Bull Trout

The Service has consulted on the effects of proposed Federal actions on the marbled murrelet and the bull trout for numerous actions within the Offshore Area and Olympic MOA Subunits, especially on the Olympic Peninsula. Since 2007, there were approximately 170 formal, and 106 informal consultations on proposed Federal actions within the Olympic Peninsula. Over 150 of the formal consultations are within the Queets and Quinault watersheds, and are associated with forest practice (i.e., timber management) actions. Many of these actions are specific to timber sales and cedar salvage operations. Some of the other projects consulted on include bank stabilization, culvert replacement, road relocations, and bridge repair and installations.

Forest practice actions include timber harvesting and road construction. Adverse effects of these actions include direct loss and fragmentation of nesting habitat, increased risk of nest predation near clearcut edges, habitat degradation associated with clearcut edges, disruption of nesting behaviors associated with noise and visual disturbance, and the potential for direct injury or mortality of murrelet eggs or chicks. Bank stabilization, culvert replacement, road relocation, and bridge repair and installation projects result in adverse effects to the marbled murrelet from noise and visual disturbance due to operating heavy equipment during construction, predation risk by altering the patterns of activity and habitat structure of avian predators, habitat alteration through removing trees within potential and documented nesting habitat, delayed nest establishment, and reduced feeding of nestlings.

Forest practice actions, bank stabilization, culvert replacement, and road construction activities caused degradation of aquatic habitat conditions including influencing water temperature, increase in sediment input and contaminants, changes in peak and base flows, and reductions in large wood input to the rivers and streams. These effects result from the loss of riparian function, ground disturbance for road construction and bank stabilization, chemical applications, and clearcutting. Many projects involved fish capture and handling during construction operations to remove affected bull trout out of harm’s way.

9.5.3 Inland Waters Subunit

9.5.3.1 Marbled Murrelet and Bull Trout

Within the Inland Waters Subunit, the Service has conducted 44 formal consultation in Puget Sound (35) and Hood Canal (9) and 1,289 informal consultations. Within Puget Sound, Federal projects included harbor expansions, seawall replacement, ferry terminal upgrades, aquaculture activities, and discharge of wastewater treatment plants. Within Hood Canal, Federal projects involved estuarine restoration, bridge repair, and road, pier, and wharf maintenance and upgrade.

The Service's previous consultation includes the Navy's Northwest Training and Testing Activities and Explosive Ordnance Disposal activities in 2008 and 2010.

The adverse effects to murrelets and bull trout associated with most of these projects are very similar and are associated with exposure to increased sound levels from pile driving activities, decreased water quality through increased suspended sediments and contaminants (creosote and wastewater outfall discharge), and adverse impacts to forage fish species.

9.5.4 Population Effects of Previously Consulted-on Federal Actions

9.5.4.1 Bull Trout

Although these Federal projects involved adverse effects to individual bull trout and aquatic habitat, the Service determined that the effects of the actions are not expected to result in any measurable reduction in the numbers, distribution, or reproduction of the bull trout at the core area, recovery unit, or range-wide scales.

9.5.4.2 Marbled Murrelet

In general, any loss of murrelet reproduction associated with disturbance effects caused by the proposed Federal actions was considered insufficient to increase the present rates of observed population declines at the Conservation Zone and range-wide scales. The consulted-on projects were also not anticipated to result in a significant reduction in marbled murrelet numbers or distribution because most of these projects were not likely to cause direct mortality to adult breeding marbled murrelets or to eggs and chicks, and the patches of nesting habitat removed as a result of the Federal actions were typically widely dispersed over a large managed landscape. In addition, many of the documented occupied stands are located in Conservation Easements and in other set-asides that will continue to provide nesting opportunities for marbled murrelets.

9.5.4.3 Short-tailed Albatross

The Service determined that implementation of the Longline Fishery, Groundfish Fishery, operation and maintenance of the Midway Atoll National Wildlife Refuge, and the Alaska Federal/State Preparedness Plan are not likely to jeopardize the continued existence of the short-tailed albatross.

10 EFFECTS OF THE ACTION

10.1 Introduction

The effects of the action[2] refers to 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). Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur.

Although the Navy indicated the term of the proposed action is the foreseeable future, we have limited our analysis to a 20-year period based on the best available information regarding future climate-related environmental conditions, as relied upon by the IPCC and cited below. Climate change is a factor influencing the condition of the listed species and critical habitats at issue in this consultation. Over the next 20 years, models of climate change all give relatively similar projections of the geographic pattern and magnitude of climate changes, but after approximately 2035, the model projections diverge depending on initial assumptions about greenhouse gas emissions (Collins et al. 2013, p. 1093; Kirtman et al. 2013, p. 978-980, 1004-1012). For variables such as sea surface temperature, ocean heat content, and frequency of non-tropical storms over the North Pacific, these differences between projections become more pronounced beyond 2035 (Collins et al. 2013, p. 1075, 1093). Given the uncertainty of climate (and habitat) conditions beyond 2035, relying on a 20-year period where the best available information on the environment in which the species and critical habitats at issue in this consultation exist is relatively certain seems reasonable for purposes of assessing the effects of the proposed action (and cumulative effects) on those species and critical habitats.

Our approach to the analysis of effects is based on an estimation of exposure, consideration of potential responses to any exposure that is not discountable, and a determination whether there will be any resulting adverse effects. The following effects analysis is structured according to components of activities (i.e., explosions) that have similar stressors (i.e., shock wave, noise, etc.). Please note that stressors to listed species caused by the proposed action that are likely to cause injury, mortality, or significant impairment or disruption of their normal behaviors such as breeding, feeding, migration, or sheltering are discussed below as "potentially significant adverse effects" (see pages 90, 119, and 123). Stressors that are not likely to cause those effects are discussed below as "insignificant" or "discountable" effects.

For purposes of this analysis, the term "range to effect" means the distance from the source of a stressor within which injury or death of a listed species is likely to occur. This value varies between stressors and species. The term "group" applied to the marbled murrelet means two marbled murrelet individuals, which is the average marbled murrelet group size rounded to the nearest whole number of birds (Appendices A and G). The Navy described distance as km and nautical miles (nm). Bird density is typically described as birds per km^2. Our exposure analysis

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[2] In accordance with Service national policy (USFWS and NMFS 1998, p. 1-6) and congressional intent [H.R. Conf. Rep. No. 697, 96th Congress, 2nd Session 12 (1979)], the following analysis relies on best available information and provides the benefit of the doubt to the listed species in light of uncertainty or data gaps (see also p. 19952, middle column, of the preamble to the implementing regulations for section 7 of the ESA at 50 CFR 402; 51 FR 19926).

describes area in marine waters as nm^2. As such, we provide areas as km^2 and nm^2 to allow easier synthesis of effects and conversion between number of birds present/exposed and the units that describe area of effect. In some instances depth is described in meters or feet, and distance over land is also described in km or miles.

For purposes of this analysis, the distribution and abundance of the marbled murrelet and short-tailed albatross within the action area were modeled and those results were used to calculate the probability of overlap with training-related impact zones, taking into account the "range to effect" determinations. Because of the uncertainties inherent in modeling distribution and abundance of these species, and in particular because of large gaps in the information and small sample sizes where information does exist, we modeled two different scenarios: the "reasonable worst-case" scenario and the "reasonably certain" scenario. In the "reasonable worst-case" scenario, when there was uncertainty in the information we used to form our model, we erred on the side of the species. We used this version of the model to determine whether or not exposure to stressors was discountable (although for some stressors, we could determine that exposure would be discountable based on the mode of operation of the stressor and the behavioral characteristics of the species). In the "reasonably certain" scenario, we did not attempt to err on the side of the species, but took information at face value, even when there was great uncertainty. We used this version of the model to determine whether exposure to stressors was reasonably certain to occur. For example, in the "reasonable worst-case" scenario, we assumed that marbled murrelets might be present anywhere in the Offshore Area (out to a maximum of 463 km or 250 nm) during the winter, but in the "reasonably certain" scenario, we assumed that the winter marbled murrelet distribution would be limited to the area within 93 km (50 nm) of the shore. Therefore, marbled murrelet exposure to stressors that will be used farther than 93 km (50 nm) from shore might not be discountable, but is not reasonably certain to occur. A detailed description of the methods used to complete these analyses is presented in Appendix A.

Table 48 at the end of this section summarizes the findings of the following analysis by stressor and by species in terms of the anticipated numbers of individuals and habitat area affected within the range of effect zones defined above. The significance of these findings, taken together with cumulative effects, relative to the conservation needs of the listed species and to the conservation role of the action area for that species, is discussed in the section entitled "Integration and Synthesis."

10.2 Description of Stressors

The Navy analyzed potential impacts caused by the proposed action to environmental resources through stressors as "…an agent, condition, or other stimulus that potentially causes stress to an organism or alters physical, socioeconomic, or cultural resources" (Navy 2015a, p. 3.0-1). In some cases, a proposed training activity may involve more than one stressor. For example, decelerators/parachutes involve both physical disturbance and a risk of strikes, as well as entanglement. The following list of stressors was used by the Navy to assess the impacts of the proposed action to the environment and listed species:

10.2.1 Acoustical

Sounds produced during naval training and testing activities in conjunction with:

- Use of Sonar
- Use of Explosives
- Weapons firing, launch, and impact noise for non-explosive practice munitions.
- Vessel Noise (Navy vessels produce low-frequency, broadband underwater sound during operation).
- Aircraft Noise (Emitted by motors, propellers, and rotors from fixed-wing and rotary aircraft).

10.2.2 Energy

Electromagnetic and lasers: Electromagnetic energy is emitted from magnetic mine neutralization systems. Low energy lasers are used to illuminate or designate targets, to guide weapons, and to detect or classify mines.

10.2.3 Physical Disturbance

- Vessels strikes – Vessels include ships, submarines, and small boats.
- In-water devices – unmanned vehicles, such as remotely operated vehicles, unmanned surface vehicles, unmanned undersea vehicles, and towed devices.
- Military expended material – Military munitions, devices, equipment, and materials that are used and expended include: all sizes of non-explosive practice munitions, fragments from high explosive ordnance/munitions, sonobuoys, decelerators/parachutes, torpedo launch accessories, expendable targets, drones, flares, chaffs, projectile casings, propellants, weights, and guidance wires.

- Seafloor devices – Items that are deployed onto the seafloor. These items include moored mine shapes, anchors, bottom placed instruments, and robotic vehicles referred to as "crawlers." Seafloor devices are either stationary or move very slowly along the bottom.

- Aircraft strikes – Fixed-wing, rotary-wing, and unmanned aircraft.

10.2.4 Entanglement

This stressor involves fiber optic cables, guidance wires, and decelerator/parachutes. Guidance wires are used to guide some torpedoes, and missiles. Parachutes are used for sonobuoys, lightweight torpedoes, illumination flares, and targets.

10.2.5 Ingestion

The sources of this material are non-explosive practice munitions (small- and medium-caliber gun shells), fragments from high-explosive munitions, and military expended materials other than munitions (e.g., plastic or rubber target fragments, chaff, and flares) that may be ingested by birds and fishes.

10.2.6 Air Quality

Air pollutants, including hazardous air pollutants, are emitted during Navy training and testing activities. Air pollutants are generated by the combustion of fuel by surface vessels and by aircraft. Combustion of explosives and propellants in various types of munitions also releases pollutants. The major air pollutants of concern, called "criteria pollutants," are carbon monoxide, sulfur dioxide, nitrogen dioxide, ozone, suspended particulate matter, and lead.

10.2.7 Sediment and Water Quality

This category of stressor is caused by explosives and explosion byproducts, metals, chemicals other than explosives, and other materials (i.e., chaff and flares).

10.3 Approach to the Analysis

For the purposes of this analysis, the Service assessed stressors similarly but, in some cases, further subdivided a stressor into more specific categories. We also identified "in-water disturbance" as an additional stressor in our analysis. In-water disturbance may occur when divers and swimmers cause disturbance to both the water column and potentially the seafloor if in shallow water or while getting into or out of the water.

Project-related stressors of sufficient magnitude, duration, or frequency can affect the habitat use and essential behaviors of listed species, as well as cause direct impacts (i.e., injury and mortality) to individuals. In this analysis, we assessed whether or not listed species were likely to be exposed to stressors and whether or not any expected exposures (of individuals) was likely to result in measureable effects.

If exposure of a listed resource to a given stressor was extremely unlikely to occur, we concluded that the effects of that stressor on the listed resource were discountable. If we were unable to conclude the effect was discountable, we assumed the listed resource was likely to be exposed to the potential stressor(s) and we evaluated the consequence of that exposure accordingly.

Similarly, if we determined, based on the best available information, that we could not meaningfully measure, detect, or evaluate the effect of a stressor, we concluded the effect was insignificant. If we were unable to reach either of these conclusions (i.e., insignificant or discountable), we then, as required, gave that resource the benefit of the doubt by considering the effect to be adverse.

The location of each proposed training and testing activity, the listed resource potentially affected, and the stressors associated with each activity are listed in Table 14.

Table 14. Proposed training and testing activities, potential stressor caused by those activities, and the listed species adversely affected to those stressors.

Activity Name	Action Area Subunit	Activity Components	Associated Stressors	Species/CH Exposed
Navy Training Exercises				
Air Combat Maneuver	Offshore Area (W-237)	Aircraft Expendable materials (chaff, flares)	Aircraft noise Aircraft strike Air quality Ingestion Sediment and water quality	Short-tailed albatross Marbled murrelet
	Olympic MOAs			Marbled murrelet
Missile Exercise, Air-to-Air	Offshore Area (W-237)	Aircraft, drones, and missile Expendable materials (decoys, flares) Targets	Aircraft noise Aircraft strike Air quality In-air explosions Ingestion Sediment and water quality Entanglement	Short-tailed albatross Marbled murrelet
Gunnery Exercise, Surface-to-Air	Offshore Area (W-237)	Aircraft Surface ships Medium/large caliber guns Targets	Aircraft noise Aircraft strike Air quality Vessel strike Vessel noise Weapons firing noise In-air explosions Ingestion Sediment and water quality	Short-tailed albatross Marbled murrelet

Table 14. Proposed training and testing activities, potential stressor caused by those activities, and the listed species adversely affected to those stressors.

Activity Name	Action Area Subunit	Activity Components	Associated Stressors	Species/CH Exposed
Missile Exercise, Surface-to-Air	Offshore Area (W-237)	Aircraft, drones, missiles Surface ships Missile launch	Aircraft noise Aircraft strike Air quality Vessel strike Vessel noise Weapons firing noise In-air explosions Ingestion Sediment and water quality	Short-tailed albatross Marbled murrelet
Gunnery Exercise, Surface-to-Surface	Offshore Area	Surface ships Small/medium/large caliber guns Targets Divers	Vessel strike Vessel noise Sediment and water quality Weapons firing noise Ingestion Underwater explosions In-water disturbance	Short-tailed albatross Marbled murrelet
Missile Exercise, Air-to-Surface	Offshore Area (W-237)	Aircraft, missiles Surface ships Targets	Aircraft noise Aircraft strike Air quality Vessel strike Vessel noise Sediment and water quality Underwater explosions Ingestion	Short-tailed albatross Marbled murrelet
High-Speed Anti-Radiation Missile, Non-Firing	Offshore Area (W-237)	Aircraft	Aircraft noise Aircraft strike Air quality	Short-tailed albatross Marbled murrelet

Table 14. Proposed training and testing activities, potential stressor caused by those activities, and the listed species adversely affected to those stressors.

Activity Name	Action Area Subunit	Activity Components	Associated Stressors	Species/CH Exposed
Bombing Exercise, Air-to-Surface	Offshore Area (W-237)	Aircraft Buoys (smoke) Bombs	Aircraft noise Aircraft strike Air quality Sediment and water quality Underwater explosions Ingestion	Short-tailed albatross Marbled murrelet
Tracking Exercise, Submarine	Offshore Area	Submarines Sonar Submarine/Targets	Vessel strike Vessel noise Sediment and water quality In-water sound (sonar)	Short-tailed albatross Marbled murrelet
Tracking Exercise, Surface	Offshore Area	Surface ships Submarine/target Sonar	Vessel strike Vessel noise Sediment and water quality In-water sound (sonar) In-water devices	Short-tailed albatross Marbled murrelet
Tracking Exercise, Helicopter	Offshore Area	Helicopters Submarine/target Sonar Sonobuoys	Aircraft noise Aircraft strike Air quality Vessel noise Vessel strike Sediment and water quality In-water sound (sonar) Entanglement In-water devices	Short-tailed albatross Marbled murrelet

Table 14. Proposed training and testing activities, potential stressor caused by those activities, and the listed species adversely affected to those stressors.

Activity Name	Action Area Subunit	Activity Components	Associated Stressors	Species/CH Exposed
Tracking Exercise – Maritime Patrol Aircraft	Offshore Area	Aircraft Submarine/target Sonobuoys	Aircraft noise Aircraft strike Air quality Vessel noise Vessel strike Sediment and water quality In-water sound (sonar) Entanglement In-water devices	Short-tailed albatross Marbled murrelet
Tracking Exercise – Maritime Patrol Aircraft, Extended Echo Ranging Sonobuoys	Offshore Area	Aircraft Submarine Sonobuoys	Aircraft noise Aircraft strike Air quality Vessel noise Vessel strike Sediment and water quality In-water sound (sonar) Entanglement	Short-tailed albatross Marbled murrelet
Electronic Warfare Operations	Offshore Area (W-237), Olympic MOAs	Aircraft Surface ships Submarines Expendable materials (chaff, flares)	Aircraft noise Aircraft strike Air quality Vessel noise Vessel strike Sediment and water quality Ingestion	Short-tailed albatross Marbled murrelet
Land-Based Electronic Warfare	Olympic MOAs	Fixed electronic emitter Mobile electronic emitters	Vehicle noise disturbance Vehicle strike Energy stressors (electromagnetic)	Marbled murrelet

Table 14. Proposed training and testing activities, potential stressor caused by those activities, and the listed species adversely affected to those stressors.

Activity Name	Action Area Subunit	Activity Components	Associated Stressors	Species/CH Exposed
Mine Neutralization, Explosive Ordnance Disposal	Inland Waters – Crescent Harbor	Surface ships Divers	Vessel noise Vessel strike Sediment and water quality Underwater explosion Ingestion In-water disturbance	Marbled murrelet Bull trout
	Inland Waters – Hood Canal EOD Training Range			Marbled murrelet Bull trout
Submarine Mine Exercise	Offshore Area	Submarines Sonar Buoys, expendable	Vessel noise Vessel strike Sediment and water quality In-water sound (sonar)	Short-tailed albatross Marbled murrelet
Maritime Homeland Defense/Security Mine Countermeasures Integrated Exercise	Inland Waters (Puget Sound)	Helicopter Surface ships Divers Submersible unmanned vessels Sonar Electromagnetic devices	Aircraft noise Aircraft strike Air quality Vessel noise Vessel strike Sediment and water quality In-water disturbance In-water sound (sonar) In-water devices	Marbled murrelet Bull trout
Personnel Insertion/Extraction, Submersible	Inland Waters - Keyport	Submersible, mini sub	Vessel strike Sediment and water quality In-water devices	Marbled murrelet Bull trout
	Inland Waters – Indian Island			Marbled murrelet Bull trout
	Inland Waters – Dabob Bay Range Complex			Marbled murrelet Bull trout
	Inland Waters – Crescent Harbor			Marbled murrelet Bull trout
	Inland Waters – Navy 7			Marbled murrelet Bull trout

Table 14. Proposed training and testing activities, potential stressor caused by those activities, and the listed species adversely affected to those stressors.

Activity Name	Action Area Subunit	Activity Components	Associated Stressors	Species/CH Exposed
Personnel Insertion/Extraction, Non-Submersible	Inland Waters – Crescent Harbor	Aircraft, helicopter Surface ships Divers	Aircraft noise Aircraft strike Air quality Vessel noise Vessel strike Sediment and water quality In-water disturbance	Marbled murrelet Bull trout
	Inland Waters – R6701			Marbled murrelet Bull trout
Maritime Security Operations	Inland Waters (Puget Sound)	Surface ships Small caliber guns	Vessel strike Vessel noise Sediment and water quality Weapons firing noise Ingestion	Marbled murrelet Bull trout
Precision Anchoring	Inland Waters – Everett	Surface ships Anchors	Vessel strike Vessel noise Sediment and water quality Seafloor habitat disturbance	Marbled murrelet Bull trout
	Inland Waters – Indian Island			Marbled murrelet Bull trout
Small Boat Attack	Inland Waters – Everett	Surface ships Small caliber guns	Vessel strike Vessel noise Sediment and water quality Weapons firing Noise Ingestion	Marbled murrelet Bull trout
	Inland Waters – Bangor			Marbled murrelet Bull trout
	Inland Waters – Bremerton			Marbled murrelet Bull trout
Intelligence, Surveillance, and Reconnaissance	Offshore Area	Aircraft Sonobuoys	Aircraft noise Aircraft strike Air quality Entanglement In-water sound (sonar)	Short-tailed albatross Marbled murrelet
Search and Rescue	Inland Waters – Crescent Harbor	Helicopters Swimmers Expendable material (marker flares)	Aircraft noise Aircraft strike Air quality In-water disturbance	Marbled murrelet Bull trout
	Inland Waters – Navy 7			Marbled murrelet Bull trout

Table 14. Proposed training and testing activities, potential stressor caused by those activities, and the listed species adversely affected to those stressors.

Activity Name	Action Area Subunit	Activity Components	Associated Stressors	Species/CH Exposed
Surface Ship Sonar Maintenance	Inland Waters – Everett	Sonar Surface ship	In-water sound (sonar) Vessel noise Vessel strike Sediment and water quality	Marbled murrelet Bull trout
	Offshore Area			Short-tailed albatross Marbled murrelet
Submarine Sonar Maintenance	Inland Waters – Bangor	Submarine Sonar	In-water sound (sonar) Vessel noise Vessel strike Sediment and water quality	Marbled murrelet Bull trout
	Inland Waters – Bremerton			Marbled murrelet Bull trout
	Offshore Area			Short-tailed albatross Marbled murrelet
Navy Testing Exercises				
Torpedo Testing	Offshore Area – Quinault Range Site	Submarine Surface ship Sonar Torpedoes Expendable material (wires) Targets Unmanned surface or underwater vessels Sonobuoys Aircraft (QRS only)	Vessel noise Vessel strike Sediment and water quality In-water sound (sonar) Ingestion Entanglement Aircraft noise Aircraft strike Air quality In-water devices	Short-tailed albatross Marbled murrelet Bull trout
	Inland Waters - Dabob Bay Range Complex			Marbled murrelet Bull trout
Autonomous and Non-Autonomous Vessels – Unmanned Underwater Vessel Testing	Inland Waters - Dabob Bay Range Complex	Surface ship Sonar Submarine Unmanned surface or underwater vessels Torpedoes Targets Expendable material (wires) Seafloor devices	Vessel noise Vessel strike Sediment and water quality In-water sound (sonar) Energy stressors (electromagnetic, lasers) Seafloor habitat disturbance Ingestion Entanglement In-water devices	Marbled murrelet Bull trout
	Inland Waters – Keyport Range Complex			Marbled murrelet Bull trout
	Offshore Area – Quinault Range Site			Short-tailed albatross Marbled murrelet Bull trout

Table 14. Proposed training and testing activities, potential stressor caused by those activities, and the listed species adversely affected to those stressors.

Activity Name	Action Area Subunit	Activity Components	Associated Stressors	Species/CH Exposed
Autonomous and Non-Autonomous Vessels – Unmanned Aircraft System	Offshore Area – Quinault Range Site	Aircraft Unmanned aircraft Surface ships	Aircraft noise Aircraft strike Air quality Vessel noise Vessel strike Sediment and water quality	Short-tailed albatross Marbled murrelet Bull trout
	Inland Waters - Dabob Bay Range Complex			Marbled murrelet Bull trout
Autonomous and Non-Autonomous Vessels – Unmanned Surface Vessel Testing	Offshore Area – Quinault Range Site	Surface ships Unmanned surface ships Targets Seafloor devices	Vessel noise Vessel strike Sediment and water quality Seafloor habitat disturbance	Short-tailed albatross Marbled murrelet Bull trout
	Inland Waters – Keyport Range Complex			Marbled murrelet Bull trout
	Inland Waters - Dabob Bay Range Complex			Marbled murrelet Bull trout
Fleet Training Support – Cold Water Training	Offshore Area – Quinault Range Complex	Surface ships Divers	Vessel noise Vessel strike Sediment and water quality In-water disturbance	Short-tailed albatross Marbled murrelet Bull trout
	Inland Waters - Dabob Bay Range Complex			Marbled murrelet Bull trout
	Inland Waters – Keyport Range Complex			Marbled murrelet Bull trout
Fleet Training Support - Post-Refit Sea Trial	Inland Waters - Dabob Bay Range Complex	Submarine Surface ship Sonar	Vessel noise Vessel strike Sediment and water quality In-water sound (sonar)	Marbled murrelet Bull trout

Table 14. Proposed training and testing activities, potential stressor caused by those activities, and the listed species adversely affected to those stressors.

Activity Name	Action Area Subunit	Activity Components	Associated Stressors	Species/CH Exposed
Fleet Training Support – Anti-Submarine Warfare Testing	Offshore Area – Quinault Range Complex	Surface ship Submarine Sonar Targets Aircraft	Vessel noise Vessel strike Sediment and water quality In-water sound (sonar) Aircraft noise Aircraft strike Air quality	Short-tailed albatross Marbled murrelet Bull trout
Maintenance and Miscellaneous – Side Scan/Multi-beam Sonar	Inland Waters - Dabob Bay Range Complex	Surface ship Unmanned surface or underwater vessels Sonar Seafloor devices	Vessel noise Vessel strike Sediment and water quality In-water sound (sonar) Seafloor habitat Disturbance In-water devices	Marbled murrelet Bull trout
	Inland Waters – Keyport Range Complex			Marbled murrelet Bull trout
Maintenance and Miscellaneous – Non-Acoustic Tests	Offshore Area – Quinault Range Complex	Surface ship Unmanned surface or underwater vessels	Vessel noise Vessel strike Sediment and water quality In-water devices	Short-tailed albatross Marbled murrelet Bull trout
	Inland Waters - Dabob Bay Range Complex			Marbled murrelet Bull trout
	Inland Waters – Keyport Range Complex			Marbled murrelet Bull trout
Acoustic Component Test – Countermeasures Testing	Offshore Area – Quinault Range Complex	Surface ship Submarine Targets Unmanned surface or underwater vessels Sonar	Vessel noise Vessel strike Sediment and water quality Energy stressor (electromagnetic) In-water sound (sonar) In-water devices	Short-tailed albatross Marbled murrelet Bull trout
	Inland Waters - Dabob Bay Range Complex			Marbled murrelet Bull trout
	Inland Waters – Keyport Range Complex			Marbled murrelet Bull trout

Table 14. Proposed training and testing activities, potential stressor caused by those activities, and the listed species adversely affected to those stressors.

Activity Name	Action Area Subunit	Activity Components	Associated Stressors	Species/CH Exposed
Acoustic Component Test – Acoustic Test Facility	Inland Waters – Keyport	Sonar	In-water sound (sonar)	Marbled murrelet Bull trout
	Inland Waters - Dabob Bay Range Complex			Marbled murrelet Bull trout
Acoustic Component Test – Pierside Integrated Swimmer Defense	Inland Waters – Keyport Range Complex	Sonar Surface ship Divers	In-water sound (sonar) Vessel noise Vessel strike Sediment and water quality In-water disturbance	Marbled murrelet Bull trout
Pierside Acoustic Testing	Inland Waters – Bangor	Surface ship Unmanned surface or underwater vessel Targets Seafloor devices Sonar	Vessel noise Vessel strike Sediment and water quality Seafloor habitat disturbance In-water sound (sonar) In-water devices	Marbled murrelet Bull trout
	Inland Waters – Bremerton			Marbled murrelet Bull trout
Performance At-Sea Testing: Operating Autonomous Underwater Vessel	Inland Waters - Dabob Bay Range Complex	Surface ship Unmanned surface or underwater vessel Sonar Targets Seafloor devices	Vessel noise Vessel strike Sediment and water quality Seafloor habitat disturbance In-water sound (sonar) In-water devices	Marbled murrelet Bull trout
	Inland Waters – Carr Inlet			Marbled murrelet Bull trout
System, Subsystem and Component Testing – Development Training and Testing	Inland Waters - Dabob Bay Range Complex	Surface ship Unmanned surface or underwater vessel Sonar Targets Seafloor devices	Vessel noise Vessel strike Sediment and water quality Seafloor habitat disturbance In-water sound (sonar) In-water devices	Marbled murrelet Bull trout
	Inland Waters – Carr Inlet			Marbled murrelet Bull trout

Table 14. Proposed training and testing activities, potential stressor caused by those activities, and the listed species adversely affected to those stressors.

Activity Name	Action Area Subunit	Activity Components	Associated Stressors	Species/CH Exposed
Proof of Concept Testing	Inland Waters - Dabob Bay Range Complex	Surface ship Unmanned surface or underwater vessel Sonar Targets Seafloor devices Divers	Vessel noise Vessel strike Sediment and water quality Seafloor habitat disturbance In-water sound (sonar) In-water disturbance In-water devices	Marbled murrelet Bull trout
	Inland Waters – Carr Inlet			Marbled murrelet Bull trout
Pierside Sonar Testing	Inland Waters – Bangor	Sonar	In-water sound (sonar)	Marbled murrelet Bull trout
	Inland Waters – Bremerton			Marbled murrelet Bull trout
	Inland Waters – Everett			Marbled murrelet Bull trout
Shipboard Protection Systems and Swimmer Defense Testing – Pierside Integrated Swimmer Defense	Inland Waters – Bangor	Sonar Divers	In-water sound (sonar) In-water disturbance	Marbled murrelet Bull trout
	Inland Waters – Keyport			Marbled murrelet Bull trout
Unmanned Vessel Testing – Unmanned Vessel Development and Payload Testing	Inland Waters - Dabob Bay Range Complex	Surface ship Unmanned surface or underwater vessel Sonar Expendable material (wires)	Vessel noise Vessel strike Sediment and water quality Energy stressors (electromagnetic, Lasers) In-water sound (sonar) Entanglement In-water devices	Marbled murrelet Bull trout
	Inland Waters – Keyport			Marbled murrelet Bull trout

Table 14. Proposed training and testing activities, potential stressor caused by those activities, and the listed species adversely affected to those stressors.

Activity Name	Action Area Subunit	Activity Components	Associated Stressors	Species/CH Exposed
Anti-Surface Warfare/Anti-Submarine Warfare Testing – Torpedo (Explosive) Testing	Offshore Area	Submarine Surface ship Aircraft Torpedoes Sonar Expendable material (wires) Targets	Vessel noise Vessel strike Sediment and water quality Aircraft noise Aircraft strike Air quality Underwater explosion Ingestion In-water sound (sonar) Entanglement In-water devices	Short-tailed albatross Marbled murrelet
Anti-Surface Warfare/Anti-Submarine Warfare Testing – Torpedo Non-Explosive Testing	Offshore Area – Quinault Range Complex	Submarine Surface ship Aircraft Torpedoes Sonar Expendable material (wires) Targets Sonobuoys	Vessel noise Vessel strike Sediment and water quality Aircraft noise Aircraft strike Air quality Ingestion In-water sound (sonar) Entanglement In-water devices	Short-tailed albatross Marbled murrelet
Anti-Surface Warfare/Anti-Submarine Warfare Testing – Countermeasure Testing	Offshore Area – Quinault Range Complex	Surface ship Torpedoes Sonar Expendable material (cables and wires)	Vessel noise Vessel strike Sediment and water quality Ingestion In-water sound (sonar) Entanglement In-water devices	Short-tailed albatross Marbled murrelet
	Inland Waters - Dabob Bay Range Complex			Marbled murrelet Bull trout

Table 14. Proposed training and testing activities, potential stressor caused by those activities, and the listed species adversely affected to those stressors.

Activity Name	Action Area Subunit	Activity Components	Associated Stressors	Species/CH Exposed
New Ship Construction – Anti-Submarine Warfare Mission Package Testing	Offshore Area – Quinault Range Complex	Surface ship Submarine Aircraft Torpedoes Sonar Sonobuoys	Vessel noise Vessel strike Sediment and water quality Aircraft noise Aircraft strike Air quality Ingestion In-water sound (sonar) Entanglement In-water devices	Short-tailed albatross Marbled murrelet
Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft, Directional Command Activated Sonobuoy System	Offshore Area	Aircraft Submarines Sonobuoys Sonar	Aircraft noise Aircraft strike Air quality Vessel noise Vessel strike Sediment and water quality In-water sound (sonar) Ingestion Entanglement	Short-tailed albatross Marbled murrelet
Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft (Multistatic Active Coherent)	Offshore Area	Aircraft Submarines Sonobuoys Sonar	Aircraft noise Aircraft strike Air quality Vessel noise Vessel strike Sediment and water quality In-water sound (sonar) Ingestion Entanglement	Short-tailed albatross Marbled murrelet

Table 14. Proposed training and testing activities, potential stressor caused by those activities, and the listed species adversely affected to those stressors.

Activity Name	Action Area Subunit	Activity Components	Associated Stressors	Species/CH Exposed
Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft (Sound Underwater Signal)	Offshore Area	Aircraft Submarine Sonobuoys Sonar	Aircraft noise Aircraft strike Air quality Vessel noise Vessel strike Sediment and water quality In-water sound (sonar) Ingestion Entanglement	Short-tailed albatross Marbled murrelet
Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft (Improved Extended Echo Ranging)	Offshore Area	Aircraft Submarine Sonobuoys	Aircraft noise Aircraft strike Air quality Vessel noise Vessel strike Sediment and water quality Ingestion Entanglement	Short-tailed albatross Marbled murrelet
Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft (High Duty Cycle)	Offshore Area	Aircraft Submarine Sonobuoys Sonar	Aircraft noise Aircraft strike Air quality Vessel noise Vessel strike Underwater explosions Sediment and water quality In-water sound (sonar) Ingestion Entanglement	Short-tailed albatross Marbled murrelet
Flare Test	Offshore Area	Aircraft Expendable Materials (flares)	Aircraft noise Aircraft strike Air quality Ingestion	Short-tailed albatross Marbled murrelet

10.4 Analysis of the Effects of Acoustics and Impulses

10.4.1 Definitions of Acoustics Terminology

Throughout this section we use a number of technical terms when discussing the physical properties of sound-related stressors that can result in physiological or behavioral effects in exposed animals. The following is a list of terms and a brief explanation of each.

Amplitude: A measurement of the total change in the pressure caused by the sound vibrations. Sound amplitude is often expressed in units called decibels (dB).

Bow Shock/Projectile Shock Wave: Bow shock wave or projectile shock wave occurs when a projectile travels at supersonic speeds. Bow shock/projectile shock waves originate off the bow of a flying projectile as it pushes the air in front of it out of the way, similar to the bow wave generated by a boat traveling through the water, but at supersonic speed. The shock wave generated by this movement of air is cone-shaped and trails behind the projectile as it travels supersonically through the air. This shock wave creates a sonic boom when the velocity is high enough.

Decibel (dB): The unit of measurement for the sound amplitude or sound energy representing the relative loudness of a sound.

Frequency: A measurement of oscillations with units 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 by humans (less than 20 Hz).

Impulse: A quantity (Pa-sec) derived by multiplying the peak of a shock wave by the amount of time it takes for the shock wave to attenuate to (1/e) * (peak).

Muzzle Blast: A blast that occurs at the end of a weapon when munitions are fired. Muzzle blasts are usually characterized by two blast waves, two jet flows, and the shock-wave/moving-body interaction (Jiang 2003, p. 1665). The pressure is higher behind the projectile and lower in front of it due to the friction force between the projectile and the shock tube wall, which maintains a balance between the driving and the drag forces acting on the projectile (Jiang 2003, p. 1665).

Overpressure: Instantaneous pressure excursion of a pressure wave from ambient static pressure at a particular point in space; overpressure and sound pressure are equivalent terms. The term “sound pressure” is generally used in reference to acoustics, i.e., the study of weak pressure waves, while overpressure is the study of strong pressure waves, especially shock waves due to explosive detonations (Pater 1981, p. 2).

Reference Pressure: The reference scale for underwater sound is 1 micro-Pascal (μPa) and is expressed as dB re: 1 μPa. The reference pressure for in-air sound is 20 μPa and is expressed as dB re: 20 μPa. The two values are different because the properties of water and air differ.

Shock Wave: The waveform that develops when components of the wave attempt to travel faster than the speed of sound within the medium, typically formed at the onset of high-intensity events like explosions or where an object is moving through the medium at speeds faster than the speed of sound. This typically results in an abrupt change in pressure at the leading edge of the waveform and additional broadening of the signal's spectrum. Highly compressed air traveling at supersonic velocities and rapidly decreasing pressures. Shock waves create a vacuum, resulting in wind in the vicinity of the detonation.

Sound: A term describing the physical effect of vibrations in air, water, or other matrix that stimulates the auditory nerves and produce the sensation of hearing. The perception of a sound depends on the amplitude and frequency, both of which can be measured.

Sound Exposure Levels (SEL): SEL is the level of sound accumulated, both positive and negative pressure, during a given event. SEL is a metric that incorporates both SPL and duration. SEL is calculated as 10 times the logarithm of the integral, with respect to duration, of the mean-square sound pressure, referenced to μPa2-sec. Using this metric, 0 - SEL corresponds to a continuous sound whose root mean square (rms) sound pressure equals the reference pressure of 1 μPa at a duration of 1 s (Morfey 2001).

Sound Pressure Levels (SPL): Sound pressure level is 10 log $(P/P_{ref})^2$, where P is the sound pressure (Pa) and Pref is a reference pressure. The reference pressure is 1 μPa in water and 20 μPa in air. A SPL should be identified as a peak or rms.

Peak pressure: The highest level, amplitude, or greatest absolute SPL during the time of observation. SPLs that are expressed as peak may be used when discussing injury or mortality to aquatic species.

Root mean square (rms): The rms of a periodic waveform. It is computed by calculating the mean of the square value over a single period of the waveform and then taking the square root. SPLs expressed as rms are commonly used in discussing behavioral effects, typically associated with sounds that are not instantaneous in duration. Behavioral effects often result from auditory cues, often associated with longer durations of exposure, and may be better expressed through averaged units than by peak pressures.

Transmission loss: The loss of sound energy as sound passes through a medium, such as water or air. Several factors may affect transmission loss such as the spreading of the sound over a wider area (spreading loss), losses to friction (absorption), scattering and/or reflection from objects in the sound’s path, and destructive 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).

10.4.2 General Principles of Sound

Sound is a vibration or acoustic wave that travels through a medium and is the physical stimulus responsible for the sensation of perceiving vibrations and/or hearing. Thus, sound is a mechanical disturbance in the medium in which the animal lives. The pressure of an acoustic wave is described through its change in amplitude, phase, and frequency with respect to time. A tone is a sound of a constant frequency that continues for a substantial time. A pulse is a sound of short duration, and may include a broad range of frequencies. Explosions are impulsive sounds. The sonar ping resembles a continuous tone with respect to its frequency content, and it also resembles an impulse with respect to its time duration, making sonar different from both impulses and continuous signals. We will describe how both impulsive sounds (in-air and underwater) and sonar (underwater) affect bull trout, marbled murrelets, and short-tailed albatross in the following sections.

The perception, or hearing of sound, according to Wever (1974), is the response of an animal to sound vibration by means of special organs for which such vibrations are the most effective stimuli. Animals that live in the terrestrial environment typically detect sound via hair cells in their ears that are stimulated, or vibrated by what is producing the sound; while aquatic animals, such as marine mammals, have mechanisms by which their hair cells may be bypassed and their hearing is instead stimulated via bone conduction. Sensory functions can be stimulated by hearing (sound pressure waves) and also by particle displacements. Some animals have other sensory organs besides the hair cells in their inner ears. For example, fish have a lateral line (called neuromasts) while other invertebrates have chordotonal organs that are responsive to mechanical and sound vibrations, sensing changes in gravity, pressure, tension, and motion) (Sebeok 1977). Sensory functions can be stimulated by hearing if the frequency is audible, and by other mechanisms via other sensory organs. For instance, although an animal may not hear frequencies ranging from the infrasonic to ultrasonic, they may be able to sense them via other methods. We expect that although some of the Navy sonar tones may be outside the hearing range of an animal, they may still detect it via other sensory organs.

A decibel (dB) is a relative measure of sound that must be accompanied by a reference scale and a metric that identifies whether the sound dB is a peak, a root mean square, and is often denoted as an SEL. When this Opinion describes an underwater SPL, the reference pressure is 1 micro-Pascal (μPa) and is expressed as "dB re: 1 μPa." For in-air sound pressure, the reference pressure is 20 μPa, expressed as "dB re: 20 μPa." In-air sound, typically measured on an A-weighted scale (which approximates human hearing), will always be re: 20 μPa and is denoted as dBA. For this Opinion we have assumed that some of the limited resources available regarding in-air sound are A-weighted, although the documents only denote the sound metric as "dB" (these instances are noted). Ambient noise is background noise that incorporates the broad range of individual sources. Some sources of ambient noise include wind, waves, organisms, shipping traffic, rain, and industrial activity.

As sound propagates away from a source, several factors can change its amplitude. The sum effect of all propagation and loss of a signal is called the transmission loss. Transmission loss is the reduction of energy as sound passes through a medium, such as water or air. Several factors are involved in transmission loss 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, land, air-water interface, etc.).

10.4.3 Auditory Effects to Fish and Birds Caused by Exposure to Impulses and Sonar

Exposure to elevated SPLs from impulses or sonar can cause auditory injury. Exposure to impulses and elevated SPLs, including those associated with explosive detonations, weapons firing, and sonar can cause "threshold shift," (TS) where there is decreased hearing capability, at specific frequencies, for periods lasting from hours to days, or permanently. The onset and degree of TS resulting from noise exposure varies among species. Popper et al. (2005) and Song et al. (2008) investigated the effects of exposing three species of fish to seismic and airgun shots. The inner ears of these fishes were examined and no physical damage to the sensory cells was found (Song et al. 2008, pp. 1362-1365); specific to fishes, this is referred to as non-injurious TS.

When hearing loss is temporary it is sometimes categorized as a short-term fatiguing of the auditory system (rather than "injury") (Popper et al. 2005). However, Ryals et al. (1999) documented hair cell loss in birds that experienced acoustic overexposure. Using scanning electron photomicrographs the authors showed that hair cell loss and damage occurred on the surface of the papillae in the inner ears of birds. In several instances the hair cells did not recover, and the TS was permanent. When exposure to acoustic sources results in shifts in hearing sensitivity and there is loss and/or physical damage of hair cells, whether permanent or temporary, we refer to this as TS and consider it a form of injury.

Smith et al. (2006, p. 4189) found continuous white noise at 170 dB rms re: 1 μPa for 48 hours caused goldfish (*Carassius auratus*) to experience significant temporary threshold shift (TTS (13 to 20 dB)) at frequencies between 0.2 - 2 kHz. Scanning electron microscopy showed recovery from the TTS took up to seven days and full replacement of the sensory cells took eight days. Some recoverable loss of sensory hair cells occurred in the ear after 48 hours of exposure to white noise at 170 dB rms re: 1 μPa; however, there was evidence of scarring in the saccule, characteristic of hair cell loss (Smith et al. 2006, p. 4189). Smith et al. (2006, p. 4189) found that the TTS involved significant hair cell loss in the caudal and central regions of the goldfish saccule. The greatest loss of hair cells occurred during the 48 hours of noise exposure and continued after one day of recovery. This pattern of hair cell loss coincides with the period of maximum cell death in the caudal saccule. In the central saccule, maximum bundle loss was observed after 3 to 5 days of recovery from noise, indicating ongoing degeneration following cessation of noise. Progressive post-exposure development of noise-induced morphological damage has also been noted in other teleost fishes and in the mammalian cochlea (Hastings et al. 1996; McCauley et al. 2003). Significant apoptosis was only detected for 2 days after noise exposure, suggesting that some dying hair cells in the central saccule may have retained their bundles for one or more days before the bundle degenerated.

Hastings et al. (1996) found the oscar (*Astronotus ocellatus*) experienced damage to the small regions of the utricle and lagena (inner ear organs) from 1 hour of continuous sound at frequencies ranging from 60 to 300 Hz, and sound levels from 100 to less than 180 dB rms re: 1 μPa. The utricle is fluid-filled cavity forming part of inner ear, part of vestibular system, an otolith organ that contains hair cells and sends signals to the brain concerning orientation of the head. The lagena is the 3rd otolith organ and discriminates sound oscillations, identifies gravitation vector, and orientation in the course of movement within the vertical plane (in birds is navigation ability related to magnetic fields). Popper et al (Popper et al. 2007) found rainbow trout didn't not experience TTS from sonar at frequencies between 100-500 Hz, and 193 dB re: 1 μPa; however, histology of the inner ear occurred prior to 4 days post-exposure, and it is possible that the damage had not yet manifested. Hastings et al. (1996, p. 1763) performed histology at 1-4 days post-exposure with scanning electron microscopy of the ciliary bundles and found that damage was not evident in fish necropsied 1 day post-exposure, but damage to the inner ear organs was evident in fish necropsied 4 days post-exposure.

With regard to auditory damage, the inner ear is most susceptible to trauma, although intense sounds can also damage the middle and outer ear (Gisiner et al. 1998, p. 25). Not all frequencies of sound produce equivalent damage at the same exposure level, nor will the same frequency-exposure combination cause equivalent damage in all species (Gisiner et al. 1998, p. 25). The severity of resulting impact depends upon several factors such as the sensitivity of the subject, and the level, frequency, and duration of the sound (Gisiner et al. 1998, p. 25). These effects are not completely understood, however, it is generally acknowledged that there is considerable variation within and between species, that for narrow-band noises, hearing loss centers around the exposure frequency, and that there is some combination of sound level and exposure time when hearing loss becomes irreversible (Gisiner et al. 1998, p. 25; Saunders and Dooling 1974, p. 1). The majority of studies on mammals [cats and rodents (especially chinchilla)] used relatively long duration stimuli (> 1 hour) and mid to low frequencies (1 to 4 kHz). These studies noted that intensity and duration of exposure can act synergistically to broaden the extent of the hearing loss (Gisiner et al. 1998, p. 25). Repeated exposure to sounds that produce TS without adequate recovery periods can also induce permanent, acute, hearing loss (Gisiner et al. 1998). An organism that is experiencing TS may suffer consequences from not detecting biologically relevant sounds such as approaching predators or prey, and/or their mates attempting to communicate.

Due to a lack of data on seabirds, we rely on data from other vertebrate species to draw conclusions about levels of effect and effects thresholds for the marbled murrelet and the short-tailed albatross. After examining underwater sound mechanisms in dolphins, seals, turtles, and seabirds (species not defined), Ketten et al. (2000) note that both seals and seabirds share external auditory canals that are sheathed with fatty tissues. These mechanisms indicate evolutionary adaptations that probably act as low impedance channels for underwater sound (Ketten et al. 2000). Woehler (2002, p. 97) evaluated six species of penguins and concluded that emperor penguins (*Aptenodytes forsteri*) can detect frequency sounds with an upper range limit of 12.5 kHz (based on in-air sound). Since the auditory range of marbled murrelets is unknown, we assume they can detect sounds ranging from 480 Hz to 12.5 kHz in air based on the frequencies of their vocalizations (Nelson 1997; Sanborn et al. 2005; Science Applications International Corporation (SAIC) 2012) and the penguin data (penguins are diving seabirds, while short-tailed albatross are more surface feeders).

Vocalizations of Laysan albatross indicated that their auditory range includes frequencies between 85 Hz and 25 kHz (Sparling Jr. 1977, p. 256). Behavioral analysis of "eh" calls revealed frequencies ranging as high as approximately 15 kHz (Sparling Jr. 1977, p. 262), while the average frequency of a "squeak" was approximately 28 kHz, and could be as high as 32 kHz (Sparling Jr. 1977, p. 264). The "eh" calls and "squeaks" primarily serve to maintain pair bonding, during incubation, and/or maintain territories (Sparling Jr. 1977, p. 267). Therefore, similarly to marbled murrelets, we expect that short-tailed albatross vocalize at the same frequency ranges with which they can hear; we expect short-tailed albatross can hear frequencies ranging from 85 Hz to 32 kHz [based on the albatross audiogram data by Sparling (1977)].

10.4.4 Non-Auditory Effects to Fish and Birds Caused by Exposure to Impulses and Sonar

The acoustic impedance of fish and other aquatic animals nearly matches that of water, so most of the sound energy will enter their bodies if they are exposed (Hastings 1995, p. 979). Hastings reports that "fish suffer damage to their auditory system and other parts of their bodies, and may even die when exposed to high sound pressure levels (SPLs) underwater for relatively short periods of time" and "damage may be apparent physically, or by changes in behavior or morphology of sensory cells" (1995, p. 979). Many types of damage appear to be temporary, but no studies found in the literature have assessed long-term effects (Hastings 1995, p. 979).

Sources of sound can cause internal bleeding and stunning (complete immobilization) (Hastings 1995). Gouramis (*Trichogaster sp*.) and goldfish exposed to continuous sound waves for 2 hours experienced stunning between 8 and 30 minutes and/or death. Approximately 50 percent of fish died when exposed to sound level at 192 dB peak re: 1 μPa and 400 Hz, 56 percent died at a sound level of 198 dB peak re: 1 μPa and 150 Hz, and 25 percent died when exposed to sound at 204 dB re: 1 μPa at 250 Hz. If the amplitude and exposure of a fish to elevated underwater SPLs is sufficient, we would expect they may be injured or killed.

Impulses can also injure and/or kill fishes by causing barotraumas (pathologies associated with high sound levels including hemorrhage and rupture of internal organs) (Turnpenny and Nedwell 1994; Turnpenny et al. 1994; Popper 2003; Hastings and Popper 2005). The injuries associated with exposure to impulses are referred to as barotraumas, and include hemorrhage and rupture of internal organs, hemorrhaged eyes, and temporary stunning (Yelverton et al. 1973, p. 37; Yelverton et al. 1975, p. 17; Yelverton and Richmond 1981, p. 6; Turnpenny and Nedwell 1994; Hastings and Popper 2005). Death from barotrauma can be instantaneous, occurring within minutes after exposure, or several days later (Abbott et al. 2002). 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. Necropsy results from Sacramento blackfish (*Othodon microlepidotus*) exposed to impulses 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). Sublethal injuries can reduce osmoregulatory efficiency and increase energy expenditure (Gaspin et al. 1976, p. 32; Govoni et al. 2008, p. 1) and can effect equilibrium and interfere with the ability to carry out essential life functions such as feeding and predator avoidance (Gaspin 1975; Turnpenny et al. 1994; Hastings et al. 1996; Popper 2003).

Exposure to impulse can cause the swimbladder of fishes to repeatedly expand and contract, which essentially hammers adjacent tissue and organs that are bound in place near the swimbladder (Gaspin 1975). Exposure to this type of pneumatic pounding (resulting from explosions) can cause rupture of capillaries in the internal organs, as observed in fishes with blood in the abdominal cavity, and maceration of kidney tissues (Abbott et al. 2002; Stadler, pers. comm. 2002).

Yelverton and Richmond (1981, p. 3) and Yelverton and others (1973, p. 9) exposed many fish species, various birds, and terrestrial mammals to underwater explosions. Common to all the species that were exposed to underwater blasts were injuries to air and gas-filled organs, as well as eardrums. These 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. As a sound travels from a fluid medium into these gas-filled structures there is a dramatic drop in pressure which can cause rupture of the hollow organs (Gisiner et al. 1998, p. 61).

10.4.5 Effect Thresholds for Sonar and Explosions

We previously established thresholds for the effects of impulsive sound (i.e., impact pile driving) on the bull trout and the marbled murrelet that we developed in coordination with the inter-agency Fisheries Hydroacoustic Working Group (FHWG) and an interdisciplinary Science Panel. Much of the basis for these thresholds is research of the effects of underwater explosions on fish and birds (Cudahy and Ellison 2002; Gisiner et al. 1998; Hastings and Popper 2005; Yelverton et al. 1973; Yelverton and Richmond 1981).

In 2004, the FHWG proposed the use of a SEL to correlate physical injury to fishes exposed to elevated levels of underwater sound produced during pile driving. Threshold criteria recommended from the FHWG for injury, to salmonids were:

- 206 dBpeak (re: 1 μPa2-sec)
- 187 dB SEL (re: 1 μPa2-sec) for fishes 2 grams or larger
- 183 dB SEL (re: 1 μPa2-sec) for fishes smaller than 2 grams

To address potential impacts of pile driving on marbled murrelets, the Service, in coordination with the Navy, convened an interdisciplinary science panel to develop and recommend interim criteria for evaluation on the onset of injury to the marbled murrelet from underwater sounds (SAIC 2011; 2012). The science panel consisted of technical experts and scientists affiliated with federal agencies, academia, and consulting firms that had expertise in underwater acoustics; sound impacts on fish, marine mammals, and terrestrial and marine birds; and the life history and demography of the marbled murrelet.

In July, 2011, Science Panel I recommended thresholds for marbled murrelets for onset of non-injurious TS in hearing, onset of auditory injury, and onset of non-auditory injury (barotrauma) (SAIC 2011). Thresholds recommended were:

- Non-injurious TS of 187 dB SEL re: 1 µPa2-sec
- Auditory injury threshold of 202 dB SEL re: 1 µPa2-sec
- Barotrauma at 208 SEL re: 1 µPa2-sec

In March, 2012, in response to the lack of data regarding non-injurious TS and masking effects that occur to marbled murrelets from pile driving, the Service and the Navy convened Science Panel II to evaluate the onset of non-injurious TS (SAIC 2011). Science Panel II recommended a threshold for masking and ranges to the masking threshold: 42 meters for piles smaller than 36-inch diameter and 168 meters for piles equal to 36-inch diameter, and recommended moving away from a non-injurious TS threshold.

The Service established these thresholds for all activities involving pile driving. These thresholds are based on research that examined explosions. In the absence of established thresholds related to effects from sonar and underwater explosions, the Service has in the past used these thresholds, derived specifically for pile driving, for the few consultations and/or technical assistance recommendations provided for projects involving explosives or sonar.

For purposes of this analysis, effect thresholds for explosions and sonar were established because application of the pile-driving effect thresholds is not entirely appropriate, as those stressors differ both in magnitude and the mechanism of effect. The Navy proposed new sonar and explosion-specific effect thresholds based on recent work by Popper et al. (2014) and Hawkins and Popper (2014). The Navy also proposed new effect thresholds related to explosions and seabirds that were derived from the same research used by the Service to establish effect thresholds for pile driving (Damon et al. 1974; Yelverton et al. 1973; Yelverton et al. 1975; Yelverton and Richmond 1981). At the request of the Service, a further refinement was conducted by the Navy to scale the explosive impulse effect thresholds so they reflected the differing masses of a marbled murrelet and a short-tailed albatross.

Explosions can result in a variety of effects including, but not limited to, rapid changes in underpressures and overpressures, and strike by fragments traveling at high velocities. Effects and severity will vary depending on where the explosion occurs, in the air, or underwater. In the air, some effects are more severe in the near field (blast zone), while others (e.g., sound and fragmentation) extend further away, into the far field. The energy of a blast pressure wave decays fairly rapidly in the blast zone, and the energy loss (transmission loss) in the far field has relatively slow decay per unit of distance traveled. Depending on the matrix, sound from explosions can travel up to 1,500 meters per second underwater, while sound in air travels slower, around 340 meters per second. Also, when explosives contain an outer casing, the fragments can travel in the air at velocities and to distances that can result in injury beyond the extent of the blast energy (The National Counterterrorism Center 2014b).

An underwater detonation produces a blast 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), and the distance from the detonation site (the strength of the blast pressure wave dissipates with increasing distance). The typical blast pressure wave from an explosion consists of an instantaneous increase of the peak pressure, followed by a slower (but still very rapid) logarithmic decrease to ambient pressure. The pressure wave can be displayed as a waveform that describes the pressure-time history, where time is measured in milliseconds or seconds and pressure is measured in micropascals (μPa).

Exposure to explosions in air or underwater results in similar types of injuries (e.g., barotrauma, mortality, and auditory damage), but severity of injury may vary based on distance from the explosion. For example, if animals are close enough to the detonation they may experience injuries to lungs, eyes, gastrointestinal tract, ears, kidneys, and other organs. The animals' proximity to the explosion will influence the severity and nature of their injuries. Explosive impulses behave differently underwater than in the air because of the different properties of air versus water. Sound travels much faster underwater than in air, while explosive casing fragments will travel much farther and faster in air than underwater. This is why the potential "areas where injury may occur" or "ranges to thresholds" are different when explosions occur in the air versus underwater. Animals will be similarly injured by exposure to an explosion depending on 1) their physiological characteristics, 2) proximity to the explosion, 3) charge weight of the explosive and the energy released upon detonation, and the 4) medium the explosion occurs in (air or water, or both).

When animals are exposed to explosions, behavioral responses can range from stress to avoidance or fleeing the area. Allostasis is 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) (Korte et al. 2005; Mcewen and Wingfield 2003). 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). When stress responses are repeated or chronic, allostatic loading occurs.

Allostatic load refers to the cumulative wear and tear on the body as 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 response (in biotic terms) 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; Korte et al. 2005; Mcewen and Wingfield 2003) that humans commonly associate with stress. These responses are relatively short in duration and may or may not involve significant long-term effects 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, in turn, impair those functions that experience the diversion. For example, when a stress response diverts energy away from growth in young animals, those animals may experience stunted growth. A stress response diverts energy away from egg production, an animal's reproductive success and its fitness may suffer.

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

Relationships between the physiological response 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. 2004; Smith et al. 2004; Trimper et al. 1998). These stress responses are expected from exposure to the following events in which multiple-per-day activities occur; detonations, helicopters in marine waters, and the overflights occurring over nesting habitat in the terrestrial environment (see Aircraft Noise section). We anticipate that when birds experience permanently reduced hearing sensitivity (TS) or repeated exposure to detonations and overflights, they may experience additional physiological effects, including increased risk of predation, reduced reproductive success, and reduced foraging efficiency.

The Navy's use of explosives is expected to be intermittent and interspersed over large areas. The stressors associated with explosives are typically short in duration. In the event that individual bull trout, marbled murrelets, and short-tailed albatross are exposed to explosions and not injured or killed, we expect that they will respond with a startle response, flushing, and/or avoidance behaviors (i.e., diving, or leaving the area). Whether these behavioral responses result in a measureable effect to individuals depends largely on the duration of the exposure, as detailed below.

Table 15 describes the explosives that will be used by the Navy over the next 20 years in Inland Waters of Puget Sound and/or in Offshore Areas. Detonations may occur in the air, underwater, or at the water surface (within 1 meter of the surface). Explosive devices include bombs, missiles, explosive projectiles, shock wave action generators, explosive sonobuoys, and torpedoes.

Table 15. Explosives used in the proposed training and testing activities.

Source Class	Example Ordnance	Net Explosive Weight (pounds [lb.])	NWTT Detonation Matrix (Air, Underwater, Water Surface < 1 m)
< E1	Shock wave action generators	< 0.1	Underwater
E1*	Medium-caliber projectiles	0.1–0.25	At Surface/Air
E3*	Large-caliber projectiles	> 0.5–2.5	Air, Underwater, or Water Surface < 1m
E4	Improved Extended Echo Ranging Sonobuoy	> 2.5–5.0	Underwater
E5*	5-inch projectiles	> 5–10	Air or Water Surface < 1m
E7*	Rolling airframe anti-air missile	> 20-60	Air or Underwater
E8*	MK-46 Torpedo	> 60–100	Underwater
E10*	Air-to-surface missile	> 250–500	Air or Water Surface < 1 m
E11	MK-48 Torpedo	> 500–650	Underwater
E12*	2,000 lb Bomb	> 650–1,000	Air or Water Surface < 1m

* May detonate in the air.

10.4.5.1 Sonar

Sonar signals occur as pulses over a broad range of frequencies. Sonar signals present an adequate stimulus that excites the ear in vertebrates (Northcutt and Gans 1983) or sensory organs in fishes (lateral line or neuromasts) and invertebrates (gravity, pressure, tension, and motion detectors or chordotonal organs) (Sebeok 1977). Thus, we expect that bull trout, marbled murrelets, and short-tailed albatross can detect sonar sounds that contain energy in the frequency range that they can hear.

Sonar sound differs from sound created by explosions and impact pile driving because sonar usually operates at a single frequency or multiple single frequencies operating at once. Sound from explosions and impact pile driving is broadband sound that includes a wide array of frequencies. In the past, the Service considered sonar similar enough to explosions that sonar was analyzed in the same manner as explosions. For this analysis, the Service analyzed the effects of sonar pings as a pure tone rather than as an impulsive sound assuming that sonar operates at a single frequency (or multiple simultaneously operating single frequencies), not a broad range of frequencies like explosions. Therefore, when converting in-air sound data to an equivalent underwater sound we did not apply the extra 15 dB for spectral correction to account for this difference. More information about this approach is provided in the section below on thresholds for sonar.

High-frequency sonar sources are generally lower powered than mid-frequency sources and even with extended durations of use, these sources would not generate a cumulative SEL or operate at durations that would result in injury to bull trout, marbled murrelets, and short-tailed albatross (Commander, Pacific Fleet and Naval Sea Systems Command, in litt. 2016). With tissue injury, or damage to the auditory system, frequencies falling outside the hearing range of the animal may still be important and cannot be automatically discounted; for example, although they may be inaudible, the high frequencies associated with rapid-rise times in impulsive signals may bring about or exacerbate injury (Hawkins and Popper 2014). The sound wave from sonar does not reflect high rise times, like are seen with true impulsive sounds. When high-frequency sonar (greater than 10 kHz) is used, we expect that short-tailed albatross can hear the sonar when the frequencies used are between 10 and 31 kHz, and that marbled murrelets can hear the sonar when the frequencies are between 10 and 11.5 kHz (Nelson 1997; Sanborn et al. 2005; SAIC 2012). A complete list of sonar operated by the Navy is described in Table 16.

10.4.5.1.1 Effects of Sonar on Bull Trout

Some research on mid-frequency active sonar has shown that it does not result in physiological damage to adult fish (Halvorsen et al. 2013; Jorgensen et al. 2005; Kvadsheim and Sevaldsen 2005). Injury and mortality may occur at higher sound levels, but this has not been tested (Popper et al. 2014, p. 48). Sonar may induce TTS in some fish with swim bladders involved in their hearing (Halvorsen et al. 2012; Halvorsen et al. 2013).

There are no published studies specific to the effects of sonar on bull trout. However, there are some data specific to the effects of sonar on other fishes (Doksaeter et al. 2012; Halvorsen et al. 2012; Halvorsen et al. 2013; Kane et al. 2010) and we relied on this information in our analysis of the effects of sonar on bull trout. The general structure of the auditory system, and the lack of specializations for enhanced hearing, is the same in all salmonids; the inner ear is very similar for rainbow trout, Atlantic salmon, Chinook salmon, and other salmonids (Popper et al. 2007, p. 624). Therefore, we expect bull trout hear similarly as other salmonids.

Table 16. Source bins for sonar used in the proposed training and testing activities.

Source Class Category	Source Class	Description
Low-Frequency (LF): Sources that produce low-frequency (less than 1 kHz) signals	LF4	Low-frequency sources equal to 180 dB and up to 200 dB
	LF5	Low-frequency sources less than 180 dB
Mid-Frequency (MF): Tactical and non-tactical sources that produce mid-frequency (1 to 10 kHz) signals	MF1	Hull-mounted surface ship sonar (e.g., AN/SQS-53C and AN/SQS-60)
	MF3	Hull-mounted submarine sonar (e.g., AN/BQQ-10)
	MF4	Helicopter-deployed dipping sonar (e.g., AN/AQS-22 and AN/AQS-13)
	MF5	Active acoustic sonobuoys (e.g., DICASS)
	MF6	Active underwater sound signal devices (e.g., MK-84)
	MF8	Active sources (greater than 200 dB)
	MF9	Active sources (equal to 180 dB and up to 200 dB)
	MF10	Active sources (greater than 160 dB, but less than 180 dB) not otherwise binned
	MF11	Hull-mounted surface ship sonar with an active duty cycle greater than 80 percent
	MF12	High duty cycle – variable depth sonar
High-Frequency (HF): Tactical and non-tactical sources that produce high-frequency (greater than 10 kHz but less than 100 kHz) signals	HF1	Hull-mounted submarine sonar (e.g., AN/BQQ-10)
	HF3	Hull-mounted submarine sonar (classified)
	HF4	Mine detection, classification, and neutralization sonar (e.g., AN/SQS-20)
	HF5	Active sources (greater than 200 dB)
	HF6	Active sources (equal to 180 dB and up to 200 dB)
Very High-Frequency (VHF): Tactical and non-tactical sources that produce signals greater than 100 kHz but less than 200 kHz	VHF2	Active sources with a frequency greater than 100 kHz, up to 200 kHz with a source level less than 200 dB
Anti-Submarine Warfare: Tactical sources such as active sonobuoys and acoustic countermeasures systems used during the conduct of ASW training and testing activities	ASW1	Mid-frequency Deep Water Active Distributed System (DWADS)
	ASW2	Mid-frequency Multistatic Active Coherent sonobuoy (e.g., AN/SSQ-125) – sources analyzed by number of items (sonobuoys)
	ASW2H	Mid-frequency Multistatic Active Coherent sonobuoy (e.g., AN/SSQ-125) – Sources that are analyzed by hours
	ASW3	Mid-frequency towed active acoustic countermeasure systems (e.g., AN/SLQ-25)
	ASW4	Mid-frequency expendable active acoustic device countermeasures (e.g., MK-3)
Torpedoes (TORP): Source classes associated with the active acoustic signals produced by torpedoes	TORP1	Lightweight torpedo (e.g., MK-46, MK-54)
	TORP2	Heavyweight torpedo (e.g., MK-48, electric vehicles)
Acoustic Modems (M): Systems used to transmit data acoustically through the water	M3	Mid-frequency acoustic modems and similar sources (up to 210 dB) (e.g., UEWS, ATN)
Swimmer Detection Sonar (SD): Systems used to detect divers and submerged swimmers	SD1	High-frequency sources with short pulse lengths, used for the detection of swimmers and other objects for the purpose of port security.
Synthetic Aperture Sonar (SAS): Sonar in which active acoustic signals are post-processed to form high-resolution images of the seafloor	SAS2	High-frequency UUV (e.g., UUV payloads)

Notes: ATN = aid to navigation, dB = decibels, DICASS = Directional Command Activated Sonobuoy System, kHz = kilohertz, UEWS = underwater emergency warning system, UUV = unmanned underwater vehicle, all sound pressure levels are rms values.

Salmonids can detect sound at frequencies between 10 Hz (Knudsen et al. 1997, p. 828) and 600 Hz (Mueller et al. 1998, p. 2). Hawkins and Johnstone (1978, p. 660) found salmon did not respond to frequencies greater than 380 Hz regardless of the sound level, but there was a clear response from salmon at 580 Hz, but only at high sound levels and under special conditions. Popper et al. (2007, p. 623) found the most significant auditory threshold shift occurred in rainbow trout at 400 Hz with sound levels up to 193 dB rms re: 1 µPa. A sound level of 193 dB rms is estimated to be associated with a cumulative SEL of approximately 210 dB (re: 1 µPa). Therefore, based on the best available information, we expect that when sonar is operated within the hearing range of bull trout (up to approximately 600 Hz) and exceeds 210 dB SEL, the exposed fish may experience injury, including injury associated with TTS in which hair cells or hairs in the inner ear are damaged.

Sounds outside the hearing range of the animals, that are inaudible, may be capable of causing damage to tissues, particularly, but not exclusively, high frequencies associated with rapid-rise times, which could bring about or exacerbate injury (Popper et al. 2014, p. 6). There is a dearth of evidence demonstrating that inaudible sound cause injury to fish with swim bladders that are not associated with their hearing (e.g., bull trout); therefore, we cannot be reasonably certain that injury would occur. Based on the best available science, we assume that if bull trout cannot hear the sonar because it is at a frequency outside the their range of hearing, that they would not injured by it as long as the amplitude does not result in particle motion and pressure changes that can cause injury to them.

Salmonids only hear up to ~ 600 Hz; therefore, we expect that bull trout can hear low-frequency sonar, and can’t hear mid- or high-frequency sonar. However, if the amplitude of the sonar is high enough, we expect they can detect it when particle motion is stimulated sufficiently to incite their lateral line detection of pressure change, regardless of the frequency. The Navy acknowledged this by providing a threshold and ranges to effects related to mortality/injury of cumulative sound that exceeds 218 dB SEL (see above) for low-frequency sonar and greater than 221 for mid-frequency sonar. Because high-frequency sonar attenuates so rapidly, and the range to effects were so small, exposure of bull trout was considered extremely unlikely and thresholds and range to effects were not established.

Low-frequency sonar (400 Hz) induced TS in fish with swim bladders that are not involved in their hearing. Rainbow trout experienced 20 dB of TS at 193 dB rms and this TS was considered temporary because sensory tissue of the inner ear did not show morphological damage after several days post-exposure (Popper et al. 2007, p. 623). However, Popper et al. (2007, p. 623) performed the inner ear histology prior to four days post-exposure and there is evidence that damage may develop slowly after exposure, possibly taking at least 4 days before the damage manifests and is observable (Hastings et al. 1996, p. 1789). Low-frequency active sonar has the potential to damage any number of organs in fishes due to the sound intensity and can also directly affect hearing because the ears of fishes detect the operational frequency range of the sonar (Popper et al. 2007, p. 624).

Data for mortality and injury related to low- and mid-frequency sonar are based on Popper et al. (2007), Halvorsen et al. (2012), and Kane et al. (2010), which showed no effect on the ear or non-auditory tissues when the maximum received sound pressure levels were at 193 dB re: 1 µPa for low frequency sonar, and at 210 dB re: 1 µPa for mid-frequency sonar; injury, if it occurs, is thought to begin at higher sound levels than tested to date. Fish may die when exposed to SPLs from non-impulsive sound for longer periods of time, experiencing internal bleeding, transient stunning, and mortality when exposed to SPLs between 192 and 204 dB peak re: 1 µPa (Hastings 1995, p. 981). Injury and mortality may occur at higher sound levels than those that resulted in TS of 20 dB, at 193 dB rms re: 1 µPa, but this has not been tested (Popper et al. 2014, p. 48); almost nothing is known about the potential effects of sound to organs other than auditory (Popper et al. 2007, p. 624).

Mid-frequency sonar has not been shown to result in non-auditory physiological damage to some adult fish (Halvorsen et al. 2013; Jorgensen et al. 2005; Kvadsheim and Sevaldsen 2005), while other research showed channel catfish experienced statistically significant levels of TS of 4-6 dB at 2,300 Hz (Halvorsen et al. 2012). The hearing sensitivity of rainbow trout was not affected by sonar below 3,800 Hz (both fish exposed to a cumulative SEL of 220 dB re: 1 µPa2-sec) (Halvorsen et al. 2012). However, the hearing range of rainbow trout is lower than the frequencies that were present in the mid-frequency sound for this action (lower than 2,800 Hz) (Halvorsen et al. 2012), and histology of these fish may have been performed prior to manifestation of the damage. Kane (2010) exposed salmonids to low- and mid-frequency sonar and found "no immediate effects from low-frequency sonar" and "no apparent effects of mid-frequency sonar." However, inner ear histology occurred prior to four days post-exposure (within 48 hours post-exposure) and there is evidence that damage may develop slowly after exposure, possibly taking at least four days before the damage is evident and observable (Hastings et al. 1996, p. 1789).

We expect bull trout hearing to be most similar to other salmonids and we expect they would experience similar effects to their hearing from the same sound sources. Therefore, we do not expect bull trout can hear frequencies greater than 600 Hz or the mid-frequency sonar proposed by the Navy for this consultation.

The Service's sonar thresholds, developed in coordination with the Navy and NMFS, and the distances to these thresholds, calculated by the Navy upon request by the Service, are shown in Table 17. Thresholds were not developed for high-frequency sonar as bull trout and other salmonids are not expected to detect sounds at these frequencies (Popper et al. 2014, p. 31), and because the energy contained in high-frequency sonar emissions is not expected to accumulate to levels that exceed our effect thresholds.

10.4.5.1.1.1 Effects of Sonar on Bull Trout in the Inland Waters Subunit

Bull trout will be exposed to sonar within the Inland Waters at Naval Base Kitsap Bangor, Naval Base Kitsap Bremerton, Carr Inlet, Keyport Range Site, Dabob Bay Range Complex, and Naval Station Everett. Bull trout will also be exposed to the Maritime Homeland Defense/Security Mine Countermeasures Integrated Exercise Activity that can occur anywhere in Puget Sound. Bull trout will not be exposed to sonar in the Offshore Area because all sonar use will be conducted greater than 3 nm from shore, while bull trout are only expected to occur along the shoreline within inland waters sites.

10.4.5.1.1.1.1 Exposure

At Naval Station Everett, mid-frequency sonar (sonar source bin MF1) is used during both surface ship sonar maintenance, and pierside sonar testing activities. For surface ship sonar maintenance, the Navy estimates that up to six sonar maintenance events could occur each year. The sonar may operate for up to two hours during each of the four-hour maintenance events for a total of 12 hours. For pierside sonar testing, eight events could occur per year, with up to four hours of sonar use (MF1) for a total of 32 hours.

The area of effect for an unspecified period of sonar emissions is approximately 226 m^2. This area of effect was calculated by multiplying 12 m by 12 m, and then multiplying by 3.14 to calculate the total area (area of a circle = π r2) ensonified by sonar. The area of effect was then divided by half because it does not include areas under ships or piers as fish have been found to avoid the sharp light gradients resulting from the shade under piers (Munsch et al. 2014).

The Navy concluded that bull trout could not hear high-frequency sonar but could experience mortality and injury from mid-frequency sonar when the sonar amplitude exceeds higher than 221 dB SEL re: 1 µPa (see thresholds in Table 17). The Navy did not provide the range to effects (i.e., the distance from the sonar source at which injury of bull trout is likely to occur) for bull trout for TTS, but did provide range to effects for mortality and injury. The Service considers TTS in bull trout an effect that significantly disrupts normal behavioral patterns such that it creates a likelihood of injury. The distance to the onset of injury (for source bin MF1) is less than 12 m.

10.4.5.1.1.1.2 Response

Sonar will be used at Naval Base Kitsap Bangor, Naval Base Kitsap Bremerton, Carr Inlet, Keyport Range Site, and Dabob Bay Range Complex. These locations are in south Puget Sound, the Kitsap Peninsula, including Vashon Island and Bainbridge Island, and the eastern shore of Hood Canal. Bull trout use of these areas is rare, and considered extremely unlikely.

Bull trout may be exposed to sonar emissions at Naval Station Everett, and during the Maritime Homeland Defense/Security Mine Countermeasures Integrated Exercise Activity in Puget Sound. Only high-frequency sonar is used for the maritime homeland defense/security mine countermeasures integrated exercise activity in Puget Sound. We do not expect measureable effects from high-frequency sonar to bull trout as salmonids are not able to detect these frequencies (Popper et al. 2014, p. 31) and there won’t be a behavioral response. Also, the energies contained in high-frequency sonar emissions are not expected to accumulate to levels that exceed our threshold for TTS, or injury and mortality.

Table 17. Navy-developed distance threshold for adverse effects to bull trout caused by sonar, and the Service's injury or mortality thresholds for bull trout exposure to sonar.

Sonar Bins	**Mortality (meters)**	**Injury not including TTS (meters)**	**TTS associated with injury (meters)**
LF4	0	0	2
LF5	0	0	0
ASW2	0	0	n/a (can't hear)
MF1	<< 12	< 12	n/a (can't hear)
MF3	<< 2	< 2	n/a (can't hear)
MF4	0	0	n/a (can't hear)
MF5	0	0	n/a (can't hear)
MF6	0	0	n/a (can't hear)
MF8	<< 15	< 15	n/a (can't hear)
MF9	0	0	n/a (can't hear)
MF10	0	0	n/a (can't hear)
MF11	<< 6	< 6	n/a (can't hear)
MF12	<< 5	< 5	n/a (can't hear)
ASW4	<< 1	< 1	n/a (can't hear)
M3	0	0	0
Sonar Thresholds	**Mortality (**dB SEL re: 1 μPa^2-sec)	**Injury not Including TTS** (dB SEL re: 1 μPa^2-sec)	**TTS** Associated with Injury (hair cell damage/loss) (dB SEL re: 1 μPa^2-sec)
Low Frequency	>>218[a]	>218[a]	210[b]
Mid Frequency	>>221[c]	>221[c]	cannot hear

[a] (Kane et al. 2010; Popper et al. 2007)
[b] (Halvorsen et al. 2013; Popper et al. 2007). The Navy expects TTS in some rainbow trout at 210 dB SEL and used this value because it was considered most conservative (Navy thresholds document, dated 8/5/15).
[c] (Kane et al. 2010; Popper et al. 2007)

For surface ship sonar maintenance and pierside sonar testing, bull trout at Naval Station Everett that are within 12 m of MF1 sonar emissions may experience injury when the amplitude of the sonar exceeds 221 dB SEL re: 1 µPa2-sec. The Service expects that if bull trout were sufficiently exposed to MF1 sonar emissions with amplitudes greater than 221 dB SEL re: 1 µPa2-sec, they would be injured or killed. However, bull trout are mobile and their exposure to sonar greater than 221 dB SEL re: 1 µPa2-sec is not expected to be of durations that are reasonably certain to result in injury.

10.4.5.1.1.1.3 Conclusion

Sonar use for the Maritime Homeland Defense/Security Mine Countermeasures Integrated Exercise Activity in Puget Sound consists of only high frequency for which we expect the effects to be insignificant. An unknown number of bull trout will be exposed to MF1 sonar emissions at Naval Station Everett. Up to 44 hours of MF1 sonar will be used along the piers, with an area of effect of 226 m^2 waterward of the source where MF1 sonar emission occurs. However, bull trout are transitory (moving), and their exposure to sonar greater than 221 dB SEL re: 1 µPa2-sec is not expected to be for sufficient durations to result in injury.

10.4.5.1.2 Marbled Murrelet

10.4.5.1.2.1 Thresholds and Evaluation Criteria

There are no published studies specific to sonar and its effects on marbled murrelets, or any other seabird. In the absence of controlled studies specific to seabirds, we applied data from in-air sound that caused TS (Ryals et al. 1999) and applied correction factors for impedance and the different reference pressures between air and water. Correction factors included adding a total of 36 dB to the dB level where TS occurred for impedance and an additional 26 dB for the difference in air to water reference pressure.

Hearing sensitivity in birds may be reduced while underwater. Audiograms of several bird species found sensitivity sharply falls off at the lower and upper bounds of avian hearing (Crowell et al. 2015; Dooling et al. 2000). Dooling et al. (2000) noted that the average avian audiogram shows a loss of sensitivity below 1 kHz of ~20dB/octave and a loss of sensitivity at high frequencies above 4 kHz of ~60 dB/octave. Additionally, there is typically a shift in sensitivity to lower frequencies when sounds are presented underwater versus in-air to the same species (Dooling and Therrien 2012). Based on this information, we expect the upper range of hearing for marbled murrelets is decreased by approximately 1 kHz when underwater.

Several categories of the proposed sonar are not expected to exceed the injury threshold (220 dB SEL re 1 µPa2-sec) because the amplitude of the source levels are lower than approximately 180 to 200 dB peak (we assumed the values in Table 16, provided by the Navy, are peak dB levels). With these peak amplitudes, we do not expect injury to birds because the duration of this exposure would not result in exposure to SEL's greater than 220 dB.

The Service expects that all low- and mid-frequency sonar (0.5 kHz to 10 kHz) is audible to marbled murrelets (Sanborn et al. 2005) and lower portions of high-frequency sonar are also audible. Based on the best available science, we expect marbled murrelets can hear frequencies between 0.48 kHz to 11.5 kHz while underwater (Nelson 1997; Sanborn et al. 2005; SAIC 2012; Sparling Jr. 1977). When sonar operates at frequencies between 0.5 kHz and 10 kHz (low- and mid-frequencies) we expect marbled murrelets can hear it and if cumulative SELs exceed 220 dB SEL we expect them to experience auditory injury.

The Service coordinated with the Navy to develop thresholds for onset of injury to marbled murrelets (Table 16). The Service asked the Navy to provide the range to effects (i.e., the distance from the sonar source at which injury of marbled murrelets is likely to occur) for sonar assuming marbled murrelet exposure occurred for a single ping, 5 minutes of pinging, and 30 minutes of pinging. Because marbled murrelets are highly mobile, we used the range to effects for single ping and 5 minutes, assuming that marbled murrelets would not be exposed for durations longer than that by mobile sonar. For stationary sources of sonar (pierside), we assumed they may be exposed to up to 5 minutes of sonar pings because sources of prey may attract them within an exposure area. The assumptions made in our exposure analysis are described in detail in Appendices A and G.

For some of the sonar proposed, the Navy provided the number of units (sonobuoys, torpedoes, etc.) that would be used throughout the year and stated that each unit would typically transmit for 8 minutes (Fitzgerald, pers. comm. 2015). To conduct the exposure analysis for sonar with count units (i.e., 8 minute transmissions) rather than hours, the Service assumed that marbled murrelets would be exposed to up to five minutes of any given eight-minute transmission.

There are several activities using very high- and high-frequency sonar that were categorized by the Navy as “de minimis” (well outside the hearing range of the bird) and had operational parameters that the Navy did not anticipate would result in any exposure. No detailed information on quantity, duration, etc., was provided by the Navy. The Navy did note that these activities could emit sonar intermittently for 8 hours per day, could continue for up to 40 hours, and could be operated infrequently and intermittently for multiple, consecutive weeks. The Navy determined that the potential effects from these emissions were discountable to marbled murrelets. Based on the information that we do have on these emissions, it appears that peak sound levels will not exceed 160 dB peak and therefore will not operate at frequencies, and for durations, that would exceed the threshold for auditory injury (220 dB SEL re: 1µPa2-sec). Therefore, we anticipate that while exposure may occur, the effects would be insignificant.

10.4.5.1.2.2 Effects of Sonar on Marbled Murrelets in the Inland Waters Subunit

10.4.5.1.2.2.1 Exposure

The area of exposure for sonar is defined by the range to effects, which is based on the sonar amplitude, ping rate, and duration of pinging (i.e., the distance from the sonar source at which we expect marbled murrelets may be injured by exposure to sonar) provided by the Navy (Table 18); however, not all of this information was provided to the Service due to classification of the data. Based on the range to effects we analyzed the effects of sonar on marbled murrelets by first defining the area of exposure and then determining the likelihood of marbled murrelet exposure (see Appendices A and H for the probability of exposure in the Offshore Area and number of groups exposed within the action area and Appendix G for the probability of exposure in the Inland Waters). Table 19 describes sonar use where the probability of exposure is considered insignificant or discountable. These are primarily moving sources of sonar. Marbled murrelet exposure to moving sources of sonar of any frequency, including high-frequency sonar, is expected to result in insignificant effects because both the sonar source and marbled murrelets are transitory and exposure is unlikely to occur for durations that would result in injury. Other sonar used in Inland Waters had a range to effect of zero meters, meaning that emissions of sonar at these frequencies will not result in exposures that exceed the threshold for onset of injury. We did not calculate the probability of exposure of marbled murrelets to the sonar bins in Table 20 because we determined the effects would be insignificant, and there was no need for further analysis.

Table 18. Navy-developed distance thresholds for adverse effects to the marbled murrelet caused by sonar and the Service's injury thresholds for marbled murrelet from sonar.

Sonar Bin	Auditory Injury (meters)	
	Marbled Murrelet Single Ping	**Marbled Murrelet 5-minutes pinging**
LF4	0	0
LF5	0	0
ASW2	0	0
MF1	6	14
MF3	<1	2
MF4	0	0
MF5	0	0
MF6	0	0
MF8	1	17
MF9	0	0
MF10	0	0
MF11	1	7
MF12	<1	5
ASW4	<1	1
M3	0	0
Sonar Thresholds	**Auditory Injury (**dB SEL re: 1 μPa^2-sec)	
Low Frequency	220	
Mid Frequency	220	

Table 19. Sonar effects to the marbled murrelet in the Inland Waters Subunit that are insignificant or discountable.

Sonar BIN	Hours per year	Range to Onset Injury (meters)	Probability of marbled murrelets exposure over 20 years
Bangor - Kitsap			
Pierside Acoustic Testing: Operating Autonomous Underwater Vessels, remotely operated vessels, unmanned undersea vessels, and submersibles and prototypes.			
LF5	**30**	0	n/a, 0 rte*
MF10	**30**	0	n/a, 0 rte
Pierside Sonar Testing			
HF1	121	n/a - Insignificant	n/a - Insignificant
HF3	6	n/a - Insignificant	n/a - Insignificant
MF9	**80**	0	n/a, 0 rte
M3	**29**	0	n/a, 0 rte
Shipboard Protection Systems and Swimmer Defense Testing - Pierside Integrated Swimmer Defense			
LF4	12	0	n/a, 0 rte
SD1	228	n/a - Insignificant	n/a - Insignificant
Bremerton			
Pierside Acoustic Testing: Operating Autonomous Underwater Vessels, remotely operated vessels, unmanned undersea vessels, and submersibles and prototypes.			
LF5	**30**	0	n/a, 0 rte
MF10	**30**	0	n/a, 0 rte
Pierside Sonar Testing			
HF1	40	n/a - Insignificant	n/a - Insignificant
HF3	2.5	n/a - Insignificant	n/a - Insignificant
MF9	**120**	0	n/a, 0 rte
Carr Inlet			
Performance At-Sea Testing: Operating Autonomous Underwater Vessels, remotely operated vessels, unmanned undersea vessels, and submersibles and prototypes.			
M3	**29**	0	n/a, 0 rte
SAS2	**14**	n/a - Insignificant	n/a - Insignificant
System, Subsystem, and Component Testing - Development Training and Testing			
HF6	**58**	n/a - Insignificant	n/a - Insignificant
M3	**115**	0	n/a, 0 rte

Table 19. Sonar effects to the marbled murrelet in the Inland Waters Subunit that are insignificant or discountable.

Sonar BIN	Hours per year	Range to Onset Injury (meters)	Probability of marbled murrelets exposure over 20 years
Proof of Concept Testing			
HF6	**19**	n/a - Insignificant	n/a - Insignificant
M3	**67**	0	n/a, 0 rte
SAS2	**14**	n/a - Insignificant	n/a - Insignificant
Dabob Bay			
Torpedo Testing			
TORP1	42 counts x 2.5 hrs/day = **105**	n/a - Insignificant	n/a - Insignificant
TORP2	147 counts x 2.5 hrs/day = **368**	n/a - Insignificant	n/a - Insignificant
Autonomous & Non-Autonomous Vessels (Unmanned Underwater Vessel (UUV))			
SAS2	**43**	n/a - Insignificant	n/a - Insignificant
TORP1	67 counts x 2.5 hrs/day = **168**	n/a - Insignificant	n/a - Insignificant
TORP2	67 counts x 2.5 hrs/day = **168**	n/a - Insignificant	n/a - Insignificant
Fleet Training/Support - Post-Refit Sea Trial			
M3	**32**	0	n/a, 0 rte
MF10	**79**	0	n/a, 0 rte
Acoustic Component Test - Countermeasure Testing			
Acoustic Component Test - Acoustic Test Facility (pierside)			
HF6	**22**	n/a - Insignificant	n/a - Insignificant
LF4	**3**	0	n/a, 0 rte
MF9	**7**	0	n/a, 0 rte
VHF2	**2**	n/a - Insignificant	n/a - Insignificant
Performance At-Sea Testing: Operating Autonomous Underwater Vessels, remotely operated vessels, unmanned undersea vessels, and submersibles and prototypes. Sonar use shared between UUV and towed device configurations.			
M3	**115**	0	n/a
SAS2	**58**	n/a - Insignificant	n/a - Insignificant
System, Subsystem, and Component Testing - Development Training and Testing			
HF6	**230**	n/a - Insignificant	n/a - Insignificant
M3	**461**	0	n/a, 0 rte

Table 19. Sonar effects to the marbled murrelet in the Inland Waters Subunit that are insignificant or discountable.

Sonar BIN	Hours per year	Range to Onset Injury (meters)	Probability of marbled murrelets exposure over 20 years
Proof of Concept Testing			
HF6	**77**	n/a - Insignificant	n/a - Insignificant
M3	**269**	0	n/a, 0 rte
SAS2	**58**	n/a - Insignificant	n/a - Insignificant
Unmanned Vessel Testing-Unmanned Vessel Development and Payload Testing			
MF9	**240**	0	n/a, 0 rte
Anti-Surface Warfare/Anti-Submarine Warfare Testing			
Duration: max. ten 30 minute runs per day, 40 torpedoes per test event. 13 events/yr.			
TORP1	21 counts x 5 min/count = **105 min**	n/a - Insignificant	n/a - Insignificant
Keyport			
Autonomous & Non-Autonomous Vessels (Unmanned Underwater Vessel (UUV))			
M3	220	0	n/a, 0 rte
SAS2	220	n/a - Insignificant	n/a - Insignificant
Fleet Training Support - Cold Water Training			
HF	320	n/a - Insignificant	n/a - Insignificant
Acoustic Component Test - Acoustic Test Facility (pierside)			
HF6	435	n/a - Insignificant	n/a - Insignificant
LF4	67	0	n/a, 0 rte
MF9	134	0	n/a, 0 rte
VHF2	33	n/a - Insignificant	n/a - Insignificant
Acoustic Component Test-Pierside Integrated Swimmer Defense (boat or pierside)			
LF4	16	0	n/a, 0 rte
SD1	301	n/a - Insignificant	n/a - Insignificant
Shipboard Protection Systems and Swimmer Defense Testing - Pierside Integrated Swimmer Defense			
LF4	12	0	n/a, 0 rte
SD1	228	n/a - Insignificant	n/a - Insignificant
Unmanned Vessel Testing-Unmanned Vessel Development and Payload Testing			
MF9	240	0	n/a, 0 rte

Table 19. Sonar effects to the marbled murrelet in the Inland Waters Subunit that are insignificant or discountable.

Sonar BIN	Hours per year	Range to Onset Injury (meters)	Probability of marbled murrelets exposure over 20 years
Puget Sound (location unspecified and varies)			
Maritime Homeland Defense/Security Mine Countermeasures Integrated Exercise			
HF4	384	n/a - Insignificant	n/a - Insignificant

Note: A value of "0" indicates that the source level is below the criteria threshold even after accumulation of multiple pings (as provided by the Navy comments to Draft Opinion).
*rte = range to effects

Marbled murrelet exposure to sonar use in the Inland Waters Subunit is discussed below and addressed in Table 20. This exposure involves stationary sources of sonar.

Table 20. Sonar use in the Inland Waters Subunit that is expected to result in exposure to marbled murrelets, and the expected number of marbled murrelet groups exposed over the 20-year term of the proposed action.

Sonar BIN	Range to Onset Injury /Area of Effect	Probability of marbled murrelets exposure over 20 years*	Expected number of murrelet groups exposed over all 20 years*
Bangor - Kitsap			
Pierside Sonar Testing			
MF3**	2 m/0.00001256637 km^2	0.092	0.034
Shipboard Protection Systems and Swimmer Defense Testing - Pierside Integrated Swimmer Defense			
MF8	17 m/0.0009079203 km^2	0.85	0.652
Bremerton			
Submarine Sonar Maintenance & Pierside Sonar Testing			
MF3**	2 m/0.00001256637 km^2	0.21	0.030
Everett			
Surface Ship Sonar Maintenance & Pierside Sonar Testing			
MF1**	14 m/0.0006157522 km^2	0.99	0.590
Keyport			
Acoustic Component Test -Countermeasure Testing			
ASW4**	2 m/0.00001256637 km^2	0.91	0.020
Acoustic Component Test-Pierside Integrated Swimmer Defense (boat or pierside) & Shipboard Protection Systems and Swimmer Defense Testing - Pierside Integrated Swimmer Defense			
MF8	17 m/0.0009079203 km^2	1.0***	0.554

* Probability of exposure is based on exposure of one or more individuals (groups of one or more birds) in the "reasonable worst-case" scenario (see Appendix G), while the expected number of murrelet groups exposed was based on the "reasonably certain" scenario.

** Marbled murrelet exposure to MF1, MF3, and ASW4 sonar is not discountable but also is not reasonably certain to occur.

*** Whenever the probability was greater than or equal to 0.995, we rounded up to 1.0.

To determine the likelihood of marbled murrelet exposure to sonar, we used data from the NWFPEM to estimate densities of marbled murrelets at-sea during the summer. The NWFPEM effort provides annual estimates of marbled murrelet abundance for each Conservation Zone during the summer season from 2001 through 2015 (Falxa and Raphael 2015). Using the most recent population estimates from Falxa et al. (2015), Conservation Zone 1 had a predicted marbled murrelet population size of 4,290 birds during the summer of 2015; however, population trend information is not yet available. In 2014, there was evidence of a continued decline in population in Conservation Zone 1 (Inland Waters) of -5.4 percent between 2001 and 2014 (Falxa et al. 2015, p. 3).

Since marbled murrelet distribution and density varies spatially, seasonally, and temporally in Inland Waters (Conservation Zone 1, which includes all of Puget Sound and the Strait of Juan de Fuca), we used the most recent five year average at the Stratum level to estimate the density of birds in each Stratum in Conservation Zone 1. Strata are geographic area subdivisions of conservation zones with different densities of marbled murrelet and ecological factors. We did not predict density at a scale below the Stratum level (e.g., PSU) because it would introduce error if used to predict density over the long term. We then used a Poisson probability model, based on marbled murrelet density, to evaluate the likelihood of one or more marbled murrelet groups being within the range of a critical threshold (i.e., within proximity to the stressor where the onset of injury in likely to occur). Sonar, detonations, and other stressors within the Inland Waters Subunit may overlap with marbled murrelets when the bird is foraging underwater. We considered the foreseeable future as the next 20 years when determining the cumulative probability.

Based on the location, frequency, and duration of sonar use in the Inland Waters Subunit, and using the threshold distances discussed above, we estimated the number of marbled murrelet groups exposed to elevated SPL. For a more detailed description of how marbled murrelet density in the Inland Waters Subunit was determined and how reasonable worst-case exposure was calculated, please see Appendix G. For a more detailed description of how we determined when marbled murrelets were reasonably certain to be exposed, please see Appendix A.

10.4.5.1.2.2.2 Response

Exposure to elevated SPLs from sonar is likely to adversely affect adult and sub-adult marbled murrelets while underwater, resulting in TS, which can be associated with injuries in the inner ear. Individual marbled murrelets that experience TS may not be able to detect biologically relevant sounds such as approaching predators or prey, and/or hear their mates attempting to communicate. Birds that experience hearing impairment are at increased risk of predation and reduced foraging efficiency. Some birds may regain some or all of their hearing sensitivity. However, they are still temporarily at risk while experiencing TS. Additionally, marbled murrelets that are exposed to sonar but do not experience TS may respond by flushing or temporarily ceasing to forage. However, under those circumstances, they are expected return to normal behaviors in a short period of time.

Some of the proposed sonar use in the Inland Waters Subunit is not expected to exceed the thresholds for onset of injury (220 dB SEL re: 1 μPa2-sec) due to its particular peak amplitudes or durations. Such exposures would result in insignificant or discountable effects to the marbled murrelet (Table 20). With stationary sources of sonar, marbled murrelets are not likely to be close enough to the sonar source for adverse effects to occur. Marbled murrelets tend to dive in U-shaped configurations, generally moving away from the location where they dive, thus reducing the likelihood of a longer than 5-minute duration of exposure to sonar. With moving sources of sonar, we do not expect that exposure of marbled murrelets to elevated SPLs is reasonably certain to occur. Both the source of the sonar and the birds are moving, which further reduces the likelihood that diving birds would be within the threshold distance for sufficient durations for adverse effects to occur.

Given the relatively small area of exposure (less than 12.6 m^2/0.0000126 km^2) for MF3 and ASW4 sonar, it is not reasonable to expect that marbled murrelets are likely to be injured from MF3 and ASW4 sonar use.

For MF1 sonar, the area of effect for one five-minute period of sonar emissions (615 m^2/0.0006 km^2/0.00017 nm^2) and the distance threshold for adverse effects is larger than MF3 and ASW4 sonar (MF1 exceeds onset of injury threshold to 14 meters; see Table 20), which increases the potential for exposure. Therefore, there is an increased opportunity and likelihood of marbled murrelet exposure to MF1 sonar emissions. Based on our modeling results of marbled murrelet distribution and abundance within the action area (see Appendices A and G), 0.590 groups (=1.18 birds, assuming 2 birds per foraging group) of marbled murrelets could be exposed to injurious SPLs from MF1 sonar activities over the next 20 years. Our modeling results showed that marbled murrelet exposure to MF1 sonar is not discountable. Since exposure to MF1 sonar is neither insignificant nor discountable, MF1 sonar is likely to adversely affect marbled murrelets. However, in the "reasonably certain" scenario, there was a 55 percent probability that no murrelet groups would be exposed over the next 20 years, so we are not reasonably certain that murrelets will be exposed to injurious SPLs from MF1 sonar.

For MF8 sonar, which occurs in two locations, Bangor and Keyport, the area of effect for one five-minute period of sonar emissions (908 m^2/0.0009 km^2/0.00026 nm^2) and the distance threshold for adverse effects are larger than for MF1 (MF8 exceeds onset of injury threshold to 17 meters; see Table 20). Therefore, there is an increased opportunity for and likelihood of marbled murrelet exposure to MF8 sonar emissions. Based on our modeling results of marbled murrelet distribution and abundance within the action area (see Appendices A and G), 1.2 groups (2.4 birds, assuming 2 birds per foraging group) of marbled murrelets are likely to be exposed to elevated SPLs from MF8 sonar activities over the next 20 years at distances from the sonar source where injury is likely to occur. Our analysis of the "reasonably certain" scenario showed a 70 percent probability that one or more murrelet groups would be exposed, and a 34 percent probability that two or more groups would be exposed.

10.4.5.1.2.2.3 Conclusion

A total of 1.8 groups of marbled murrelets (3.6 birds, assuming 2 birds per foraging group) may be exposed to injurious SPLs from MF1 and MF8 sonar activities over the next 20 years, but only the exposure of 1.2 groups of birds (2.4 murrelets) from MF8 sonar is reasonably certain to occur. We used an exposure model to estimate the number of marbled murrelets that may be affected by sonar because there is significant variability in marbled murrelet distribution and density in the marine environment. Affected individuals would be difficult to detect as they may show no outward signs of injury, mortality may be delayed, and affected birds may leave the area. Our model includes explicit assumptions about the seasonal distribution of marbled murrelets and the extent of the potential effects.

The area of habitat reasonably certain to be subject to elevated SPLs from MF8 sonar emissions, at distances where injury to marbled murrelets is likely to occur, can be reliably quantified as 908 m^2 (0.0009 km^2 or 0.00026 nm^2) per five-minute period of sonar emissions. Because we analyzed a total of 40 hours of MF8 sonar per year for 20 years, the total cumulative area affected (i.e., the sum of all individual areas of effect) will be 435,840 m^2 (0.44 km^2 or 0.13 nm^2). We assume that each sonar emission will be emitted from the same place at each of the two locations (Bangor and Keyport), so these effects will be geographically confined to a total of 1,815.8 m^2/0.0018 km^2/0.00053 nm^2 (i.e., two times the area of effect for a single five-minute period of MF8 sonar emission) and this area will be exposed repeatedly. The expected value of 1.2 groups of marbled murrelets from our probability analysis represents a reasonable estimate of the number of marbled murrelets that are reasonably certain to be injured by MF8 sonar over the 20-year term of the proposed action.

10.4.5.1.2.3 Effects of Sonar to Marbled Murrelets in Offshore Areas

Other than sonobuoys, sonar use in the Offshore Area Subunit involves mobile sources (e.g., hull-mounted, towed devices, etc.; for a complete description of all sonar proposed for use in the Offshore Area subunit, including transitory sonar, see Table 2 and Table 4). Marbled murrelets are also highly mobile because they are carried by the currents and they dive and chase after prey. Given those factors, marbled murrelet exposure to sonar SPLs at distances and durations that are likely to cause injury is extremely unlikely to occur in the Offshore Area Subunit. For that reason, the effects of proposed sonar use, other than sonobuoys, on the marbled murrelet in the Offshore Area Subunit are considered discountable.

Although sonobuoys move with the current, they were considered stationary for the purposes of our analysis because they are likely to appear relatively stationary to marbled murrelets, which are also affected by currents. However, all sonar emitted by sonobuoys is expected to have a range to effect of zero meters, meaning that these sources of sonar would not exceed the threshold for onset of injury.

10.4.5.1.3 Short-tailed Albatross

10.4.5.1.3.1 Thresholds and Evaluation Criteria

There are no published studies specific to sonar and its effects on short-tailed albatross, or any other seabird. In the absence of controlled studies specific to seabirds, we applied data from in-air sound associated with TS in birds (Ryals et al. 1999) and applied correction factors to account for impedance and the variation in reference pressure between air and water. We added 36 dB to the level where TS is expected, to account for impedance and then we added an additional 26 dB for the difference in air to water reference pressure

Hearing sensitivity in birds may be reduced while underwater. Audiograms of several bird species found sensitivity sharply falls off at the lower and upper bounds of avian hearing (Crowell et al. 2015; Dooling et al. 2000). For example, Dooling et al. (2000) noted that the average avian audiogram shows a loss of sensitivity below 1 kHz of ~20 dB/octave and a loss of sensitivity at high frequencies above 4 kHz of ~60 dB/octave. Additionally, there is typically a shift in sensitivity to lower frequencies when sounds are presented underwater versus in-air to the same species (Dooling and Therrien 2012). Based on this information, we expect the upper range of hearing for short-tailed albatross is decreased by approximately 1 kHz when underwater.

Therefore, the upper boundary of short-tailed albatross hearing sensitivity (approximately 32 kHz) is likely to be shifted lower (approximately 31 kHz or below) while the bird is underwater. Several categories of the proposed sonar are not expected to exceed the injury threshold (220 dB SEL re 1 µPa2-sec) because the source levels are lower than approximately 180 to 200 dB peak (the sound levels in Table 16 are rms values). Based on the rms values described in Table 16, which are typically below 200 dB rms, we do not expect injury to short-tailed albatross because the anticipated duration of exposure would not result in exposure to SEL's greater than 220 dB re: 1 µPa2-sec. However, we expect that short-tailed albatross can hear sonar when the frequencies are below 31 kHz.

The Service expects that all low and mid high-frequency sonar (0.5 kHz to 10 kHz) is audible to short-tailed albatross, and lower portions of high-frequency sonar are also audible. Based on the best available science, we expect short-tailed albatross can hear frequencies ranging from 0.85 kHz to 32 kHz (Nelson 1997; Sanborn et al. 2005; SAIC 2012; Sparling Jr. 1977). However, there is no information available on the upper range of their hearing capacity. When sonar operates at frequencies between 0.5 kHz and 10 kHz (low and mid-frequencies) we expect short-tailed albatross can hear it, and if cumulative SELs exceed 220 dB SEL re: 1 µPa2-sec we expect them to experience auditory injury.

The Service and Navy coordinated to develop thresholds for onset of injury to short-tailed albatross from sonar (Table 21). The Service asked the Navy to provide the range to effects for sonar assuming short-tailed albatross exposure occurred for a single ping. Because short-tailed albatross are highly mobile we used the range to effects for single pings, assuming that short-tailed albatross would not be exposed for durations longer than that from mobile sonar. All stationary sonar sources had ranges to effect of zero meters.

Table 21. The Service's thresholds for injury of short-tailed albatross from sonar.

Sonar Frequency Band	Auditory Injury SEL dB re: 1 μPa^{2}sec
Low Frequency	220
Mid Frequency	220

10.4.5.1.3.1.1 Exposure

The area of exposure for sonar is defined by the range to onset of injury, sonar amplitude, duration of use, and ping rate, which were the basis of the range to effects provided by the Navy (Table 22); however, not all of this information was provided to the Service. We expect short-tailed albatross could be anywhere in the Offshore Area Subunit of the action area at any time of year. Short-tailed albatross are primarily surface feeders, spending relatively little time with their heads underwater, and therefore, there is little opportunity for them to be exposed to sonar.

Table 22. Navy provided range to effects for short-tailed albatross from sonar.

Sonar Bin	Auditory Injury (meters)
	Short-tailed Albatross (single ping)
LF4	n/a
LF5	n/a
ASW2	0
MF1	6
MF3	< 1
MF4	0
MF5	0
MF6	n/a
MF8	n/a
MF9	n/a
MF10	0
MF11	1
MF12	< 1
ASW4	< 1
M3	0

10.4.5.1.3.1.2 Response

Other than sonobuoys, sonar sources in Offshore Areas are mobile (e.g., hull-mounted, towed devices, etc.; for a complete description of all sonar proposed for use in the Offshore Area subunit, including transitory sonar, see Table 2 and Table 4). Short-tailed albatross are mobile, are transported by currents, and only dive to shallow depths when foraging. It is extremely unlikely that a short-tailed albatross would be exposed to sonar in Offshore Areas for durations that would result in injury. We do not anticipate short-tailed albatross would be exposed and therefore no response is expected.

Although sonobuoys move with the current, they were considered stationary for the purposes of our analysis because they are likely to appear relatively stationary to short-tailed albatross, which are similarly affected by currents. However, all sonar emitted by sonobuoys is expected to have a range to effect of zero meters, meaning that these sources of sonar would not exceed the threshold for onset of injury at any distance.

10.4.5.1.3.1.3 Conclusion

Therefore, the effects of sonar, other than sonobuoys, on short-tailed albatross in Offshore Areas are considered discountable.

10.4.5.2 Underwater Explosions

10.4.5.2.1 Effects of Underwater Explosions on Bull Trout

Underwater explosions can affect fish behavior in a manner that reduces their fitness or survival. For fish that are close enough, the blast can physically injure or kill them (Nedwell and Edwards 2002; Nedwell et al. 2003).

The principal mechanism by which pressure waves from blasts cause physical injuries to organisms is through oscillations of body tissues and sudden compression and expansion of air-filled organs. Most blast injuries in marine animals involve damage to air- or gas-containing organs (Yelverton and Richmond 1981). For example, fish with swim bladders (including salmonids) are vulnerable to the effects of explosives, while fish without swim bladders (sand lance, flatfish, sharks, and rays) and invertebrates are much more resistant (Yelverton and Richmond 1981; Young 1991). When exposed 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 1975; O'Keeffe 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).

In our previous consultation on the NWTT activities, the Service used the best experimental data available on the effects of underwater detonations to determine thresholds (impulse levels) for injury to fish, including bull trout (Yelverton et al. 1975). These thresholds were based on the mass (size and weight) of the experimental fish. Hastings and Popper (2005) used the Yelverton et al. (1975) data to derive an SEL-based threshold where injury was not observed (absent).

The Service, in coordination with the Navy and NMFS, developed injury and mortality thresholds for fish from explosives (Table 23). The Service asked the Navy to calculate the ranges to effect for these thresholds. Calculated range to effects area provided in Table 24.

Table 23. The Service's injury or mortality thresholds for bull trout from explosives.

Mortality (dB SPL_{peak} re: 1µPa)	**Injury Including TTS** (dB SEL re: 1 μPa^2-sec)
229	186

Table 24. Onset of injury ranges to effect for bull trout from explosions.

Explosive Bins	**Injury Including TTS (meters)**	
	Juveniles (10 g)	**Adults (3.5 kg)**
< E1	49	n/a
E3 off shore	n/a	n/a
E3 inland	261	151
E4	n/a	n/a
E5	n/a	n/a
E8	n/a	n/a
E10	n/a	n/a
E11	n/a	n/a
E12	n/a	n/a

10.4.5.2.1.1 Effects of Underwater Explosions on Bull Trout at the Hood Canal EOD Training Range Site

10.4.5.2.1.1.1 Exposure

Based on historic observations (1980's) in the Duckabush, Quilcene, and other nearby rivers and estuaries entering Hood Canal from the west, we expect that very few bull trout occur near the Hood Canal EOD Training Range site (Brenkman and Corbett 2007; Brenkman and Corbett 2005; Goetz et al. 2004; Goetz et al. 2007). These rivers are approximately 12.9 km (8 miles) west of the Hood Canal EOD Training Range site. The closest population of bull trout in Hood

Canal is in the Skokomish River located 53.1 km (33 miles) to the south of Hood Canal EOD Training Range site. Hood Canal has been identified as an important foraging, migration, and overwintering habitat for bull trout and would likely be used as the Skokomish River core population increases in abundance (USFWS 2004, Volume II, p. 66).

Fluvial and, potentially, anadromous bull trout are present in the South Fork Skokomish River local population. Although there may be a residual expression of anadromy in the South Fork population, there are currently no indications or data that suggests that individuals are entering the marine environment. The North Fork Skokomish River local population has been isolated above Cushman No.1 and No 2 dams for over a century, but as a result of a recent settlement agreement, Tacoma Power is in the process of restoring fish passage to the North Fork. If fish passage efforts are successful, there is a potential that the anadromous life history form of bull trout could become more prevalent in the future. However, habitat degradation of nearshore foraging, migration, and overwintering habitat from natural and human sources (Brennan 2007; Goetz et al. 2004; PSAT (Puget Sound Action Team) 2007; Puget Sound Partnership 2008; Puget Sound Water Quality Action Team 2002) and the distance from the Skokomish River, is still likely to limit bull trout occurrence near the Hood Canal EOD Training Range site.

10.4.5.2.1.1.2 Response

The Hood Canal EOD Training Range site is located on the eastern shore of Hood Canal at Naval Base Kitsap Bangor. The radius of effect for < E1 and E3 explosives is 49 m and 261 m, respectively. Any bull trout that would be exposed to increased SPLs associated with underwater detonations would be injured or killed. Considering the low numbers of bull trout and their expected infrequent use of the Hood Canal EOD Training Range site, we anticipate the risk of exposure to underwater detonations to be low.

10.4.5.2.1.1.3 Conclusion

Bull trout exposure to EOD activities at Hood Canal EOD Training Range site is unlikely, and therefore, discountable.

10.4.5.2.1.2 Effects of Underwater Explosions on Bull Trout at Crescent Harbor

10.4.5.2.1.2.1 Exposure

Given the effects of underwater explosives on bull trout, the extensive distance that the underwater acoustic environment can be influenced, and the expected presence of anadromous bull trout at the Crescent Harbor EOD Training Range site, individual bull trout are at high risk of being exposed to increased SPLs associated with underwater detonations. The marine areas around Whidbey Island and Crescent Harbor play a critical role in the anadromous life-cycle of bull trout. The Service expects that large juvenile, sub-adult, and adult bull trout will be present in the Crescent Harbor portion of the action area. Larger juveniles and sub-adult bull trout are present in marine waters throughout the year and adults typically enter marine waters each year in December and January following spawning in freshwater. The adults typically remain in marine waters until July and August, when they leave and migrate to freshwater streams to spawn. Bull trout abundance is expected to vary daily and seasonally as a function of several interacting factors, including the proximity of core areas, abundance/availability of forage, distance from shore, and the time of year (life-cycle stage).

Bull trout exposure is expected at Crescent Harbor because there are three bull trout core areas in relatively close proximity. We assume bull trout presence at the Crescent Harbor EOD Training Range site will be predominately from the Lower Skagit River core area. This core area has one of the highest populations of bull trout and the Skagit River flows directly into the marine waters near the Crescent Harbor EOD Training Range site. We expect bull trout from the Snohomish/Skykomish and Stillaguamish core areas will also be present, though to a much lesser degree due to the farther distance and smaller population sizes.

Crescent Harbor is located near the Skagit River estuary and the shallowness of Skagit Bay allows large juveniles, sub-adults and adults to migrate towards Whidbey Island and Crescent Harbor. Most of Skagit Bay at mean lower low tide is less than 3.7 m (12 ft) deep (Figure 12) (NOAA 1993). Deeper water [less than 18.3 m (60 ft)] occurs near Whidbey Island, but radio-tagged bull trout have been documented crossing areas of Puget Sound that are more than 183 m (600 ft) deep (Goetz et al. 2012). Adult bull trout have been caught within Crescent Harbor and the surrounding marine waters from April through July, all in shallow water near shore. The Crescent Harbor EOD Training Range site is no closer than 1,000 meters from shore to minimize increased underwater exposure levels to salmonids. However, bull trout have been documented crossing waters deeper than 600 ft. Therefore, we have determined that it is reasonably certain that bull trout will be exposed to the Navy's use of high explosive ordnance for underwater mine detonations at the Crescent Harbor EOD Training Range site.

The risk of exposure to these stressors varies annually, with highest risk occurring between December to August as adult bull trout inhabit the marine environment and lowest risk occurring between August and November when most adult bull trout are in the fresh water environment. Exposure will also be greater if/when stressors occur in shallow water or, as in the case of underwater detonations, high SPLs reach shallow nearshore habitat where bull trout occur in higher abundance.

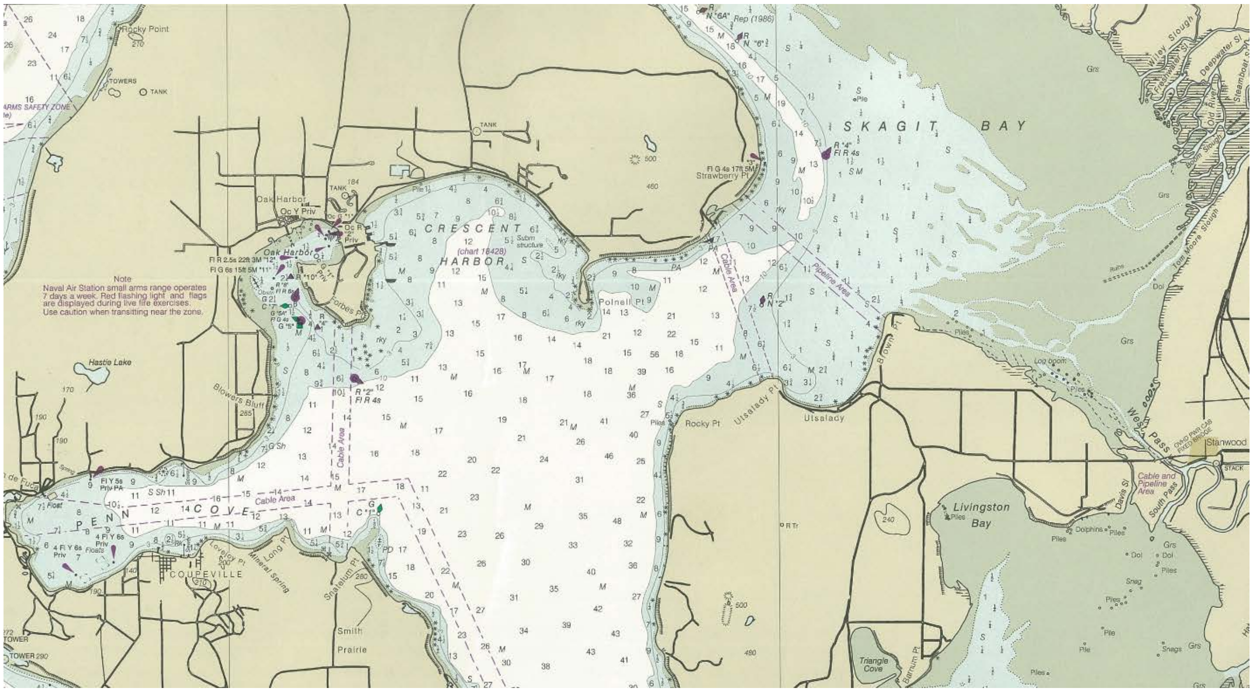

Figure 12. Bathymetry of Skagit Bay and Crescent Harbor.
Values are provided in fathoms (1 fathom = 6 ft).

10.4.5.2.1.2.2 Response

We expect that bull trout will be exposed at Crescent Harbor to the effects of underwater detonations in exceedance of our established thresholds. We expect bull trout to be injured or killed as a result of these exposure. The Service estimated the number of bull trout that may be injured or killed based on the number of detonations, the detonation site, and the month of the detonations provided by the Navy. At the Crescent Harbor EOD Training Range site, the Navy proposes to detonate up to three 2.5-lb charges, and 18 SWAG charges per year. The SWAGs are a highly focused single charge consisting of less than 0.1 lb of explosive. The Navy calculated the distances to the bull trout injury and mortality threshold for a 2.5-lbs detonation (E3; Table 24). For a 10 g juvenile bull trout, the smallest size the Service estimates to be within the Crescent Harbor action area, the distances to injury and mortality thresholds are 261 m and 151 m, respectively. The Navy did not calculate the distances to injury and mortality for the SWAG charges (less than 0.1 lb). The Service analyzed SWAG charge impacts using the 49 m distance to effects for injury to marbled murrelets (Table 27). This approach is conservative because the area of effect for the most vulnerable juvenile bull trout would be within the area of effect analyzed for the larger marbled murrelets (220 g).

Using a radius of 261 m, we determined the area of effect for one E3 detonation will be slightly less than 214,008 m^2 (0.21 km^2/0.06 nm^2) for each 2.5-lbs charge (assuming a 95 ft depth for charge placement). Bathymetry data in Crescent Harbor indicate bottom depths range from 9.1 to 30.5 m (30 to 100 ft; Figure 12) and previous detonation occurred between 3 and 24.4 m (10 and 80 ft) (Department of the Navy 2015; U.S. Department of the Navy 2009).

For SWAG charges, using a 49 m radius, the area where injury to bull trout could occur is approximately 7,543 m^2 (0.008 km^2/0.21 nm^2) for each < E1 detonation.

In our reasonable worst-case analysis, we assumed the use of explosives could occur any month of the year (with a limit of one EOD exercise during the winter period). When adult bull trout return to spawn in the freshwater in July and August, bull trout density decreases in the marine environment during the period of August through November each year. The remaining large juveniles and sub-adult bull trout likely will be concentrated near the estuaries and lower reaches of large river systems.

To estimate the number of bull trout that may be killed during underwater detonations, we assumed a higher risk of bull trout exposure during the months in which larger juveniles, sub-adults, and adult bull trout may be in the marine environment (January through August). Based on the size of the area of injury, number of detonations per year, and probability that bull trout will be in the Crescent Harbor EOD Training Range area, it is reasonable to assume that bull trout will be exposed to underwater SPLs that will result in injury or death each year for the duration of the project (20 years).

The primary factors considered in estimating bull trout injury and mortality associated with Navy EOD activities included the number of underwater detonations that the Navy will conduct, the month in which the detonations might occur, the risk factors associated with each detonation, and bull trout use of the marine environment. Assumptions about the timing of EOD exercises were necessary because bull trout abundance and risk of exposure varies seasonally in the marine environment.

Adult bull trout spend 25 percent of the time in any given year engaged in spawning behaviors (migrating, staging, and spawning in fresh water), and therefore, the number of individuals (non-spawning adults and sub-adults) that are in the marine environment during late summer and fall is low. Given the uncertainty in the Navy's EOD training plans, and using a worst-case scenario, we assumed that all three 2.5-lb EOD events at Crescent Harbor would occur during the 9 month period when bull trout density in the marine environment is highest (December through August). We therefore assumed the occurrence of one large juvenile, sub-adult, or adult bull trout within the 261 m (856 ft) radius of the detonation site for each E3 event (one E3 detonation per event, three events per year), and one large juvenile, sub-adult, or adult bull trout within the 49 m radius of the detonation site during each < E1 detonation event (six < E1 detonations per event, three events per year). These detonations result in exposure to SPLs of 186 dB SEL re: 1 μPa2-sec for injury (Tables 23 and 24). As a result, the Service estimates that a maximum of one bull trout will be killed or injured per event, with six events occurring per year. Each event consists of either one E3 or six < E1 detonations. A total of six bull trout total are expected to be injured or killed annually in Crescent Harbor. Over 20 years, a total of 120 bull trout are expected to be injured or killed by these detonations. A total of 16 km^2 of bull trout habitat (i.e., the sum of all individual areas of effect) will be affected by these detonations over 20 years.

10.4.5.2.1.2.3 Conclusion

Because injured or dead bull trout are hard to detect, we used the area of effect for < E1 and E3 detonations to determine when bull trout will be injured or killed. The Service expects bull trout within 49 m of < E1 detonations and 261 m of all E3 detonations will be injured or killed as a result of increased SPLs resulting from underwater detonations at the Crescent Harbor EOD Training Range site.

10.4.5.2.2 Effects of Explosives on Bull Trout Prey

The use of high explosive ordnance for Navy EOD training at both the Hood Canal and Crescent Harbor EOD Training Range sites may cause mortality in marine forage fish which are an important prey resource for bull trout. Surface counts of fish collected by the Navy after training exercises held at Crescent Harbor indicate the underwater detonations primarily resulted in mortality to Pacific herring and surf smelt (Phillips, pers. comm. 2007). Other species identified include shiner surfperch (*Cymatogaster aggregata*; 271 total over 46 detonations), Pacific tomcod (*Microgadus proximus*; 29 total), blackeye goby (*Coryphoterus nicholsii*; 1 total), and northern anchovy (*Engraulis mordax*; 7 total).

The mortality rates in fish vary with the timing of detonations, charge weight, and charge placement. For example, 10-lb charges (near the surface) in June and September (2002) resulted in relatively low surface counts of dead Pacific herring and surf smelt (Phillips, pers. comm. 2007). Similar mortality rates were reported for 5-lb charges occurring in January, April, and June of 2003 at charge depths of 21.3 m to 27.4 m. However, five-pound charges had the highest observed mortality rates in July 2003 and June 2004 at charge depths of 12.2 to 13.7 m. Underwater detonations of E3 charges placed at 10.7- to 24.4-meter depths had similarly high observed mortality rates in the months of May, July, August, and September (2005, 2006, 2007).

The observed fish mortality associated with post-detonation monitoring is expected to under represent the actual number of fish killed (number and species) because blast pressure waves can result in the rupture swim bladders in fish causing them to sink. Studies by Teleki and Chamberlain (1978) and Thomas and Washington (1988) found that up to approximately 80 percent of fish killed by underwater explosives actually sink. Additionally, fish that leave the area with significant injuries, only to die later, would also go undetected. With the difficulty associated with surveying and finding fish that sink and/or are mortally injured, the Service expects the amount of fish killed may be substantially higher than what has been observed during post-detonation monitoring of EOD training exercises.

Trawling surveys in Skagit Bay were conducted in shallower, nearshore waters (outside of the action area) (Rice et al. 2002). The variability in the number of herring and surf smelt found near the surface after a detonation is consistent with the variability observed in the trawling surveys. 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 (Utsalady), has an average mean catch per tow of 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.

10.4.5.2.2.1 Effects of Underwater Explosions on Bull Trout Prey: Pacific Herring

Pacific herring populations are the only forage fish that are monitored annually by Washington Department of Fish and Wildlife (Penttila 2007). Spawning of Pacific herring varies with the different stocks but generally occurs from late January through April (Penttila 2007). Pacific herring are found within Puget Sound throughout the year (Penttila 2007; Stout et al. 2001). The pre-spawn holding area for the Skagit Bay herring stock is located just south of Crescent Harbor and is completely within the Crescent Harbor action area. The pre-spawn holding area for herring stocks occurring in Hood Canal is northeast of the Hood Canal EOD Training Range site (Figure 13). Pacific 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.

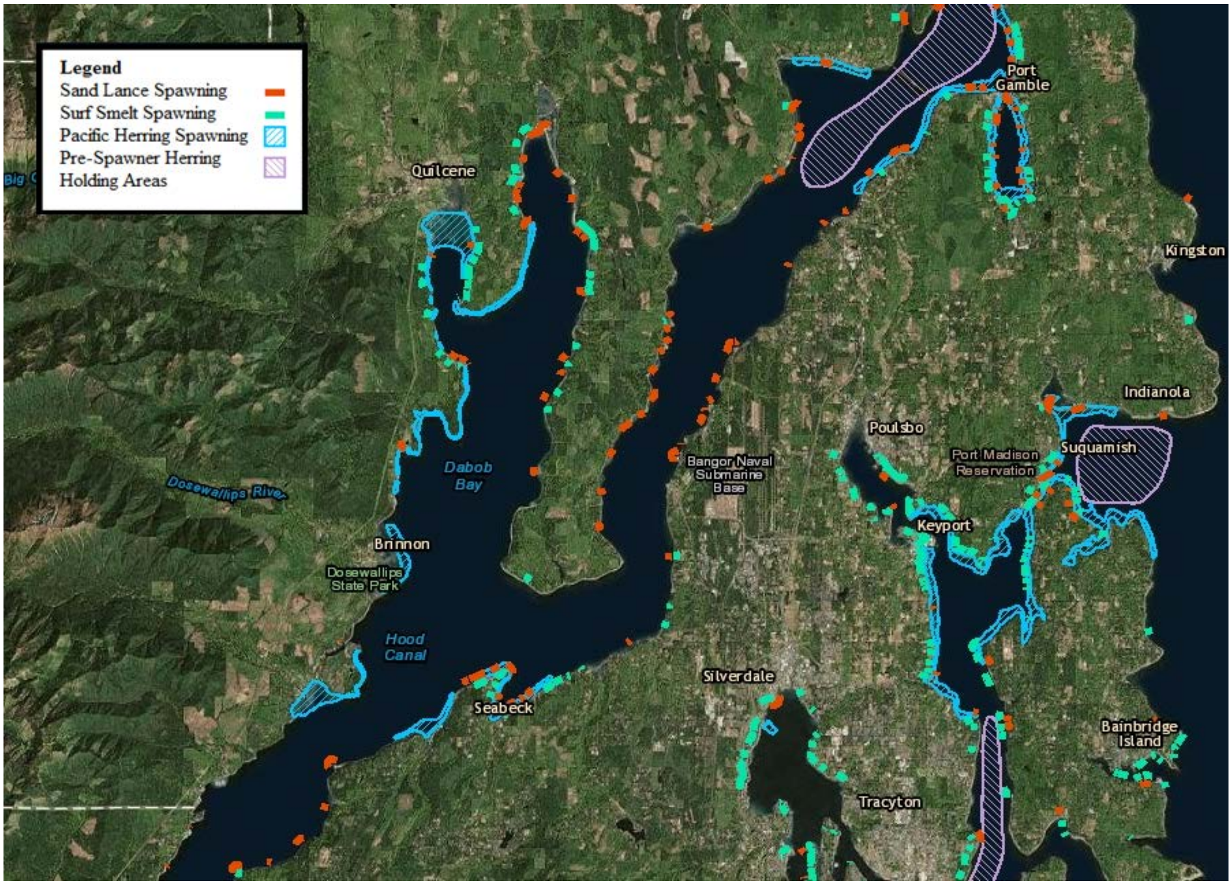

Figure 13. Sand lance, surf smelt and Pacific herring spawning locations and pre-spawn holding area for Pacific Herring within and surrounding the Hood Canal EOD Training Range site at Bangor.
(Washington Department of Wildlife (WDFW) 2015)

The Holmes Harbor herring spawning areas are located south of the Crescent Harbor EOD Training Range site. No known pre-spawn holding area exists for this stock. Because of the distance between the detonation site and the spawning areas, the EOD training detonations are not expected to impact spawning areas for this stock. However, as the herring travel through Saratoga Passage, they may migrate north and be killed or injured by detonations.

The Quilcene Bay herring stock has the closest spawning area to the Hood Canal EOD Training Range site. The Quilcene Bay herring spawning area is located along the western shores of Dabob Bay. Herring from the pre-spawn holding area must migrate through the EOD Training Range site and some individuals may be killed or injured by detonations.

We were not able to determine if fish mortality caused by the Navy's underwater detonations would have a population-level effect on any forage fish species. However, we did assess the relative impact of the Navy's actions in terms of biomass for the Skagit Bay, Holmes Harbor, and Quilcene Bay herring stocks.

The Navy will be conducting EOD training with less than 0.1-lb and 2.5-lb charges at both Hood Canal and Crescent Harbor Training Range sites. To estimate the number of herring that may be killed during EOD training, we assumed that the worst case scenario for a single, 2.5-lb detonation would be the maximum number of dead herring documented during the Navy's surface monitoring surveys. On June 3, 2004, 3,760 dead herring were detected following a 5-lb charge and the largest number of herring killed for a 2.5-lb charge was 2,520 (August 9, 2005) (Phillips, pers. comm. 2007). Because of the high spatial and temporal variability in herring density, as indicated by the monthly Skagit Bay trawling data, we used mortality estimates from the 2.5-lb charge for our analysis. Because not all of the dead fish will float to the surface and be located, we conservatively assumed that 80 percent of the fish killed from a detonation will sink (Thomas and Washington 1988). Therefore, we estimate that the potential number of herring killed from each prior EOD event is as high as 12,600 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 old fish 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, no data available for the Quilcene Bay herring stock). 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 12,600 herring estimated to be killed would be 0.057 ton for the Skagit Bay stock and 0.063 ton for the Holmes Harbor stock. These values assume that all herring killed from all detonations originate from the same stock.

This biomass represents 0.004 percent and 0.017 percent of the five-year mean spawner biomass for the Skagit Bay and Holmes Harbor herring stocks, respectively, that would be killed from each 2.5-lb detonation. With three charges detonated annually at Crescent Harbor, the total biomass removed (killed) would represent approximately 0.012 percent and 0.051 percent of the mean biomass (of spawning fish) for the Skagit Bay and Holmes Harbor stocks annually. The

Service expects similar results for the Quilcene Bay stock. With the recent evidence indicating that the Skagit Bay stock is stable and the Holmes Harbor and Quilcene Bay stocks are increasing (Stick et al. 2014), we do not anticipate that this level of annual mortality of Pacific herring caused by underwater detonations will measurably affect the abundance of either stock.

10.4.5.2.2.2 Effects of Underwater Explosions on Bull Trout Prey: 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 (Penttila 2007). Surf smelt populations within the Crescent Harbor action area may be impacted because the known spawning locations occur along the shorelines surrounding Crescent Harbor (Figure 4). Little to no surf smelt spawning occurs near the Hood Canal EOD Training Range site (Figure 13). 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 than 60 ft. Therefore, surf smelt are susceptible to exposure to 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 that may be killed from Navy EOD detonations. For the purpose of this analysis, we assumed that mortality of surf smelt would occur from each detonation. The effects of the action are broadly distributed and have little to no effect on habitat. Additionally, surf smelt and their spawning habitat are also widely distributed. Because there are relatively few detonations that occur in Inland Waters, where surf smelt are expected to be exposed, we do not anticipate that the abundance of surf smelt would be measurably reduced by the detonations in Hood Canal and Crescent Harbor. Similar to Pacific herring, the Service does not expect that the underwater explosions in Hood Canal or Crescent Harbor will measurably reduce the overall population of surf smelt.

10.4.5.2.2.3 Effects of Underwater Explosions on Bull Trout Prey: Pacific Sand Lance

Sand lance occur within Puget Sound throughout the year (Penttila 2007). Sand lance spawn in late fall and winter (Robards et al. 1999). During the daytime, sand lance forage and move through the water column and then bury themselves in the substrate at night. 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. Because sand lance do not have a gas bladder, they are less susceptible to the effect of EOD detonations. As there are a wide range of injury types associated with exposure to elevated SPLs from explosions, sand lance may still be killed or injured from exposure to explosions.

Within the Hood Canal and Crescent Harbor action areas, sand lance spawn in the same general locations as surf smelt, but the spawning grounds are much smaller (Figures 4 and 13). The data collected during Navy monitoring of detonations did not document sand lance mortalities. However, the species may occur within the water column during EOD detonations and we cannot entirely discount that sand lance may be killed or injured by the detonations. Therefore, we assumed that there will be mortality of sand lance. However, given the effects of this action relative to their total abundance and widespread distribution and the lack of data documenting mortality, the Service does not expect that the underwater detonations in Hood Canal or Crescent Harbor will measurably reduce the overall population of sand lance in the Hood Canal or Crescent Harbor EOD Training Range sites.

10.4.5.2.2.3.1 Conclusion

We anticipate there will be mortality of forage fish at both the Hood Canal and Crescent Harbor EOD Training Range sites. Our analysis of the proportion of the three primary forage fish species that will be killed during EOD detonations relative to the existing populations indicates that overall effects to their populations are likely to be insignificant. Therefore, we expect that resultant effects to bull trout due to reduced prey abundance will not be measureable and are therefore insignificant.

10.4.5.2.3 Effects of Underwater Explosions on the Marbled Murrelet

10.4.5.2.3.1 Thresholds and Evaluation Criteria

Underwater detonations are known to have negative physiological and neurological effects on a wide variety of vertebrate species; these effects include coronary air emboli, lung hemorrhaging, ruptured livers, hemorrhaged kidneys, ruptured air sacs, and ruptured and scarred eardrums (Cudahy and Ellison 2002; Gisiner et al. 1998; Hastings and Popper 2005; Yelverton et al. 1973; Yelverton and Richmond 1981). Experiments using underwater explosives found that rapid change in underwater SPLs resulted in internal hemorrhaging and mortality in submerged mallards (*Anas platyrynchos*) (Yelverton et al. 1973, p. 49). Death from barotrauma can be instantaneous, occurring within minutes after exposure, or several days later (Abbott et al. 2002). Several birds exposed to explosions survived and appeared uninjured, but upon necropsy two weeks later there was evidence of liver blood clots and lung and kidney injuries (Yelverton et al. 1973, p. 51).

There are no published studies specific to explosions and their physiological effects on marbled murrelets. However, there are some data specific to other birds from evaluations of the effects of underwater blasting and seismic testing (Cooper 1982; Flint et al. 2003; Lacroix et al. 2003; Stemp 1985; Yelverton and Richmond 1981, p. 3). During seismic explorations, it has been noted that seabirds were attracted to fishes killed as a result of the seismic work (Fitch and Young 1948; Stemp 1985). Fitch and Young (1948) found that diving cormorants were consistently killed by seismic blasts, and pelicans were frequently killed when they were exposed when their heads were below water. For exposure of fish and mammals to impulses underwater, Yelverton and Richmond (1981) and Yelverton et al. (1973) found a correlation between the size of animal and the impulse level needed to elicit an injury. While Yelverton did not do this analysis for birds, we reason that this correlation was independent of the organism's taxonomic classification and thus it also applies to birds (for underwater explosions). In the absence of controlled studies specific to seabirds, we considered evaluations of the effects of other types of blast impulses on a variety of vertebrate species, including birds, for evaluating the effects of explosions on marbled murrelets.

Detonating explosives can result in a variety of injuries to organisms. Important biological variables that influence the degree to which an animal is affected include size, anatomical variation, and location of the organism relative to the explosive source in the water column (Gisiner et al. 1998). Studies of explosives by Yelverton and Richmond (1981), Yelverton et al. (1973) and Damon et al. (1974) identified injury thresholds in relation to the size of the charge, the distance from the animal at which the charge was detonated, and the mass of the animal exposed. Much work has been done to assess impacts to avian hearing from in-air sound (Brittan-Powell and Dooling 2002; Dooling et al. 2000; Dooling and Popper 2007; Dooling 1980; Dooling 1982; Dooling and Dent 2002; Dooling and Brittan-Powell 2005; Ryals et al. 1999; Ryals and Dooling 2001; Saunders and Dooling 1974; Saunders and Henry 1989); most of this work assessed avian hearing range and hearing loss from over-exposure to in-air sound. The principal mechanism by which blast pressure waves cause physical injuries to organisms is through oscillations of body tissues and sudden compression and expansion of gas-filled organs. Most blast injuries in marine animals involve damage to gas-containing organs (e.g., lungs, gastrointestinal tract, bowels); however, injuries also occur to liver, kidneys, ears, and coronary arteries (Cudahy and Ellison 2002; Gisiner et al. 1998; Hastings and Popper 2005; Yelverton et al. 1973; Yelverton and Richmond 1981).

Injuries from high underwater pressure waves occur over a continuum of potential effects, ranging from mortality to sub-lethal physical effects including TS and gastrointestinal tract lesions, to non-injurious effects that might result in significant disruption of normal behaviors. At the most severe end of the spectrum, direct mortality or obvious injuries can occur. For example, after submerging dog's heads and exposing them to blasts at 223 dB_{peak}, Richmond et al. (1973) estimated that 50 percent of the ears facing the blast had tympanic rupture. Yelverton et al. (1973) documented less eardrum rupture in submerged mallards exposed to blasting, but noted extensive lung hemorrhage and a 50 percent prevalence of liver and kidney damage. At the least severe end of the spectrum of injurious effects, there may be temporary hearing shifts or small burst blood vessels.

Several authors have described methods for calculating the theoretical kill or injury zones around underwater explosions (Gaspin 1975; O'Keeffe and Young 1984; Young 1991). A common metric used for a single acoustic event that accounts for both the negative and positive pressure wave is sound exposure level (SEL) (Hastings and Popper 2005). An impulse, measured in Pascal seconds (Pa-sec), is the best way to describe and measure the effects of the explosion on organisms because it captures all the forces occurring with a fast-acting explosion over time. Impulse values better reflect the complex components of the pressure wave associated with an explosion, such as over pressure and under pressure, and the peak SPL. If we used a single component to describe the effects to marbled murrelets, such as peak SPL, or SEL, we may not adequately account for the energy from the shock wave or the over pressure. These components contain significant energy, so by accounting for that energy we have increased confidence that the distances to effect for barotrauma or injury are comprehensive.

The Service established thresholds for onset of injury to marbled murrelets from underwater explosions (Table 25). The Service requested that the Navy calculate the ranges to effect (i.e., the area in which we expect injury of marbled murrelets to occur) for underwater explosions based on information provided for mallards in Yelverton et al. (1973). We requested that the Navy adjust these values for the mass of a marbled murrelet, which is much smaller than a mallard. The Navy calculated these ranges to effect (Table 26).

Table 25. The Service's injury or mortality thresholds for marbled murrelets from underwater explosions.

Explosions Underwater			
Bird Species	**Auditory Injury dB SEL re: µ1 Pa^{2-}sec**	**Barotrauma (Pa-sec)**	**Mortality (Pa-sec)**
Marbled Murrelet	212	36	138

Table 26. Navy-developed distance thresholds for adverse effects to the marbled murrelet caused by underwater explosions.

Marbled Murrelet			
Explosive Bins	**Auditory Injury (≥ 212 dB SEL) (meters)**	**Barotrauma (≥ 36 Pa-sec) (meters)**	**Mortality (≥ 138 Pa-sec) (meters)**
E3 off shore	9	144	56
E3 inland	9	83	37
E4	13	147	66
E5*	2	43	22
E8	57	351	176
E10*	15	87	45
E11	144	498	256
E12*	21	98	51

*May detonate at the surface of the water.

The ranges to effect values the Navy provided (Table 26) were based on impulse data from Swisdak (1978). The Navy calculations for range to effects from detonations (above) also applied a time cut-off equation from Yelverton (1973) to account for how the overpressure and underpressure cancel each other out. The Navy FEIS provides graphs of threshold profiles for slight lung injury and mortality based on different animal masses for each size class of underwater explosive (Navy 2015a, pp. 3.4-215 to 3.4-218). We compared the ranges to effect provided by the Navy (Table 26) with these tables in the FEIS, explosive impulse ranges from Swisdak (1978), and explosive SPLs from Hildebrand (2009). Because there were large differences between the range to effects values the Navy provided in Table 26 and these other sources, we requested the calculations that the Navy used to determine the ranges to effect in Table 27. We also requested the Navy provide the calculations in a spreadsheet, which we could then use to calculate the ranges to effect at different diving depths for marbled murrelets. The Navy provided the spreadsheet, which we then used to derive the ranges to effect below in Table 27. For more details on how these ranges to effects were used in the exposure analysis, see Appendix A.

We verified the assumptions made by the Navy in calculating these range to effects (i.e., the distance from the explosion source at which injury of marbled murrelets is likely to occur). We used this information to predict the range to effects to our thresholds for underwater explosions assuming two different diving depths; 47 m diving depth for our "reasonable worst-case" scenario and 27 m for our "reasonably certain" scenario. The values we used for range to effects for marbled murrelets from underwater detonations are provided below in Table 27. The range to effects for barotrauma represents the largest area of effect and also encompasses other effects from exposure, including auditory injury and mortality. On that basis, we consider this distance as the threshold for the onset of injury to marbled murrelets caused by underwater explosions, and modeled the probability of marbled murrelet exposure and injury based on this distance.

Table 27. Ranges to effect for marbled murrelet from underwater explosions from Swisdak (1978) and Yelverton et al. (1973).

Marbled Murrelet		
Explosive Bins	**Onset of Injury (Barotrauma) (36 Pa-sec) at 27 m diving depths**	**Onset of Injury (Barotrauma) (36 Pa-sec) at 47 m diving depths**
< E1 Inland	49	49
E1 Inland	91	92
E1 Offshore*	58	65
E3 Offshore (Sonobuoy)	349	390
E3 Inland	260	293
E4 Offshore	441	497
E5* Offshore (included E3 Projectiles)	190	239
E7* (**) Offshore	274	352
E8 Offshore	1,484	1,839
E10* Offshore	409	528
E11 Offshore	2,265	2,891
E12* Offshore	464	600

* May detonate at the surface of the water, truncating the range to effects underwater because energy is lost into the air.

** Calculated distance to effect for E7 explosion underwater as a proxy for the underwater sound resulting from non-explosive practice missiles hitting the water.

The Navy conducts a variety of activities in which underwater detonations occur. Based on the distribution and density of marbled murrelets, the location of detonations, and the calculated range to effects values (Table 27), we calculated the cumulative probability that a marbled murrelet would be exposed to and injured from underwater detonations. A comprehensive description of the assumptions made in our exposure analysis is provided in Appendices A and G.

10.4.5.2.3.2 Effects of Underwater Explosions on the Marbled Murrelet in the Inland Waters Subunit

10.4.5.2.3.2.1 Exposure

The area of exposure for underwater explosions is defined by the distance from the explosion source at which injury of a marbled murrelet is likely to occur (i.e., the range to effects). That distance is related to the specific net explosive weight of the charge. The probability of marbled murrelet presence within these areas was modeled at each location within the Inland Waters Subunit where underwater detonations are proposed. The maximum area affected by each explosive detonation is defined by the radius of the range to effect; for example, for an E3 explosive detonation, the radius extends 260 meters from the source of the detonation, which is an area of effect of 212,372 m^2 ($A = \pi$ r 2) (0.21 km^2/0.06 nm^2) for each detonation.

The Navy's Mine Neutralization/EOD disposal training involves detonating up to 18 SWAG charges (< E1 with charge weight less than 0.1 lb NEW) and three larger charges (E3 with charge weight up to 2.5 lb NEW) at the Crescent Harbor EOD Training Range site, annually. The Navy will also detonate up to 18 SWAG (< E1) and three E3's in the Hood Canal EOD Training Range site, annually. Based on the densities of marbled murrelets at these locations and the ranges to effect for the < E1 and E3 explosives, we calculated the cumulative probability that a marbled murrelet group would be exposed to these EOD detonations over the next 20 years (Table 28). Because both of the EOD detonation sites are in Stratum 2, we combined the number of underwater detonations and calculated the probability of exposure of marbled murrelet groups to EOD's that would occur at both sites combined (i.e., for a total of six E3 detonations and thirty-six < E1 detonations in Stratum 2, annually).

The Navy no longer uses detonation techniques where the detonation is delayed between the time of pre-detonation survey and the detonation in inland waters. This allows the Navy to detonate on command once the pre-detonation surveys have been completed. This may reduce the window of opportunity for birds to enter into the area where injury may occur after the surveys have been completed. There is no quantitative information on the effectiveness of the Navy's monitoring efforts and it is impossible to accurately assign a percentage to the level of effectiveness appropriate to their monitoring effort without that information. In the absence of this effectiveness monitoring information, and based on a comparison between the Navy's monitoring method and our Protocol for monitoring for marbled murrelets (for pile driving), we made an assumption that the monitoring efforts made by the Navy are 50 percent effective. We expect that the Navy observed half of the birds present during surveys, while monitoring according to their current survey methodology.

Table 28. Cumulative probabilities of marbled murrelets being exposed to EOD detonation at both the Hood Canal and Crescent Harbor EOD Training Range sites over the next 20 years.

Source Bin	Probability of marbled murrelet exposure over 20 years (“reasonable worst-case” scenario)	Expected number of marbled murrelet groups exposed over all 20 years (“reasonably certain” scenario)
With pre-detonation surveys (50 percent survey effectiveness rate)		
< E1*	0.86	0.68
E3	1.00	3.18

* Marbled murrelet exposure to < E1 EOD detonations is neither discountable nor reasonably certain to occur.

E3 explosive detonations have a radius of effect where injury of murrelets may occur (extent where the impulse exceeds the onset of injury) that extends 260 meters from the source of the detonation, which is an area of effect of 212,372 m^2 (A = π r 2) (0.21 km^2/0.06 nm^2) per detonation. Over the next 20 years, the total cumulative area affected (i.e., the sum of all individual areas of effect) will be 25,484,640 m^2 (25.5 km^2 or 7.43 nm^2). However, the area in which these detonations will occur is smaller sum of all individual areas of effect, which indicates that the same geographic area of habitat will be repeatedly exposed to these stressors.

Detonations in Crescent Harbor will occur annually within the same general area (Figure 14). This area is approximately 1,200 m wide and 2,400 m long (total area of approximately 2.88 km^2/0.84 nm^2) and is illustrated by the shaded rectangle in Figure 14. We assume that the detonations may occur anywhere within this rectangular area and the effects may extend a maximum of 260 m from the outer limits for the largest explosion (up to 2.5 lb for E3). Therefore, all effects of this stressor will be geographically restricted to the zone where these detonations may occur, plus a 260-m buffer from its edges, a total area of 5.02 km^2/1.46 nm^2. At this location, there will be three detonations per year, and assuming that they do not occur in exactly the same location every time, as much as 0.63 km^2/0.18 nm^2 of habitat (three times the area of effect for a single detonation) may be exposed to these stressors each year. Over the entire 20 year period, each portion of this area is likely to be exposed at least once, and many portions of this area will be exposed repeatedly.

Figure 14. Location of explosions within Crescent Harbor will occur within the same area every year (shaded polygon, estimated based on information provided by the Navy).

Detonations in the Hood Canal EOD Training Range site will also occur within the same general area annually (Figure 15), and this area is smaller and the detonation location is more precise than in Crescent Harbor. This area is a circle, approximately 300 m radius (total area of the circle is approximately 282,600 m^2/0.28 km^2/0.08 nm^2, assuming $A = \pi r 2$) and is illustrated by the yellow dot in Figure 15. We assume that the detonations may occur anywhere within this area and the effects may extend a maximum of 260 m from the outer limits for the largest explosion, for a maximum of 560 m radius circle (2.5 lb for E3). Therefore, all stressors associated with these detonations will be geographically limited to a 560 m radius circle, with an area of 985,203 m^2 ($A = \pi r 2$) (0.98 km^2/0.29 nm^2). Annually, there are three detonations and the exact location would vary slightly, but assuming that all are detonated within the 300 m radius circle, the areas of effect will overlap to some extent. Therefore, within a given year, the geographic area exposed to effects will be less than 0.63 km^2 of habitat (0.18 nm^2, three times the area of effect of a single detonation), and some portions of the area will be exposed to the effects of more than one detonation. Over the entire 20 year period, each portion of this area is likely to be exposed at least once, and most portions of this area will be exposed repeatedly.

SWAG (< E1) detonations have a radius of effect where injury of murrelets may occur (extent where the impulse exceeds the onset of injury) that extends 49 meters from the source of the detonation, which is an area of effect of 7,543 m^2 (A = π r 2) (0.0075 km^2/0.0022 nm^2) per detonation. Over the next 20 years, the total cumulative area affected (i.e., the sum of all individual areas of effect) will be 5,430,934 m^2 (5.4 km^2 or 1.6 nm^2). All of these SWAG detonations will take place within the geographic areas described above for E3 detonations, and it is likely that some portions of each geographic area will be exposed multiple times over the course of 20 years, while other portions of each geographic area, particularly at Crescent Harbor, may not be exposed during this period.

Figure 15. Location of explosions within the Bangor EOD site will occur within the same area every year, shown by the yellow dot.

In the Sonar section for marbled murrelets (above), we describe how we estimated marbled murrelet density in Inland Waters. Based on the location, frequency, and duration of the EOD detonations in Inland Waters, and using the threshold distances discussed above, we estimated the number of marbled murrelet groups likely to be exposed to and injured from EOD detonations in the Inland Waters Subunit. For a more detailed description of how marbled murrelet density in Inland Waters Subunit was determined and how reasonable worst case exposure was calculated, please see Appendix G. For a more detailed description of how we determined marbled murrelet exposure and the numbers of marbled murrelet groups reasonably certain to be exposed were determined, please see Appendix A.

Our modeling results showed that marbled murrelet exposure to SWAGs (< E1 underwater detonations) is not discountable (86 percent) under the "reasonable worst-case" scenario. For the "reasonably certain" scenario, we calculated that if pre-detonation monitoring successfully detects marbled murrelets with 50 percent effectiveness, the expected number of marbled murrelet groups exposed to stressors associated with SWAG detonations is 0.68 (1.4 birds, assuming two birds per group). However, under this scenario, there is a 51 percent probability that no murrelet groups will be exposed over the next 20 years, so we cannot be reasonably certain that murrelets will be exposed to underwater impulses from SWAGs.

Under the "reasonable worst-case" scenario, our modeling results showed a likelihood of marbled murrelet exposure to E3 detonations approaching 100 percent. For the "reasonably certain" scenario, we calculated that if pre-detonation monitoring successfully detects marbled murrelets with 50 percent effectiveness, the expected number of marbled murrelet groups exposed to stressors associated with SWAG detonations is 3.2 (6.4 birds, assuming two birds per group).

10.4.5.2.3.2.2 Response

SWAGs and E3 underwater detonations may injure or kill adult and subadult marbled murrelets by exposing them to underwater impulses. We expect that if birds are exposed to < E1 and E3 EOD detonations, the detonations will affect adult and sub-adult marbled murrelets through impulse-related stressors (i.e., blast waves, elevated SPLs, overpressures and underpressures, etc.), resulting in TS, barotrauma, or mortality.

Individual marbled murrelets that experience TS from exposure to explosions are expected to have damage to the hair cells in their inner ears, and may not be able to detect biologically relevant sounds such as approaching predators or prey, and/or hear their mates attempting to communicate. Birds with reduced hearing sensitivity are at increased risk of predation and reduced foraging efficiency. Some birds may regain some or all of their hearing sensitivity; however, they are still temporarily at risk while experiencing TS. Additionally, marbled murrelets that are exposed to explosives but do not experience TS may respond by flushing or temporarily ceasing to forage; however, these birds are expected to return to normal behaviors in a short period of time.

Individual marbled murrelets exposed to explosions may experience lethal or non-lethal injuries. Non-lethal injuries may include TS, scarred or ruptured eardrums, or gastrointestinal tract lesions. Individual marbled murrelets may survive their exposure to the explosions; however, we expect such individuals to have a reduced level of fitness and reproductive success, and a higher risk of predation by reducing their ability to detect and/or evade predators. Exposed individuals may also experience lethal injuries that occur instantaneously or manifest over time, such as direct mortality, lung hemorrhaging, ruptured liver, hemorrhaged kidney, ruptured air sacs, and/or coronary air embolisms. Death from barotrauma can be instantaneous, occurring within minutes after exposure, or several days later (Abbott et al. 2002). Several birds exposed to explosions survived and appeared uninjured, but upon necropsy two weeks later there was evidence of liver blood clots and lung and kidney injuries (Yelverton et al. 1973, p. 51).

For individual marbled murrelets that are exposed to explosions but not injured or killed, we expect a startle response, flushing, or avoidance (i.e., diving, or leaving the area). In uninjured individuals, these responses would be short term and we would not expect significant disruptions to their normal behavior that would create a likelihood of injury. However, if several detonations occurred per day, it may result in significant disruptions to a marbled murrelet's normal foraging behavior, potentially reducing individual fitness or their ability to feed a chick. For underwater detonations at the Hood Canal and Crescent Harbor EOD Training Range sites, we do not expect significant disruptions to normal behaviors because the associated stressors are of short-duration and do not occur frequently in a day or for an extended period of time. We expect that if a marbled murrelet is not injured or killed by the detonation, they will return to normal behaviors in a short period of time (birds may be injured or killed by these detonations, but that is addressed elsewhere, this paragraph only discusses behavioral effects).

Our exposure analysis showed that exposure to SWAGs is neither insignificant nor discountable; therefore, SWAGs may adversely affect marbled murrelets. If exposure occurs, we expect that it will result in injury or mortality. Although exposure is not discountable, we are not reasonably certain that it will occur. Under the "reasonable worst-case" scenario, there is only a 49 percent chance of exposure.

Our exposure analysis indicated that marbled murrelets are reasonably certain to be exposed to E3 underwater detonations that lead to injury or mortality. In the "reasonably certain" scenario, there is a 61 percent chance that three or more murrelet groups will be exposed, and a 40 percent chance that four or more murrelet groups will be exposed, even with the monitoring proposed by the Navy. Because marbled murrelets typically forage in pairs and frequently surface behind vessels unnoticed, we expect that both members of a foraging group would be exposed to these detonations, even with monitoring proposed by the Navy (to 400 yards/366 m).

Therefore, based on our exposure analysis and the fact that these detonations will occur over the next 20 years, 0.68 marbled murrelet groups may be, but are not reasonably certain to be, exposed to < E1 underwater detonations. However, 3.2 groups are reasonably certain to be exposed to, and injured or killed by, E3 underwater detonations.

10.4.5.2.3.2.3 Conclusion

Based on our probability analysis, 3.2 groups of marbled murrelets are reasonably certain to be exposed to, and injured or killed by, E3 underwater detonations in the Inland Waters over the next 20 years.

Our model included explicit assumptions about the seasonal distribution of marbled murrelets and the extent of the potential effects. The area of effect for each individual detonation is 212,372 m^2 ($A = \pi r 2$) (0.21 km^2/0.06 nm^2). Over the next 20 years, the total cumulative area affected (i.e., the sum of all individual areas of effect) will be 25,484,640 m^2 (25.5 km^2 or 7.43 nm^2). However, all detonations occur within the same general location within the each of the Hood Canal and Crescent Harbor EOD Training Range sites; therefore, the effects will be confined to a geographic area of 5.69 km^2 (1.66 nm^2) across two sites, and many portions of this geographic area will be affected repeatedly.

10.4.5.2.4 Effects of Underwater Explosions on Marbled Murrelet Prey

The use of explosive ordnance for Navy EOD training may cause mortality in marine forage fish which are an important prey resource for marbled murrelet. Please see the analysis for impacts of explosives on forage fish under the Underwater Explosions, Bull Trout section above, for more details.

10.4.5.2.4.1.1 Conclusion

To summarize, underwater explosions will result in mortality of forage fish species. However, we do not expect a measurable reduction in marine forage fish from exposure to underwater explosions that would consequently lead to measurable effects in marbled murrelets.

10.4.5.2.4.2 Effects of Underwater Explosions on the Marbled Murrelet in Offshore Areas

10.4.5.2.4.2.1 Exposure

The area of exposure for underwater explosions is defined by the range to effects (i.e., the distance from the explosion source at which injury of a marbled murrelet is likely to occur) for a particular net explosive weight of a charge. We used the range to effects (Table 27) and marbled murrelet density values to model the probability of marbled murrelet exposure to these explosive detonations in the Offshore Area Subunit.

To estimate the density of marbled murrelets in the Offshore Area (further than 1.9 km/1.04 nm offshore), we used a different approach than was used for the Inland Waters Subunit where the NWFPEM surveys provided marbled murrelet density data. The NWFPEM surveys describe marbled murrelet density at the scale of the Conservation Zone for Zones 2, 3, 4, and 5; however, the information is limited because surveys only extend between 1.6 km and 8 km (0.86 nm and 4.3 nm) from shore, and were only conducted during the marbled murrelet breeding season. Most areas where the Navy will perform training and testing are farther offshore than the NWFPEM surveys, and the Navy's activities will occur year-round. In order to estimate marbled murrelet densities in the winter (defined as October 11 through April 10) and farther than 3 nm (5.56 km) from shore, we modeled marbled murrelet densities based on information from other studies (Adams et al. 2014, pp. 32-33; Menza et al. 2015, pp. 16, 20-21) in addition to the NWFPEM surveys. To predict the density of marbled murrelets expected beyond the area surveyed under the NWFPEM program, we relied on Menza et al. (2015). A comprehensive description of the assumptions made in our exposure analysis for the marbled murrelet is provided in Appendices A and G.

For the “reasonable worst-case” scenario, we assumed marbled murrelets were present beyond 50 nm offshore to calculate the overall probability of exposure. For the “reasonably certain” scenario, used to calculate the numbers of birds likely to be exposed, we assumed marbled murrelets were only present within 50 nm (93 km) offshore.

Based on the expected density of marbled murrelets in the Offshore Area and the likelihood of marbled murrelet exposure within the range of effects of underwater explosions, the Service calculated the cumulative probably for marbled murrelets being injured and/or killed for each of the explosive source bins (Table 29).

Table 29. Cumulative probabilities of marbled murrelets being exposed to explosions in Offshore Areas over the next 20 years.

Source Bin	**Probability of marbled murrelet exposure over 20 years (”reasonable worst-case” scenario)**	**Expected number of marbled murrelet groups exposed over all 20 years (”reasonably certain” scenario)**
With no pre-detonation surveys		
E1	< 0.10 (discountable)	n/a - discountable
E3 (SUS)	0.95	1.08
E4	0.99	2.77
E5*	0.72	0.13***
E10	0.27	n/a, only > 50 nm
E11**	1.0	n/a, only > 50 nm
E12	0.64	n/a, only > 50 nm

* Explosive source bins E3 and E5 (large-caliber projectiles);, either could be used by the Navy; therefore, for the Service analyzed explosive with the larger range to effects (190 m).

** Explosive source bins E8 and E11 are used for the Anti-Surface Warfare/Anti-Submarine Warfare Testing – Torpedo (Explosive) Testing activity. Either of the source bins could be used, therefore for the Service analyzed the larger explosive (E11).

*** Exposure to this type of explosive (E3/E5, large-caliber projectiles) is not reasonably certain to occur.

Underwater E1 explosives are associated with medium-caliber projectiles used for Surface-to-Surface Gunnery Exercises in the Offshore Area. The probability of exposure of marbled murrelet to underwater explosions associated with E1use in Offshore Areas is considered discountable.

E3 explosives are associated with explosive sonobuoys used in Offshore Areas for Maritime Patrol Aircraft (Sound Underwater Signal) activities. We estimated that 15 explosive sonobuoys will be dropped per year during the winter within 50 nm of shore in the Offshore Area, for 20 years, with an area of effect of 0.3844 km^2 (0.1115614 nm^2) per explosion. Based on the range to effect distances of the E3 explosive sonobuoys, the Service modeled the cumulative probability that a marbled murrelet group would be exposed to these explosive sonobuoys over the next 20 years (Table 29). Based on our exposure analysis of E3 explosive sonobuoys there is a 70 percent probability that one or fewer groups of marbled murrelets would be exposed, and a 30 percent probability that two or more groups would be exposed. There is a 34 percent probability that no groups of marbled murrelets would be exposed, with a 66 percent probability that one or more would be exposed. Therefore, based on our exposure analysis we expect exposure of 1.08 groups of marbled murrelets to underwater explosions associated with E3 explosive sonobuoys is reasonably certain to occur over the next 20 years.

E4 explosives are associated with explosive sonobuoys used in Offshore Areas for Maritime Patrol Aircraft (Improved Extended Echo Ranging) activities. We estimated that 24 explosive sonobuoys will be dropped per year, for 20 years, during the winter within 50 nm of shore, with an area of effect of 0.6111 km^2 (0.1781312 nm^2) per explosion. Based on the range to effect distances of the E4 explosive sonobuoys, we modeled the cumulative probability that a marbled murrelet group would be exposed to explosive sonobuoys over the next 20 years (Table 29). Based on our exposure analysis of E4 explosive sonobuoys (underwater), there is a 47 percent probability that two or fewer groups of marbled murrelets would be exposed, with a 53 percent probability that three or more groups would be exposed. And, there is a 70 percent probability that three or fewer groups of marbled murrelets would be exposed, with a 30 percent probability that four or more groups would be exposed. Based on our exposure analysis, 2.77 groups of marbled murrelets are likely to be exposed to underwater explosions associated with E4 explosive sonobuoys over the next 20 years.

Underwater E3 and E5 explosives are associated with large-caliber projectiles used in Offshore Areas for Surface-to-Surface Gunnery exercises, which includes firing 310 detonations per year, for 20 years. The Navy indicated that either E3 or E5 would be used, so we analyzed exposure based on use of the explosive bin with the larger range to effects area (0.1133 km^2/0.03306512 nm^2). Based on the range to effect distances of the E5 explosives, we calculated the cumulative probability that a marbled murrelet group would be exposed to these projectiles over the next 20 years (Table 29). In the “reasonable worst-case” scenario, there is a 72 percent probability that one or more marbled murrelet groups would be exposed during the next 20 years. However, in the “reasonably certain” scenario, there is an 87 percent probability that no marbled murrelets would be exposed, and a 13 percent probability that one or more marbled murrelet would be exposed; therefore, we are not reasonably certain that marbled murrelet exposure to underwater explosions of E3/E5 Surface-to-Surface Gunnery large-caliber projectiles will occur.

E10 explosives are associated with Air-to-Surface Missile Exercises in Offshore Areas. Missiles are only used farther than 93 km (50 nm) from shore. Exposure of marbled murrelets to air-to-surface missiles was analyzed based on the range to effects values presented in Table 27. We are not reasonably certain of marbled murrelet presence farther than 50 nm from shore. Therefore, we conclude that marbled murrelet exposure to air-to-surface missile explosions under water is not reasonably certain to occur.

E8 and E11 explosives are associated with Torpedo Testing in Offshore Areas. Torpedo Testing only occurs farther than 50 nm from shore. We are not reasonably certain of marbled murrelet presence farther than 50 nm from shore. Therefore, we conclude that marbled murrelet exposure to underwater explosions associated with Torpedo Testing is not reasonably certain to occur.

E12 explosives are associated with Air-to-Surface Bombing Exercises in Offshore Areas. Bombing Exercises only occur farther than 50 nm from shore. We are not reasonably certain of marbled murrelet presence farther than 50 nm from shore. Therefore, we conclude that marbled murrelet exposure to underwater explosions associated with Air-to-Surface Bombing Exercises in Offshore Areas is not reasonably certain to occur.

10.4.5.2.4.2.2 Response

Based on the above analyses, marbled murrelet exposure to underwater explosions associated with the following activities is likely to adversely affect adult and sub-adult marbled murrelets as a result of their exposure to impulse-related stressors (i.e., blast waves, elevated SPLs, overpressures and underpressures, etc.):

- E3 Explosive Sonobuoys – Maritime Patrol Aircraft (Sound Underwater Signal)

- E4 Explosive Sonobuoys –Maritime Patrol Aircraft (Improved Extended Echo Ranging)

- E3/E5 Surface-to-Surface Gunnery large-caliber projectiles

Marbled murrelets exposed to underwater explosions and other stressors may be subject to lethal or non-lethal injuries. Non-lethal injuries may include TS, scarred or ruptured eardrums, or gastrointestinal tract lesions. Marbled murrelets may survive their exposure to the explosions and associated stressors; however, we expect such individuals to have reduced levels of fitness and reproductive success, and higher risk of predation by reducing their ability to detect and/or evade predators. Lethal injuries may include direct mortality, lung hemorrhaging, ruptured liver, hemorrhaged kidney, ruptured air sacs, and/or coronary air embolisms. Death from barotrauma can be instantaneous, occurring within minutes after exposure, or several days later (Abbott et al. 2002).

For individual marbled murrelets that are exposed to explosions but not injured or killed, we expect a startle response, flushing, or avoidance (i.e., diving, or leaving the area). In uninjured individuals, these responses would be short term and we would not expect significant disruptions to their normal behavior that would create a likelihood of injury. However, if several detonations occurred per day, it may result in significant disruptions to a marbled murrelet’s normal foraging behavior, potentially reducing individual fitness or their ability to feed a chick. However, in Offshore areas, we do not expect significant disruptions to normal behaviors because the associated stressors are of short-duration and do not occur frequently in a day or for an extended period of time. We expect that if a marbled murrelet is not injured or killed by the detonation, they will return to normal behaviors in a short period of time.

Individuals that experience TS from exposure to the stressors associated with underwater detonations are expected to have damage to the hair cells in their inner ears, and may not be able to detect biologically relevant sounds such as approaching predators or prey, and/or hear their mates attempting to communicate. Birds that lose their hearing are at increased risk of predation and reduced foraging efficiency. Some birds may regain some or all of their hearing sensitivity; however, they are still temporarily at risk while experiencing TS. Additionally, marbled murrelets that are exposed to the stressors caused by underwater detonations, but do not experience TS, may respond by flushing or temporarily ceasing to forage; however, due to the intermittent nature and short-duration of the exposure, they are expected return to normal behaviors in a short period of time.

10.4.5.2.4.2.3 Conclusion

The expected value of 3.85 groups of marbled murrelets represents the number of groups that are reasonably certain to be injured or killed from E3 and E4 explosive sonobuoys within a cumulative area (i.e., the sum of all individual areas of effect) of 409 km^2 (119 nm^2) over the next 20 years. This expected value includes 1.08 groups within a cumulative area (i.e., the sum of all individual areas of effect) of 115 km^2 (33.5 nm^2) for E3 explosive sonobuoys, and 2.77 groups within a cumulative area (i.e., the sum of all individual areas of effect) of 293 km^2 (85.5 nm^2) for E4 explosive sonobuoys.

10.4.5.2.5 Effects of Underwater Explosions on the Short-tailed Albatross

10.4.5.2.5.1 Thresholds and Evaluation Criteria

Underwater detonations are known to have negative physiological and neurological effects on a wide variety of vertebrate species; including coronary air emboli, lung hemorrhaging, ruptured livers, hemorrhaged kidneys, ruptured air sacs, and ruptured and scarred eardrums (Cudahy and Ellison 2002; Gisiner et al. 1998; Hastings and Popper 2005; Yelverton et al. 1973; Yelverton and Richmond 1981). Experiments using underwater explosives resulted in internal hemorrhaging and mortality in submerged mallards (*Anas platyrynchos*) (Yelverton et al. 1973, p. 49). Death from barotrauma can be instantaneous, occurring within minutes after exposure, or several days later (Abbott et al. 2002). Several birds exposed to explosions survived and appeared uninjured, but upon necropsy two weeks later there was evidence of liver blood clots and lung and kidney injuries (Yelverton et al. 1973, p. 51).

There are no published studies specific to explosions and their physiological effect on short-tailed albatross, or any other seabird. However, there are some data specific to other birds from evaluations of the effects of underwater blasting and seismic testing (Cooper 1982; Flint et al. 2003; Lacroix et al. 2003; Stemp 1985; Yelverton and Richmond 1981, p. 3). Fitch and Young (1948) found that diving cormorants were consistently killed by seismic blasts, and pelicans were frequently killed when their heads were below water. In the absence of controlled studies specific to seabirds, we considered these evaluations of the effects of other types of blast impulses on a variety of vertebrate species, including birds, for evaluating the effects of explosions on short-tailed albatross.

Detonating explosives can result in a variety of injuries to organisms. Important biological variables that factor into the degree to which an animal is affected include its size, anatomical variation, and location of the organism relative to the explosive source in the water column (Gisiner et al. 1998, p. 61). Studies of explosives by Yelverton and Richmond (1981), Yelverton et al. (1973) and Damon et al. (1974) identified injury thresholds in relation to the size of the charge, the distance from the animal at which the charge was detonated, and the mass of the animal exposed. Much work has been done to assess the impacts to avian hearing from in-air sound (Dooling 2002; Dooling and Popper 2007; Dooling 1980; Dooling 1982); however, most of their work assessed avian hearing range and hearing loss from over-exposure to in-air sound.

The principal mechanism by which blast pressure waves cause physical injuries to organisms is through oscillations of body tissues and sudden compression and expansion of gas-filled organs. Most blast injuries in marine animals involve damage to gas-containing organs (e.g., lungs, gastrointestinal tract, bowels); however, injuries also occur to liver, kidneys, ears, and coronary arteries (Cudahy and Ellison 2002; Gisiner et al. 1998; Hastings and Popper 2005; Yelverton et al. 1973; Yelverton and Richmond 1981).

Injuries from high underwater pressure waves occur over a continuum of potential effects, ranging from mortality and sub-lethal physical effects including TS and gastrointestinal tract lesions, to non-injurious effects that might result in significant disruption of normal behaviors. At the most severe end of the spectrum, direct mortality or obvious injuries can occur. For example, after submerging dog's heads and exposing them to blasts at 223 dB_{peak}, Richmond et al. (1973) estimated that 50 percent of the ears facing the blast had tympanic rupture. Yelverton et al. (1973) documented less eardrum rupture in submerged mallards exposed to blasting, but noted extensive lung hemorrhage and a 50 percent prevalence of liver and kidney damage. At the least severe end of the spectrum of injurious effects, there may be temporary hearing shifts or small burst blood vessels.

Several authors have described methods for calculating the theoretical kill or injury zones around underwater explosions (Gaspin 1975; O'Keeffe and Young 1984; Young 1991). A common metric used for a single acoustic event that accounts for both the negative and positive pressure wave is sound exposure level (SEL) (Hastings and Popper 2005). An impulse, measured in Pascal seconds (Pa-sec), is the best way to describe and measure the effects of the explosion on organisms because it captures all the forces occurring with a fast-acting explosion over time. Impulse values include all the effects associated with an explosion, such as blast pressure wave/shock wave, over pressure and under pressure, and peak SPL. If we used a single component to describe the effects to short-tailed albatross, such as peak SPL, or SEL, we may not adequately account for the energy from the shock wave or the over pressure. These components contain significant energy, so by accounting for that energy we have increased confidence that the distances to effect for barotrauma or injury are comprehensive.

The Service coordinated with the Navy to develop thresholds for onset of injury to short-tailed albatross (Table 30). The Service requested that the Navy calculate the ranges to effect (i.e., the area in which we expect injury of short-tailed albatross to occur) for underwater explosions based on information provided for mallards in Yelverton et al. (1973). We also requested that the Navy adjust these values for the mass of short-tailed albatross, which are much larger than the mallards used in Yelverton's underwater impulse research. The Navy calculated these ranges to effects, shown in Table 31. For exposure of fish and mammals to impulses underwater, Yelverton (1981) and Yelverton et al. (1973) found a correlation between the size of fish and mammals and the impulse level needed to elicit an injury. While Yelverton did not do this analysis for birds, we reason that this correlation was independent of the organism's taxonomic classification and thus it also applies to birds (for underwater explosions).

Table 30. The Service's injury or mortality thresholds for short-tailed albatross from underwater explosions.

Explosions Underwater			
Bird Species	**Auditory Injury dB SEL re: µ1 Pa^2-sec**	**Barotrauma (Pa-sec)**	**Mortality (Pa-sec)**
Short-tailed Albatross	212	94	361

Table 31. Navy-provided ranges to effects for short-tailed albatross from underwater explosions.

Short-tailed Albatross			
Explosive Bins	**Auditory Injury (≥ 212 dB SEL) (meters)**	**Barotrauma (≥ 94 Pa-sec) (meters)**	**Mortality (≥361 Pa-sec) (meters)**
E3 off shore	9	74	26
E4	13	82	33
E5*	2	26	13
E8	57	211	106
E10*	15	53	29
E11	144	304	160
E12*	21	60	33

* May detonate at the surface of the water.

The range to effect values the Navy provided (Table 31) were based on Swisdak (1978) impulse data, to which the Navy also accounted for time cut-off using an equation from Yelverton et al. (1973) to account for the effect of overpressure and underpressure cancelling each other out. The Navy FEIS provides graphs of threshold profiles for slight lung injury and mortality based on different animal masses for each size class of underwater explosive (Navy 2015a, pp. 3.4-215 to 3.4-218). We compared the ranges to effects provided by the Navy (Table 31) with these tables in the FEIS and explosive impulse ranges from Swisdak (1978), and explosive SPLs from Hildebrand (2009). Because there were large differences in the distances between the range to effects values the Navy provided in Table 31 and these other sources of comparison, we requested that the Navy provide the calculations of the range to effects in Table 31. In some cases, the ranges to effect for barotrauma represent the largest area of effect and also encompass other effects from exposure, including auditory injury and mortality. In other cases, the range to 237 dB peak was larger. We considered the larger of these two values to be the onset of injury and we modeled probability of exposure based on the associated range to effects.

The Navy provided the calculations we requested (Table 31) and we used that information to estimate the range to effects to the thresholds (Table 32). We used this information to predict the range to effects to our thresholds for underwater explosions assuming a maximum diving depth of two meters (short-tailed albatross are generally surface feeders and shallow divers). The values we used for range to effects for short-tailed albatross from underwater detonations are provided below in Table 32.

Table 32. Ranges to effect for onset of injury of short-tailed albatross from underwater explosions from Swisdak (1978) and Yelverton (1973).

Short-tailed Albatross	
Explosive Bins	**Onset of Injury (Barotrauma) (94 Pa-sec) at 2 m diving depths** **
E1 Offshore*	22
E3 Offshore (Sonobuoy)	92
E4 Offshore	109
E5* Offshore (included E3 Projectiles)	75
E7* (***) Offshore	136
E8 Offshore	299
E10* Offshore	276
E11 Offshore	437
E12* Offshore	347

* May detonate at the surface of the water, truncating the range to effects underwater because energy is lost into the air.

** Used the larger range to effect of 94 Pa-sec impulse or 237 dB peak

*** Calculated distance to effect for E7 explosion underwater as a proxy for the underwater sound resulting from non-explosive practice missiles hitting the water.

10.4.5.2.5.1.1 Exposure

The area of exposure for underwater explosions is defined by the range to effects of a particular net explosive weight of a charge. We used the range to effects (Table 32) and density of birds to model the probability of short-tailed albatross exposure to these explosive detonations in the Offshore Area.

To determine the likelihood of short-tailed albatross exposure to explosions, we considered data from our 5-year status review of short-tailed albatross (USFWS 2014). These data were derived from direct counts of a breeding colony on Torishima, in which Dr. Hasegawa and his staff collected information about adults, eggs, chicks, and productivity (USFWS 2014, p. 8). The population estimates were calculated using a deterministic population model (USFWS 2014, p.

8). The current total population estimate is 4,354 individuals and the population is growing by approximately 7.5 percent annually (ranges from 5.2 to 9.4 percent), with 1,928 breeding age birds as of the 2013-2014 nesting season (USFWS 2014, pp. 8-9). For a more detailed description of how we determined the number of short-tailed albatross exposure and numbers of groups reasonably certain to be exposed was determined, please see Appendix A.

At-sea sightings since the 1940's indicate that short-tailed albatross are widely distributed throughout their historical foraging range in the North Pacific Ocean and are often found close to the U.S. coast. From December through April, distribution is concentrated near the breeding colonies, although foraging trips may extend hundreds of miles or more from the colony sites, similarly to other albatross. In summer during the breeding season, individuals appear to disperse widely throughout the historical range of the North Pacific Ocean based on observations from the northern Gulf of Alaska, Aleutian Island, and Bering Sea, and along the west coast of North America as far south as the Baja Peninsula, Mexico (65 FR 46643 [July 31, 2000]). Based on this information, we expect short-tailed albatross could be anywhere in the offshore portion of the action area at any time of year, regardless of the season. Additionally, short-tailed albatross are primarily surface feeders, spending relatively little time with their heads underwater.

Based on the distribution and density of short-tailed albatross, the location of detonations, and the calculated range to effects values (Table 32), the Service calculated the cumulative probability that a short-tailed albatross would be exposed to and injured from underwater detonations over the next 20 years (Table 33). A comprehensive description of assumptions made in our exposure analysis is provided in Appendices A and G.

A number of different types of explosive ordnance may generate underwater explosions. Underwater E1 explosions are associated with medium-caliber projectiles used for Surface-to-Surface Gunnery Exercises in the Offshore Area. Underwater E3 explosions are associated with explosive sonobuoys used in Offshore Areas for Maritime Patrol Aircraft (Sound Underwater Signal) activities. Underwater E4 explosions are associated with explosive sonobuoys used in Offshore Areas for Maritime Patrol Aircraft (Improved Extended Echo Ranging) activities.

Underwater E3 and E5 explosives are associated with large-caliber projectiles used in Offshore Areas for Surface-to-Surface Gunnery exercises. The Navy indicated that either E3 or E5 would be used, so we analyzed exposure based on the explosive bin with the larger range to effects area (E5). Underwater E10 explosions are associated with Air-to-Surface Missile Exercises in Offshore Areas. Underwater E8 and E11 explosions are associated with Torpedo Testing in Offshore Areas. The Navy indicated that either E8 or E11 would be used, so we analyzed exposure based on use of E11 because these had the larger range to effects area. Underwater E12 explosives are associated with Air-to-Surface Bombing Exercises in Offshore Areas. For each explosive class, we analyzed the probability of short-tailed albatross exposure based on the range to effects (see range to effects in Table 32 and probability of exposure below in Table 33). We determined that exposure of short-tailed albatross to any of these underwater explosions was extremely unlikely to occur over the next 20 years.

Table 33. Cumulative probabilities of short-tailed albatross being exposed to underwater explosions in Offshore Areas over the next 20 years.

Source Bin	Probability of exposure over 20 years ("reasonable worst-case" scenario)	Expected number of individuals exposed over all 20 years ("reasonably certain" scenario)
With no pre-detonation surveys		
E1	< 0.10 (discountable)	n/a
E3 (SUS)	< 0.10 (discountable)	n/a
E4	< 0.10 (discountable)	n/a
E5*	< 0.10 (discountable)	n/a
E10	< 0.10 (discountable)	n/a
E11**	< 0.10 (discountable)	n/a
E12	< 0.10 (discountable)	n/a

* Explosive source bins E3 and E5 (large-caliber projectiles), either could be used by the Navy; therefore, for the Service analyzed explosive with the larger range to effects (190 m).

** Explosive source bins E8 and E11 are used for the Anti-Surface Warfare/Anti-Submarine Warfare Testing – Torpedo (Explosive) Testing activity. Either of the source bins could be used, therefore for the Service analyzed the larger explosive (E11).

10.4.5.2.5.1.2 Response

Exposure is extremely unlikely; therefore, no responses by short-tailed albatross are expected.

10.4.5.2.5.1.3 Conclusion

Based on density and distribution of short-tailed albatross in the Offshore Area, the range to effects of the explosives described above, and the conditions under which the explosives will be detonated (i.e., depth underwater), we do not expect exposure to short-tailed albatross from underwater explosions associated with any of the activities involving underwater detonations in the Offshore Area over the next 20 years.

10.4.5.2.6 Effects of Underwater Explosions on Short-tailed Albatross Prey

The use of explosive ordnance for Navy EOD training may cause mortality in marine forage fish which are an important prey resource for the short-tailed albatross.

10.4.5.2.6.1.1 Conclusion

We expect that underwater explosions will result in mortality of forage fish. However, we do not expect a measurable reduction in marine forage fish from exposure to underwater explosions that would consequently lead to measurable effects in short-tailed albatross.

10.4.5.3 In-Air Explosions

Explosive munitions are associated with a variety of stressors, including, but not limited to, bow shock, muzzle blast, pressure/shock waves, elevated SPLs, rapid changes in underpressures and overpressures, and projectiles and fragments traveling at high velocities. Some of these stressors occur at the point of firing and along the trajectory of a projectile, in addition to effects surrounding the site of the explosion. Of the stressors associated with the explosion itself, some are more severe in the near field (blast zone), while others extend further away, in the far field (e.g., sound and fragmentation). The energy of a blast pressure wave decays fairly rapidly in the blast zone, and the energy loss (transmission loss) in the far field has relatively slow decay per unit of distance traveled. Also, when explosives contain an outer casing, the fragments can travel in the air at velocities and to distances that can result in injury beyond the extent of the blast energy (The National Counterterrorism Center 2014b).

An explosion in air produces a blast pressure wave that radiates quickly from the detonation site. The strength of this wave depends on the type and amount of explosive and the distance from the detonation location (the strength of the blast pressure wave dissipates with increasing distance). The typical blast pressure wave from an explosion consists of an instantaneous increase in the peak pressure, followed by a slower (but still very rapid) logarithmic decrease to ambient pressure. The pressure wave can be displayed as a waveform that describes the pressure-time history, where time is measured in milliseconds or seconds, while pressure is measured in micropascals (μPa).

In-air explosions release energy as light, heat, sound, and shock waves. A shock wave is highly compressed air traveling at supersonic velocities and rapidly decreasing pressures. When the shock wave meets a surface that is in line-of-sight of the explosion, the shock wave is reflected and amplified by up to a factor of 13 (FEMA 2003, pp. 4-1, 4- 2). A shock wave also creates a vacuum, resulting in wind and flying debris in the vicinity of the detonation. On land, some of the energy creates a crater in the ground and generates a shock wave similar to a high-intensity, short duration earthquake (FEMA 2003, p. 4-2). The distance (radius) at which injury or death may occur is expected to vary depending on the size of artillery and munitions that are used.

According to information provided by the Navy during meetings with the Service, some explosives meant to detonate in air or at the surface may instead detonate below the surface of the water. Table 34 below describes the explosives that will be used by the Navy over the next 20 years in the Offshore Area. In-air explosives will be used in the Offshore Area only, not in Inland Waters. The sections below describe the effects to marbled murrelets and short-tailed albatross when these munitions detonate in the air in the Offshore Area and include an analysis of all the stressors expected from the use of a particular type of projectile.

Exploding projectiles can produce the following stressors: blast pressure waves (rapid changes in pressure, also called underpressure and overpressure fluctuations), elevated sound pressure waves, projectile shock waves (discussed in detail in the section on non-explosive projectiles), strike by projectiles and projectile fragments traveling at high velocity. Onset of injury occurs at the distance at which the farthest ranging stressor extends (the stressor with the largest distance). These ranges will depend on the explosive device, whether it has an outer casing, and the quantity of explosives contained within. These explosive devices include bombs, missiles, explosive projectiles, and torpedoes (Table 34).

Table 34. Explosives that detonate in the air in the Offshore Area.

Source Class	Example Ordnance	Net Explosive Weight (pounds [lb.])	NWTT Detonation Matrix (Air, Underwater, Water Surface < 1 m)
E1	Medium-caliber projectiles	0.1–0.25	Air or Water Surface < 1 m
E3	Large-caliber projectiles	> 0.5–2.5	Air or Water Surface < 1m
E5	5-inch projectiles	> 5–10	Air or Water Surface < 1m
E7	Rolling airframe anti-air missile	> 20-60	Air
E8	Surface-to-air missile	> 60–100	Air
E10	Air-to-surface missile	> 250–500	Air or Water Surface < 1 m
E12	2,000 lb Bomb	> 650–1,000	Air or Water Surface < 1m

10.4.5.3.1 Effects of In-Air Explosions on the Marbled Murrelet

10.4.5.3.1.1 Thresholds and Evaluation Criteria

There are no published studies specific to in-air explosions and their physiological effect on marbled murrelets. However, Damon et al. (1974) evaluated the effects of in-air explosions to birds. Exposure to in-air explosions can result in mortality (instantaneous or delayed), extensive lung hemorrhaging, eardrum rupture, contused skeletal muscle, ruptured liver, ruptured kidney, hearing TS, physical displacement (forced by pressure waves into hard objects), and broken bones. Other non-injurious effects can include disruption of normal behaviors (Damon et al. 1974).

Proximity to the explosion and the quantity of explosives influence the severity and type of injuries. Explosive impulses behave differently underwater than in the air because of the difference in reference pressure between the two mediums. Sound travels much faster underwater than in air, while explosive casing fragments will travel much farther and faster in air than underwater. This is why the potential “areas where injury may occur” or “ranges to effect” are different when explosions occur in the air versus underwater. Animals will be similarly injured by exposure to an explosion depending on 1) their physiological characteristics, 2) proximity to the explosion, 3) charge weight of the explosive and the energy released upon detonation, and the 4) medium the explosion occurs in (air or water, or both).

Much work has been done to assess the impacts to avian hearing from in-air sound (Brittan-Powell and Dooling 2002; Dooling et al. 2000; Dooling and Popper 2007; Dooling 1980; Dooling 1982; Dooling and Dent 2002; Dooling and Brittan-Powell 2005; Ryals et al. 1999; Ryals and Dooling 2001; Saunders and Dooling 1974; Saunders and Henry 1989); most of their work assessed avian hearing range and hearing loss from over-exposure to in-air sound. The time integrated energy average of a frequency-weighted sound pressure thus accounts for amplitude and spectral characteristics of the noise level (Pater 1981, p. 4). For determining onset of injury from sound, a SEL is the best metric, while an impulse value is most appropriate for an explosion. SEL is considered superior to other metrics (i.e., peak SPL), because it allows one to sum the energy produced with multiple sound sources (Hastings and Popper 2005).

Peak overpressure or dB equivalent peak SPL alone is not always an adequate descriptor of the effect of blast waves; it is better to apply a weighting for frequency (Pater 1981, p. 3). The time integrated energy average of a frequency-weighted sound pressure thus accounts for amplitude and spectral characteristics of the noise level. Because of the complex nature and multiple stressors associated with an in-air explosion, other than elevated SPLs, we use an impulse metric (Pa-sec) to establish thresholds and range to effects for onset of injury.

The Service established an in-air threshold for onset of auditory injury of 140 dBA peak re: 20 µPa based on Dooling and Popper (2007, pp. 23-24), who report that birds exposed to noise at 140 dBA peak re: 20 µPa or greater are likely to suffer hearing damage (i.e., onset of injury). Since most data on effects to hearing from exposure to in-air explosions relates to human auditory shift, we used 2 psi [TS in humans (Champion 2009, p. 1470)] as the threshold for onset of auditory injury in this analysis.

We are currently unable to further distinguish between the degree of injuries sustained by marbled murrelets at sound levels at or above 2 psi re: 20 µPa, fragmentation, and/or other far-reaching stressors. In other words, birds exposed to high-velocity fragmentation or SPLs that exceed 140 dBA peak could experience injuries that range from hearing damage to internal injuries and/or mortality. The range to effects to onset of injury is meant to describe the farthest ranging effect expected to occur to the birds, and depends on the type of munitions used.

The Service coordinated with the Navy to develop thresholds for onset of injury and mortality for marbled murrelets from exposure to in-air explosions (Table 35). The Service requested that the Navy calculate the ranges to effect for in-air explosions based on information provided in the work of Damon et al. (1974) on in-air explosives with quail, chickens, and pigeons. We requested that the Navy adjust these values accordingly for the mass of the marbled murrelet and the short-tailed albatross, due to the variations in size from the birds used in research by Damon et al. (1974). The Navy estimated these range to effects based on Damon et al. (1974, p. 32) (Table 36).

Table 35. The Service's injury or mortality thresholds for marbled murrelets and short-tailed albatross from in-air explosions.

Explosions *in Air*			
Species	**Barotrauma**	**Mortality**	**Auditory Injury dBA peak re: 20 μPa**
Marbled Murrelet & Short-tailed Albatross	34.5 kPa peak 185 dB re: 20 μPa	69 kPa peak 191 dB re: 20 μPa	140 dBA peak
	34.5 Pa-sec Impulse	69 Pa-secs impulse	

Table 36. Navy provided range to effects for marbled murrelets and short-tailed albatross from in-air explosions.

Explosions *in Air*		
Explosive Bins	**Barotrauma (≥ 5 psi msec) (meters)**	**Mortality (≥ 10 psi msec) (meters)**
E1	< 1.5	Not provided
E3	2	1.5
E5	5	4
E10*	30	24
E12*	46	34

* Only occur at distances greater than 50 nm offshore.

The ranges to effect values that the Navy provided (Table 36) were based on visual interpretation of graphs in Damon et al. (1974, p. 32) (in-air impulse data). We compared these range to impulse ranges in Swisdak (1975) and in-air SPL ranges in Hildebrand (2009). There were large differences between the distances provided by the Navy, based on Damon et al. (1974, p. 32), and the ranges provided by Swisdak (1975) and Hildebrand (2009). Additionally, many of the explosive munitions the Navy will use that detonate in the air also contain other stressors we must evaluate; projectile shock waves, elevated SPLs, rapid changes in overpressures and underpressures, and strikes from projectiles and projectile fragments.

When fragments are expected from explosions, our analysis showed that the range of effects for fragments extends farther than the range of effects for blast pressure waves. For fragmentation, most distances at which adverse effects from artillery and munitions are described in terms of their impacts to humans. Buffer distances of 366 m and 518 m are recommended for humans in unconfined areas (i.e., not in a building) to avoid injuries associated with blast waves from detonating 5 lb and 20 lb explosives (Department of Homeland Security 2009; The National Counterterrorism Center 2014b), respectively. These distances are recommended to protect humans from glass breakage, fragmentation (shrapnel), and ear drum rupture (Department of Homeland Security 2009). Absent more species-specific information, we considered this to be the best available information when determining ranges of effect for in-air explosions.

We calculated the distances that the impulse energy and fragmentation would extend until they attenuated below the threshold for onset of injury (Table 37). In some cases, the range to onset of injury will reflect the distance where fragmentation can result in injury because explosive casings will produce fragments that will travel at high-velocities to greater distances than other stressors associated with an in-air detonation, such as shock waves, elevated SPLs, and rapid changes in overpressures and underpressures. Please note that the indicated safety range for fragments in Table 37 is the distance to zero probability of fragments striking a bird, which we acknowledge is conservative. Some exploding munitions have an outer casing. When in-air explosives do not contain an outer casing that can fragment upon detonation, we expect that the greatest range to injurious effects will be the range to onset of auditory injury because elevated SPLs represent the stressor with the greatest range to effects for onset of injury; this range is greater than those for barotrauma and mortality that may occur from impulse stressors. We did not have information regarding which of the explosive munitions to be used in NWTT activities had outer casings, so we analyzed in-air explosions as if all of the explosive munitions would fragment. If this is not the case, some of the explosives may have smaller areas of effect than we analyzed.

Table 37. Range to effects for onset of injury (TS or strike by fragmentation) caused by in-air explosions.

Class	Charge Wt (NEW lb)	Range to 2 psi (onset TS) (m) *	Distance to Human Safety (m)**
E1	0.1-0.25	17.2	**241**
E3	0.5-2.5	28.7	**367**
E5	5-10	49.2	**442**
E7	21-60	91.3	**539**
E8	60-100	106.0	**567**
E10	250-500	179.6	**655**
E12	650-1000	228.2	**692**

* Swisdak data (Swisdak 1975).

** NCTC data (The National Counterterrorism Center 2014a; The National Counterterrorism Center 2014b). We used these ranges for exposure analysis because this is the farthest range that fragmentation traveling at high velocities could extend.

Explosions are expected to be intermittent, interspersed over a large area, and of short duration. If individual marbled murrelets are exposed to explosions and not injured or killed, we expect a startle response, flushing, and/or avoidance behaviors (i.e., avoidance diving, or leaving the area). If individuals are exposed but uninjured, these responses would be short term in duration and we do not expect significant disruptions to their normal behaviors that would create a likelihood of injury. We do expect that exposures to these stressors could cause physical injuries and/or mortality and these effects are addressed below.

10.4.5.3.1.2 Effect of In-Air Explosions on the Marbled Murrelet in the Offshore Area

10.4.5.3.1.2.1 Exposure

We modeled the probability of marbled murrelet exposure based on the range to effects of the suite of stressors associated with each type of explosive projectile and the density of marbled murrelets in the Offshore Area. For a more detailed description of how exposure probabilities and numbers of groups reasonably certain to be exposed were determined, please see Appendix A.

Explosive projectiles will be used in the Offshore Area further than 37 km (20 nm) from shore. We assumed that half of the projectile use would occur in winter and half in summer. During winter, we expect there is a greater potential for exposure to marbled murrelets that disperse further from shore. During the summer, marbled murrelets typically remain close to shore because they are breeding and feeding their young, and we considered that their presence at distances greater than 22 km (12 nm) from shore to be discountable; therefore, we do not expect exposure from summer projectile use. We have little information about marbled murrelet distribution offshore during the winter, and although it is possible that marbled murrelets may be present at great distances from shore, we are not reasonably certain of their presence at distances greater than 93 km (50 nm) from the coast. Therefore, we would only expect exposure to marbled murrelets that disperse further from shore during winter, outside of breeding season.

Based on the area of exposure, and the expected density of marbled murrelets in the Offshore Area, the Service calculated the cumulative probably for marbled murrelet exposure to each of the explosive source bins and other stressors associated with these explosive munitions (Table 38).

Table 38. Probability of marbled murrelet exposure from explosive projectiles (in-air).

Source Bin	**Probability of marbled murrelet exposure over 20 years (“reasonable worst-case” scenario)**	**Expected number of marbled murrelet groups exposed over all 20 years (“reasonably certain” scenario)**
No Pre-detonation Surveys		
E1	1.0	18.8
E5/E3	1.0	4.8
E7	0.73	n/a, greater > 50 nm
E10	0.98	n/a, greater > 50 nm
E8	1.0	n/a, greater > 50 nm
E12	0.74	n/a, greater > 50 nm

E1 explosives are associated with medium-caliber projectiles used for Surface-to-Air and Surface-to-Surface Gunnery Exercises in the Offshore Area (in the area between 20 nm and 50 nm). Medium-caliber projectiles travel at high-velocities and create a sonic boom (supersonic projectile). They also create other stressors, including strikes by projectile and high-velocity fragments, elevated SPLs from the explosion, and blast waves from the explosion. The area of effect is defined by the areas of effect from all these stressors combined. The areas of effect used in our analysis include a circle with a radius equal to the distance to human safety for E1 explosions listed in Table 37, added to the areas of effect for projectile shock wave of medium-caliber projectiles shown in Table 42. Note that we assumed that all explosive projectiles used in the Surface-to-Surface Gunnery Exercises would be 25 mm, while those used in the Surface-to-Air Gunnery Exercises would be evenly distributed among the four sizes we analyzed. The Service calculated the cumulative probability that a marbled murrelet would be exposed over the next 20 years (Table 38) based on the ranges to effect of these stressors, the estimated density of marbled murrelets, and the number of medium-caliber explosive projectiles to be used. Assuming that an average of 416 medium-caliber E1 projectiles are used each winter at distances less than 50 nm (92.6 km) from shore, we expect that 18.8 groups of two marbled murrelets will be exposed over 20 years. Over 20 years, the sum of all individual areas of effect reasonably certain to be exposed is 1,988.3 km^2 (579.7 nm^2).

E3 and E5 explosives are associated with large-caliber projectiles used in Offshore Areas for Surface-to-Air and Surface-to-Surface Gunnery exercises (in the area between 20 nm and 50 nm). Large-caliber projectiles travel at high-velocities and create a sonic boom (supersonic projectile). They also create other stressors, including strikes by projectile and high-velocity fragments, elevated SPLs from muzzle blast and the explosion, and blast waves from the explosion. The Navy indicated that either E3 or E5 explosives would be used, so we analyzed exposure based on use of E5 explosives because these had the larger area of effect. The area of effect is defined by the combined areas of effect of all these stressors. The areas of effect used in our analysis include a circle with radius equal to the distance to human safety for E5 explosions listed in Table 37 added to the areas of effect for muzzle blast and projectile shock wave of large-caliber projectiles shown in Table 43. The Service calculated the cumulative probability that a marbled murrelet would be exposed over the next 20 years (Table 38) based on the ranges to effect of these stressors, the estimated density of marbled murrelets, and the number of large-caliber explosive projectiles to be used. Assuming that an average of 21 large-caliber projectiles (E3/E5) are used each winter at distances less than 50 nm (92.6 km) from shore, we expect that 4.8 groups of two marbled murrelets will be exposed over 20 years. Over 20 years, the sum of all individual areas of effect reasonably certain to be exposed is 507.6 km^2 (148.0 nm^2).

E7 explosives are associated with Air-to-Air Missile Exercises. E7 stressors only include falling fragments because these missiles are used at elevations higher than murrelets are known to fly. In addition, these missiles are only used in locations farther than 50 nm from shore. If murrelets are present farther than 50 nm from shore there is the potential they would be exposed, but under the “reasonably certain” scenario, we did not expect to find murrelets at that distance from shore. Therefore, although exposure of murrelets to falling fragments is not discountable, it is also not reasonably certain to occur.

E8 explosives are associated with Surface-to-Air Missile Exercises. Stressors include missile strike, strike by falling fragments, elevated SPLs from bow shock and the explosion, and blast waves from the explosion. These Missile Exercises are only used farther than 50 nm from shore. If marbled murrelets are present farther than 50 nm from shore, they may be exposed, so exposure to these stressors is not discountable. However, we are not reasonably certain of marbled murrelet presence in these areas, so we cannot be reasonably certain of their exposure.

E10 explosives are associated with Air-to-Surface Missile Exercises. Stressors include missile strike, strike by high-velocity fragmentation, elevated SPLs from bow shock and the explosion, and blast waves from the bow shock and the explosion. These Missile Exercises are only used farther than 50 nm from shore. We are not reasonably certain of marbled murrelet presence in these areas, so we cannot be reasonably certain of their exposure.

E12 explosives are associated Air-to-Surface Bombing Exercises. Stressors include bomb strike, strike by high-velocity fragmentation, in-air sound from the explosions, and blast waves from the explosion. Explosive bombs are only used farther than 50 nm from shore. We are not reasonably certain of marbled murrelet presence farther than 50 nm from shore, so we cannot be reasonably certain of their exposure.

10.4.5.3.1.2.2 Response

Medium and large-caliber projectiles may injure or kill adult and subadult marbled murrelets by striking them, or exposing them to blast waves, muzzle blast, shock waves, bow shock, projectile shock waves, or elevated SPLs. We expect exposure of marbled murrelets from the following activities:

- E1 medium-caliber projectiles from Surface-to-Air and Surface-to-Surface Gunnery Exercises

- E5/E3 large-caliber projectiles from Surface-to-Air and Surface-to-Surface Gunnery Exercises

Individuals exposed to explosions and other stressors may experience lethal or non-lethal injuries. Non-lethal injuries may include TS, scarred or ruptured eardrums, or gastrointestinal tract lesions. Individuals may survive their exposure to the explosions and other stressors; however, we expect a reduced level of fitness and reproductive success, and higher risk of predation. Exposed individuals may also experience lethal injuries that occur instantaneously or manifest over time. These effects include direct mortality, lung hemorrhaging, ruptured liver, hemorrhaged kidney, ruptured air sacs, and/or coronary air embolisms. Death from barotrauma can be instantaneous, occurring within minutes after exposure, or several days later (Abbott et al. 2002).

If individual marbled murrelets are exposed to the stressors and/or detonations, but not injured or killed, we expect a startle response, flushing, or avoidance (i.e., diving, or leaving the area). In uninjured individuals, these responses would be short term and we would not expect significant disruptions to their normal behavior that would create a likelihood of injury. However, if several detonations occurred per day, it may result in significant disruptions to a marbled murrelet's normal foraging behavior, potentially reducing individual fitness or their ability to feed a chick. For explosions in Offshore Areas, we do not expect significant disruptions to normal behaviors because the associated stressors are of short-duration and do not occur frequently in a day or for an extended period of time (less than three hours). We expect that if a marbled murrelet is not injured or killed by the detonation, they will return to normal behaviors in a short period of time.

Individuals that experience TS from exposure to the stressors associated with these activities are expected to have damage to their inner ear hair cells, and may not be able to detect biologically relevant sounds such as approaching predators or prey, or hear their mates attempting to communicate. Birds that lose their hearing are at increased risk of predation and reduced foraging efficiency. Some birds may regain some or all of their hearing sensitivity; however, they are still temporarily at risk while experiencing TS. Additionally, marbled murrelets that are exposed to the activity stressors, but do not experience TS, may respond by flushing or temporarily ceasing to forage; however, due to the intermittent nature and short-duration of exposure, they are expected return to normal behaviors in a short period of time.

Several assumptions were necessary to predict exposure. For example, if E1 (medium-caliber projectiles) and E5/E3 (large-caliber projectiles) are fired in bursts of several projectiles, rather than individually, our analysis would overestimate the number of opportunities for exposure, but may underestimate area of effect from the sequence of explosions. These sources of over- or underestimation may partially compensate for each other; however, we cannot precisely predict these factors without more complete information regarding the deployment of these projectiles. Additionally, because we assumed all E5 and E3 explosions were E5 (Navy could not provide more specifics), the results of our exposure analysis may be conservative, because we assumed the greater range of effects for all of these projectiles.

Many factors could change our estimated area of exposure, if accurate information were available. For example, the area of marbled murrelet exposure would be smaller if the projectiles and the projectile shock waves travel higher than 20 m (65.6 ft) above the surface, if the projectiles travel shorter distances than we estimated, and if the projectiles travel at slower velocities than we anticipated. (Note that, for surface-to-air projectiles, we truncated the area of effect to account for the portion of the trajectory along which the injurious sound from the projectile shock wave is expected to be exclusively above 20 m (65.6 ft) above the surface.) Additionally, projectile shock waves are cone-shaped and trail behind supersonic projectiles. Muzzle blast spreads away from the muzzle spherically. Depending on the height at which the projectile is fired, the area to which a marbled murrelet may be exposed to injury may be smaller. Furthermore, the area of exposure for muzzle blasts includes areas such as the ship deck from which projectiles are fired, and other areas where marbled murrelets are unlikely to be present. While the area of exposure may be smaller than we analyzed, we are unable to quantify how much smaller, and therefore could not quantify how these factors would influence the expected number of birds exposed and injured.

Our quantitative analysis also illustrated that the actual number of bird groups exposed to stressors could be larger than the expected numbers reported above.

- The expected number of marbled murrelet groups exposed to medium-caliber E1 projectile stressors is 18.8. There is a 52 percent probability that more than 18 groups of two marbled murrelets will be exposed, and there remains a 43 percent probability that more than 19 groups of two marbled murrelets will be exposed to medium-caliber E1 projectile stressors.

- The expected number of marbled murrelet groups exposed to large-caliber E3 or E5 projectile stressors is 4.8. There is a 53 percent probability that more than four groups of two marbled murrelets will be exposed, and there remains a 36 percent probability that more than five groups of two marbled murrelets will be exposed to large-caliber E3 or E5 projectile stressors.

10.4.5.3.1.2.3 Conclusion

We believe that the expected value of 23.6 groups of marbled murrelets within a total habitat area of 2,496.0 km^2 (727.7 nm^2) predicted by our probability analysis represents a reasonable estimate of the number of marbled murrelets that may be affected by E1 and E3/E5 Gunnery Exercise projectiles in the Offshore Area.

We expect exposure of a total of 18.8 groups of marbled murrelets associated with 1,988.3 km^2 (579.7 nm^2) from E1 medium-caliber Gunnery Exercise projectiles, and a total of 4.8 groups associated with 507.6 km^2 (148.0 nm^2) from E3/E5 large-caliber Gunnery Exercise projectiles, over the 20 years (Table 38). The habitat areas reported here represent the cumulative area for which stressors will exceed Service thresholds (i.e., the sum of all individual areas of effect) and these areas are relatively large. These weapons are transitory, not stationary, being dispensed in different places over time. Therefore, we assess marbled murrelet exposure as these operations move over time.

We used an exposure model to estimate the number of marbled murrelets that may be affected by explosive projectiles because there is significant variability in marbled murrelet distribution and density in the marine environment. Affected individuals would be extremely difficult to detect. Our model includes explicit assumptions about seasonal distribution of marbled murrelets and the extent of the potential effects. The actual number of marbled murrelets affected by exposure to these explosive projectiles will remain unknown; however, we can reliably quantify the habitat area affected.

10.4.5.3.2 Effect of In-Air Explosions on the Short-tailed Albatross

10.4.5.3.2.1 Thresholds and Evaluation Criteria

We use the same approach to analyzing these effects to short-tailed albatross as we do for the marbled murrelet. Please see the Thresholds and Evaluation Criteria section above for details.

For this consultation, we used 2 psi as the threshold for onset of auditory injury from in-air explosions. We are currently unable to further distinguish between the degree of injuries sustained by short-tailed albatross at sound levels at or above 2 psi re: 20 µPa, fragmentation, and/or other far-reaching stressors. In other words, birds exposed to high-velocity fragmentation or SPLs that exceed 140 dBA peak could experience injuries that range from hearing damage to internal injuries and/or mortality. The range to effects to onset of injury is meant to describe the farthest ranging effect, and depends on the type of munitions used.

For in-air explosions we calculated the distances that the impulse energy and fragmentation would extend until they attenuated below the threshold for onset of injury (Table 37). In some cases, the onset of injury range to effects will reflect the distance where fragmentation can result in injury because explosive casings will produce fragments that will travel at high-velocities to greater distances than other stressors associated with an in-air detonation, such as shock waves, elevated SPLs, and rapid changes in overpressures and underpressures. Some exploding munitions have an outer casing. When in-air explosives do not contain an outer casing that can fragment upon detonation, we expect that the greatest range to injurious effects will be the range to onset of auditory injury because elevated SPLs represent the stressor with the greatest range to effects for onset of injury; this range is greater than those for barotrauma and mortality that may occur from impulse stressors. We did not have information regarding which of the explosive munitions to be used in NWTT activities had outer casings, so we analyzed in-air explosions as if all of the explosive munitions would fragment. If this is not the case, some of the explosives may have smaller areas of effect than we analyzed.

Explosions are expected to be intermittent, interspersed over a large area, and of short duration. If individual short-tailed albatross are exposed to explosions and not injured or killed, we expect a startle response, flushing, and avoidance behaviors (i.e., avoidance diving, or leaving the area). If individuals are exposed but uninjured, these responses would be short-term in duration and we do not expect significant disruptions to their normal behaviors that would create a likelihood of injury. We do expect that exposures to these stressors could cause physical injuries and/or mortality and these effects are addressed below.

10.4.5.3.2.2 Effects of In-Air Explosions on the Short-tailed Albatross in the Offshore Area

10.4.5.3.2.2.1 Exposure

We modeled the probability of short-tailed albatross exposure based on the range to effects for the suite of stressors associated with each type of explosive projectile and the density of short-tailed albatross in the Offshore Area. For a more detailed description of how we determined the numbers of individuals reasonably certain to be exposed, please see Appendix A.

Explosive projectiles will be used in the Offshore Area between 37 km and 463 km (20 nm and 250 nm) from shore. Based on the density and distribution of short-tailed albatross, we expect they may be present anywhere in this zone where projectiles will be detonated.

Based on the area of exposure and the expected density of short-tailed albatross in the Offshore Area, the Service calculated the cumulative probability of exposure to each of the explosive source bins (Table 39).

Table 39. Probability of short-tailed albatross exposure to explosive projectiles (in-air). A probability of 1.0 is used to indicate probabilities greater than or equal to 0.995, based on usual rules of rounding.

Source Bin	Probability of albatross exposure over 20 years (“reasonable worst-case” scenario)	Expected number of albatross exposed over 20 years (“reasonably certain” scenario)
No Pre-detonation Surveys		
E1	1.0	5.5
E5/E3	0.99	1.3
E7	0.20	n/a, exposure not reasonably certain
E10	0.44	0.11*
E8	0.57	0.19*
E12	0.21	n/a, exposure not reasonably certain

* Short-tailed albatross are not reasonably certain to be exposed to explosive missiles (bins E7, E8, and E10) or bombs (bin E12); however, we calculated the number of short-tailed albatross we expect to be exposed to E8 and E10 missiles, as the probability of exposure was greater than ten percent in the “reasonably certain” scenario. Note that the expected number of birds exposed is substantially less than one, indicating that exposure is unlikely.

E1 explosives are associated with medium-caliber projectiles used for Surface-to-Air and Surface-to-Surface Gunnery Exercises in the Offshore Area. Medium-caliber projectiles travel at high-velocities and create a sonic boom. They also create other stressors, including strikes by projectiles and high-velocity fragments, elevated SPLs from explosions, and blast waves from explosions. The area of effect is defined by the areas of effect of all stressors combined. The areas of effect used in our analysis include a circle with radius equal to the distance to human safety for E1 explosions listed in Table 37 added to the areas of effect for projectile shock wave of medium-caliber projectiles shown in Table 42. Note that we assumed that all explosive projectiles used in the Surface-to-Surface Gunnery Exercises would be 25 mm, while those used in the Surface-to-Air Gunnery Exercises would be evenly distributed among the four sizes we analyzed. The Service calculated the cumulative probability that a short-tailed albatross would be exposed over the next 20 years (Table 39), based on the range to effects distances of these stressors in relation to the Service’s threshold criteria, the estimated density of short-tailed albatross, and the number of medium-caliber explosive projectiles to be used. Under the “reasonable worst-case” scenario, we determined that the probability approached 100 percent that one or more bird would be exposed over 20 years. Given the annual use of 6,368 medium-caliber explosive projectiles, we expect that 5.5 short-tailed albatross will be exposed over 20 years. Over 20 years, the sum of all individual areas of effect is 30,436.9 km^2 (8,874.0 nm^2).

E3 and E5 explosives are associated with large-caliber projectiles used in Offshore Areas for Surface-to-Air and Surface-to-Surface Gunnery exercises. Large-caliber projectiles travel at high-velocities and create a sonic boom. They also create other stressors, including strikes by projectiles and high-velocity fragments, elevated SPLs from muzzle blast, bow shock and explosions, and blast waves from explosions. The Navy indicated that either E3 or E5 would be used, so we analyzed exposure based on the explosive bin with the larger range to effects area. The area of effect is defined as the radius of effect from all these stressors combined. The areas of effect used in our analysis include a circle with radius equal to the distance to human safety for E5 explosions listed in Table 37 added to the areas of effect for muzzle blast and projectile shock wave of large-caliber projectiles shown in Table 43. The Service calculated the cumulative probability that a short-tailed albatross would be exposed over the next 20 years (Table 39), based on the range to effects distances of these stressors in relation to the Service's threshold criteria, the estimated density of short-tailed albatross, and the number of large-caliber explosive projectiles to be used. Under the "reasonable worst-case" scenario, we determined that there would be a 99 percent chance that one or more bird would be exposed over 20 years. Given the annual use of 310 medium-caliber explosive projectiles, we expect that 1.3 short-tailed albatross will be exposed over 20 years. Over 20 years, the sum of all individual areas of effect is 7,408.9 km^2 (2,160.1 nm^2).

E7 explosives are associated with Air-to-Air Missile Exercises. These Missile Exercises occur at higher elevations than short-tailed albatross are known to fly; however, as the fragments fall into the areas where short-tailed albatross may be present, individuals may be struck by these fragments. Therefore, the only stressors include falling fragments. Our exposure analysis predicts that, in the "reasonable worst-case" scenario, there is a 20 percent chance that one or more individuals will be exposed over the course of 20 years. Therefore, short-tailed albatross exposure to this stressor is not discountable. However, in the "reasonably certain" scenario, there is less than a ten percent chance of exposure, so exposure to individuals from these stressors is not reasonably certain to occur.

E8 explosives are associated with Surface-to-Air Missile Exercises. Stressors include missile strike, elevated SPLs from bow shock and the explosion, and blast waves from the bow shock and the explosion. Some E8 class missiles are short-range and some are long-range; of eight E8 missiles used annually, we assumed that one would be long-range, and the rest short-range. The Service calculated the cumulative probability that a short-tailed albatross would be exposed over the next 20 years (Table 39), based on the range to effects distances of these stressors in relation to the Service's threshold criteria, the estimated density of short-tailed albatross, and the number of E8 missiles to be used. Under the "reasonable worst-case" scenario, we determined that there would be a 57 percent chance that one or more bird would be exposed over 20 years. The expected number of individuals exposed to these stressors over the next 20 years is 0.13. For the "reasonably certain" scenario, there was an 83 percent probability that no short-tailed albatross would be exposed, and a 17 percent probability that one or more individuals would be exposed. Therefore, short-tailed albatross exposure to E8 missiles is not reasonably certain to occur but is also not discountable. The total area exposed over 20 years is 1,056.3 km^2 (308.0 nm^2).

E10 explosives are associated with Air-to-Surface Missile Exercises. Stressors include strikes by missiles and high-velocity fragments, elevated SPLs from bow shock and the explosion, and blast waves from the bow shock and the explosion. Some E10 class missiles are short-range and some are long-range; of four E10 missiles used annually, we assumed that one would be long-range, and the rest short-range. The Service calculated the cumulative probability that a short-tailed albatross would be exposed over the next 20 years (Table 39), based on the range to effects distances of these stressors in relation to the Service's threshold criteria, the estimated density of short-tailed albatross, and the number of E10 missiles to be used. Under the "reasonable worst-case" scenario, we determined that there would be a 44 percent chance that one or more bird would be exposed over 20 years. For the "reasonably certain" scenario, there was an 89 percent probability that no short-tailed albatross would be exposed, and an 11 percent probability that one or more individuals would be exposed. Therefore, short-tailed albatross exposure to E10 missiles is neither discountable nor reasonably certain. The total area exposed over 20 years is 626.5 km^2 (182.7 nm^2).

E12 explosives are associated with Air-to-Surface Bombing Exercises. Stressors include strikes by bombs and high-velocity fragments, in-air sound from the explosions, and blast waves from the explosions. These Bombing Exercises may result in fragments flying into the areas where short-tailed albatross may be present and individuals may be struck by these fragments or exposed to elevated in-air sound and blast waves. Our exposure analysis predicts that in the "reasonable worst-case" scenario, there is a 21 percent chance that one or more individuals will be exposed over the course of 20 years, so exposure of short-tailed albatross to these stressors is not discountable. However, in the "reasonably certain" scenario, there is less than a ten percent chance of exposure, so exposure to individuals from these stressors is not reasonably certain to occur.

10.4.5.3.2.2.2 Response

Medium and large-caliber projectiles may injure or kill short-tailed albatross by striking them, or exposing them to blast waves, muzzle blast, shock waves, bow shock, projectile shock waves, or elevated SPLs. We expect exposure of marbled murrelets from the following activities:

- E1 medium-caliber projectiles from Surface-to-Air and Surface-to-Surface Gunnery Exercises

- E3/E5 large-caliber projectiles from Surface-to-Air and Surface-to-Surface Gunnery Exercises

Individuals exposed to explosions and other stressors may experience lethal or non-lethal injuries. Non-lethal injuries may include TS, scarred or ruptured eardrums, or gastrointestinal tract lesions. Individuals may survive their exposure to the explosions and other stressors; however, we expect a reduced level of fitness and reproductive success, and higher risk of predation. Exposed individuals may also experience lethal injuries that occur instantaneously or manifest over time; these include direct mortality, lung hemorrhaging, ruptured liver, hemorrhaged kidney, ruptured air sacs, and/or coronary air embolisms. Death from barotrauma can be instantaneous, occurring within minutes after exposure, or several days later (Abbott et al. 2002).

If individual short-tailed albatross are exposed to the stressors and/or detonations, but are not injured or killed, we expect a startle response, flushing, and avoidance behaviors (i.e., avoidance diving, or leaving the area). In uninjured individuals, these responses would be short term in duration and we do not expect significant disruptions to their normal that would create a likelihood of injury. However, if several detonations occurred per day and significantly disrupted normal foraging behavior, foraging efficiency would be impacted, thereby reducing fitness, or their ability to provision a chick. For these explosions in Offshore Areas, we do not expect significant disruptions to normal behaviors because the associated stressors are short-duration and do not occur frequently in a day or for an extended period of time such that we would expect a measurable effect to an individual. We expect that if a short-tailed albatross is not injured or killed by the detonation, they will flush and return to normal activities in a short period of time.

Individuals that experience TS from exposure to the stressors associated with these activities are expected to have damage to the hair cells in their inner ears, and may not be able to detect biologically relevant sounds such as approaching predators or prey, and/or hear their mates attempting to communicate. Birds with reduced hearing sensitivity are at increased risk of predation and may experience reduced foraging efficiency. Individuals may regain some or all of their hearing sensitivity; however, they are still temporarily at risk while experiencing TS. Additionally, short-tailed albatross that are exposed to the activities stressors, but do not experience TS, may respond by flushing or temporarily ceasing to forage; however, due to the intermittent nature and short-duration of exposure, they are expected return to normal behaviors in a short period of time.

Several assumptions were necessary to predict exposure. For example, if E1 (medium-caliber projectiles) and E3/E5 (large-caliber projectiles) are fired in bursts of several projectiles, rather than individually, our analysis overestimates the number of intendant opportunities for exposure, but may underestimate area of effect from the sequence of explosions. These sources of over or underestimation may partially compensate for each other; however, we cannot precisely predict these factors without additional information regarding how these projectiles are employed. Additionally, because we assumed all E3 and E5 explosions were E5 (the Navy could not provide more specifics), our exposure analysis results may be conservative, because we assumed the greater range of effects for all these projectiles.

Many factors would change the area of exposure we estimated if more accurate information were available. For example, the area of exposure would be smaller if the projectiles and the projectile shock waves travel higher than 20 m above the surface (where albatross presence would be expected), if the projectiles travel shorter distances than we estimated, or if the projectiles travel at slower velocities than we anticipated. (Note that, for surface-to-air projectiles, we truncated the area of effect to account for the portion of the trajectory along which the injurious sound from the projectile shock wave is expected to be exclusively above 20 m (65.6 ft) above the surface.) Additionally, projectile shock waves are cone-shaped and trail behind supersonic projectiles and muzzle blast noise spreads away from muzzles spherically. The area to which an albatross may be exposed to injury may be smaller, depending on the height at which the projectile is fired. Furthermore, the area of exposure for muzzle blasts includes areas such as the ship deck from which the projectiles are fired. Depending on the area of effect, the area of exposure may be restricted to the deck of the ship, where albatross would not be present. While the area of exposure may be smaller than we analyzed, we are unable to quantify how much these factors would influence the expected number of birds exposed and injured.

Our quantitative analysis also illustrated that the actual number of birds exposed to stressors could be larger than the expected numbers reported earlier.

- The expected number of short-tailed albatross exposed to medium-caliber E1 projectile stressors is 5.5. There is a 48 percent probability that more than five short-tailed albatross will be exposed, and there remains a 32 percent probability that more than six individuals will be exposed to medium-caliber E1 projectile stressors.

- The expected number of short-tailed albatross exposed to large-caliber E3 or E5 projectile stressors is 1.3. There is a 36 percent probability that more than one short-tailed albatross will be exposed, and there remains a 14 percent probability that more than two groups of marbled murrelets will be exposed to large-caliber E3 or E5 projectile stressors.

10.4.5.3.2.2.3 Conclusion

We believe that the expected value of 7.1 individual short-tailed albatross within a total habitat area of 39,528.4 km^2 (11,524.7 nm^2) predicted by our probability analysis represents a reasonable estimate of the number of short-tailed albatross that may be affected by E1 and E3/E5 Gunnery Exercise projectiles, and E10 and E8 Missile Exercises in the Offshore Area.

There may be exposure of a total of 7.1 short-tailed albatross within the habitat areas described below (Table 39):

- 5.5 individuals within 30,436.9 km^2 (8,874.0 nm^2) from E1 medium-caliber Gunnery Exercise projectiles

- 1.3 individuals within 7,408.9 km^2 (2,160.1 nm^2) from E3/E5 large-caliber Gunnery Exercise projectiles

- 0.11 individuals within 1,056.3 km^2 (182.7 nm^2) from E10 Missile Exercises

- 0.19 individuals within 626.5 km^2 (308.0 nm^2) from E8 Missile Exercises

We are reasonably certain that a total of 6.8 short-tailed albatross will be exposed within the habitat areas described below (Table 39):

- 5.5 individuals within 30,436.9 km^2 (8,874.0 nm^2) from E1 medium-caliber Gunnery Exercise projectiles

- 1.3 individuals within 7,408.9 km^2 (2,160.1 nm^2) from E3/E5 large-caliber Gunnery Exercise projectiles

The habitat areas reported here represent the cumulative area in which stressors will exceed Service thresholds (i.e., the sum of all individual areas of effect). These areas are relatively large because these weapons are transitory and are fired in different places over time.

We used an exposure model to estimate the number of short-tailed albatross that may be exposed to these explosive projectiles because there is tremendous variability in short-tailed albatross distribution and density in the marine environment. Affected individuals would be very difficult to detect. Our model includes explicit assumptions about seasonal distribution of albatross and the extent of the potential effects. The actual number of albatross affected these explosions is unknown; however, we can reliably quantify the habitat area affected as a surrogate for those numbers.

10.4.5.4 Non-Explosive Projectiles

Non-explosive projectiles can injure or kill seabirds if they are directly hit, and the sound/pressure wave creates a larger area where auditory injury or barotrauma can occur. The sound/pressure waves associated with non-explosive projectiles that can injure animals come from projectile shock waves and muzzle blasts. As discussed in greater detail in the section on in-air explosions (above) we consider sound/pressure waves above 140 dBA peak re: 20 μPa to be sufficient to injure birds. However, some of the available data (Pater 1981) were not presented in A-weighted values. As such, we increased the threshold value by 15 dB to account for the differences in weighting, and used 155 dB peak to approximate the same threshold when A-weighted values were not available.

If they are large enough and moving faster than the speed of sound, projectiles will be accompanied by a shock wave created by the projectile compressing the air in front of it. Larger projectiles will compress more air (creating larger projectile shock waves), and faster projectiles will compress air further (creating more intense projectile shock waves). Larger shock waves will affect larger areas of habitat, and more intense shock waves can cause greater injury. These shock waves will also affect larger areas of habitat as they require more space to dissipate to levels below injury thresholds. The projectile shock wave also trails behind the projectile as it travels supersonically through the air. With sufficiently large projectiles, projectile shock waves will be present along the entire path of the projectile while it is supersonic. Using data and equations from Pater (1981, pp. C-20, E-4), we determined that both medium- and large-caliber projectiles are large enough to create projectile shock waves that exceed the sound/pressure wave injury threshold.

Muzzle blasts are the result of air being compressed around the muzzle of guns as they fire projectiles. Near the guns, sound/pressure waves from muzzle blasts are much more intense than projectile shock waves (Pater 1981, p. 8). We considered only the firing of large-caliber projectiles would create muzzle blast sound/pressure waves exceeding the injury threshold for birds.

10.4.5.4.1 Effects of Non-Explosive Projectiles on the Marbled Murrelet in the Offshore Area

Use of non-explosive projectiles (small-caliber, medium-caliber, and large-caliber) is expected only in the Offshore Area.

10.4.5.4.1.1.1 Exposure: Small-caliber Non-Explosive Projectiles

Physical strike is the only stressor associated with small-caliber projectiles; therefore, the area of exposure for small-caliber projectiles is defined by the projectile's path. Since many weapons that use small-caliber ammunition fire the projectiles in short successions, we assumed that small caliber projectiles will be fired in bursts of five. We therefore divided the total number of small-caliber projectiles fired in the proposed action by five to determine the number of instances when marbled murrelets could be struck by small-caliber projectiles.

In order for marbled murrelets to be stuck by projectiles, those projectiles need to occur in marbled murrelet habitat, while marbled murrelets are in the path of the projectile. We estimated marbled murrelet exposure to projectiles based on the number of projectiles proposed for use and assuming an even distribution in time and space. We then reduced that number of projectiles proportional to those that will be fired in the summer when marbled murrelets will not be in the exposure area (because it begins 20 nm from shore). We also reduced the number of projectiles proportional to the number fired in the area greater than 50 nm from shore (because we are not reasonably certain that murrelets occur greater than 50 nm offshore).

Considering that small-caliber projectiles will be fired in bursts and that projectiles are proposed within and beyond marbled murrelet habitat, we determined that there will be a total of 1,697 instances (8,485 projectiles) when we are reasonably certain that marbled murrelet habitat will be exposed to stressors associated with firing small-caliber projectiles.

Each one of those instances has an area of exposure of 0.004 km^2 (0.001066 nm^2). Over the 20 years of the proposed action, a total of 124.1 km^2 (36.18 nm^2) of marbled murrelet habitat will be exposed to stressors associated with small-caliber projectiles. The total habitat area reported here represents the cumulative area for which stressors will exceed Service thresholds (i.e., the sum of all individual areas of effect). Based on the density of marbled murrelets in the offshore area where projectiles will be fired we expect 1.17 groups of marbled murrelets to be exposed to physical strike from small-caliber projectiles over the 20 years of the proposed action.

10.4.5.4.1.1.2 Exposure: Medium-caliber Non-Explosive Projectiles

Due to their size and velocity, medium-caliber projectiles have the potential to affect marbled murrelets both through physical strike and through the shock wave and elevated SPLs associated with a supersonic projectile. The area of exposure for medium-caliber projectiles is therefore defined by the extent of the shock wave from the path of the projectile. Since many weapons that use medium-caliber ammunition fire the projectiles in short succession, we assumed that medium-caliber projectiles will be fired in bursts of five. We therefore divided the total number of non-explosive medium-caliber projectiles fired in the proposed action by five to determine the number of instances when marbled murrelets could be adversely affected by medium-caliber projectiles.

In order for marbled murrelets to be exposed to stressors associated with projectiles, those projectiles need to occur in marbled murrelet habitat, while marbled murrelets are present. We estimated marbled murrelet exposure to projectiles based on the number of projectiles proposed for use and assuming an even distribution in time and space. We then reduced that number of projectiles proportional to those that will be fired in the summer when marbled murrelets will not be in the exposure area (because it begins 20 nm from shore). We also reduced the number of projectiles proportional to the number fired in the area greater than 93 km (50 nm) from shore (because we are not reasonably certain that murrelets occur greater than 93 km [50 nm] offshore). Considering that medium-caliber projectiles will be fired in bursts and that projectile firings are proposed within and beyond marbled murrelet habitat, we determined that there will be a total of 600 instances (3,000 projectiles) when we are reasonably certain that marbled murrelet habitat will be exposed to stressors associated with firing medium-caliber, non-explosive projectiles.

As stated earlier, the area of exposure to stressors associated with medium-caliber projectiles is the extent to which the projectile shock wave overlaps with marbled murrelet presence (the surface of the ocean to 20 m above). The size and speed of the projectile, as well as the length of the trajectory, determine the area affected by projectile shock wave when it is supersonic. The "medium-caliber" category is defined by the projectiles being smaller than 57 mm, and the most common sizes of medium-caliber projectiles are 20, 25, and 40 mm (Navy 2015a, p. 2-23). Without knowing the entire range of sizes for medium-caliber projectiles, we assumed a fourth size (56 mm) just smaller than the upper limit of the medium-caliber category. We used those four sizes (20, 25, 40, and 56 mm) to model the impacts of medium-caliber projectiles. Without knowing the proportions of different-sized projectiles used for training, we assumed equal proportions of each projectile size. Our model of medium-caliber projectile impacts is therefore comprised of 25 percent 20 mm projectiles, 25 percent 25 mm projectiles, 25 percent 40 mm projectiles, and 25 percent 56 mm projectiles. The areas of exposure for the different sizes of medium-caliber projectiles are summarized below in Table 40.

Over the 20 years of the proposed action, a total of 965.2 km^2 (281.4 nm^2) of marbled murrelet habitat will be exposed to stressors associated with medium-caliber non-explosive projectiles. The total habitat area reported here represents the cumulative area for which stressors will exceed Service thresholds (i.e., the sum of all individual areas of effect). Based on the density of marbled murrelets in the offshore area where projectiles will be fired, the area of effect of each burst of projectiles, and the number of projectile bursts, we expect a total of 9.1 groups of marbled murrelets to be exposed to stressors.

Table 40. Areas of exposure for stressors associated with medium-caliber non-explosive projectiles.

	Surface-to-Air				Surface-to-Surface			
	20 mm	**25mm**	**40 mm**	**56 mm**	**20 mm**	**25mm**	**40 mm**	**56 mm**
Length of trajectory in m and *(nm)*[1]	1,100 *(0.594)*	1,189 *(0.642)*	2,217 *(1.20)*	3,352 *(1.81)*	3,660 *(1.97)*	3,660 *(1.97)*	3,660 *(1.97)*	3,660 *(1.97)*
Radius of projectile shock wave in m and *(nm)*	6.20 *(3.346 x 10^{-3})*	8,35 *(4.51 x 10^{-3})*	13.6 *(7.37 x 10^{-3}) (*	19.4 *(0.0105)*	6.20 *(3.346 x 10^{-3})*	8,35 *(4.51 x 10^{-3})*	13.6 *(7.37 x 10^{-3}) (*	19.4 *(0.0105)*
Area of effect for single instance in km^2 and *(nm^2)*	0.0136 *(3.98 x 10^{-3})*	0.0198 *(5.79 x 10^{-3})*	0.0605 *(0.0176)*	0.130 *(0.0379)*	0.0453 *(0.0132)*	0.0610 *(0.0176)*	0.0998 *(0.0291)*	0.142 *(0.0414)*
Instances per year	32	32	32	32	118	118	118	118
Total marbled murrelet habitat exposed over 20 years in km^2 and *(nm^2)*	8.73 *(2.54)*	12.7 *(3.70)*	38.7 *(11.3)*	83.8 *(24.3)*	107 *(31.2)*	144 *(42.0)*	236 *(68.7)*	335 *(97.7)*

[1] The length of the projectile's trajectory is the maximum distance projectiles can travel for surface-to-air projectiles or the distance between the ship and the target (4,000 yards) for surface-to-surface projectiles. For surface-to-air projectiles, the length of trajectory also accounts for the projectiles traveling upward (based on the minimum target altitude of 500 ft) so that at a point stressors associated with the projectile no longer impact the surface of the water or altitudes where marbled murrelets are likely to be flying.

10.4.5.4.1.1.3 Exposure: Large-caliber Non-Explosive Projectiles

Since they travel faster than the speed of sound, large-caliber projectiles have the potential to affect marbled murrelets both through physical strike and through the shock wave and elevated SPLs associated with the supersonic projectile shock wave. Firing large-caliber projectiles also produces muzzle blast noise which can affect marbled murrelets. The area of exposure for large-caliber projectiles is therefore defined by adding the area of the projectile shock wave extending out from projectile paths and the area of the shock wave and injurious sound around the muzzle blast. As we did with the other categories of non-explosive projectiles, we assumed that large-caliber projectiles will be fired in bursts of five. We therefore divided the total number of non-explosive large-caliber projectiles fired in the proposed action by five to determine the number of instances when marbled murrelets could be adversely affected by large-caliber projectiles.

In order for marbled murrelets to be exposed to stressors associated with projectiles, those projectiles need to occur in marbled murrelet habitat, while marbled murrelets are present. We estimated marbled murrelet exposure to projectiles based on the number of projectiles proposed for use and assuming an even distribution in time and space. We then reduced that number of projectiles proportional to those that will be fired in the summer when marbled murrelets will not be in the exposure area (because it begins 20 nm from shore. We also reduced the number of projectiles proportional to the number fired in the area greater than 93 km (50 nm) from shore (because we are not reasonably certain that murrelets occur greater than 50 nm offshore). Assuming that large-caliber projectiles will be fired in bursts and considering that projectile firings are proposed within and beyond marbled murrelet habitat, we determined that there will be a total of 41 instances (205 projectiles) when we are reasonably certain that marbled murrelet habitat will be exposed to stressors associated with firing large-caliber, non-explosive projectiles.

We assumed that the most common size of large-caliber projectiles (5-inch diameter) (Navy 2015a, p. 2-24) would be used for all large-caliber projectile firings. The areas of exposure for large-caliber projectiles are summarized below in Table 41.

Table 41. Areas of exposure for stressors associated with large-caliber non-explosive projectiles

	Surface-to-Air	**Surface-to-Surface**
Length of trajectory in m and *(nm)*[1]	5,240 *(2.83)*	11,112 *(6)*
Radius of projectile shock wave in m and *(nm)*	41.6 *(0.0224)*	41.6 *(0.0224)*
Radius of muzzle blast in m and *(nm)*	79.7 *(0.043)*	79.7 *(0.043)*
Area of exposure for single instance in km^2 and *(nm^2)*	0.456 *(0.132)*	0.944 *(0.275)*
Instances per year	2	39
Total marbled murrelet habitat exposed over 20 years instance in km^2 and *(nm^2)*	18 *(5.31)*	736 *(215)*

[1] The length of the projectile's trajectory is the distance between the ship and target (Navy 2015b, pp. 5-41, 5-70). For surface-to-air projectiles, the length of trajectory also accounts for the projectiles traveling upward (based on the minimum target altitude of 500 ft) so that at a point stressors associated with the projectile no longer impact the surface of the water or altitudes where marbled murrelets are likely to be flying.

Over the 20 years of the proposed action, a total of 754.3 km^2 (219.9 nm^2) of marbled murrelet habitat will be exposed to stressors associated with large-caliber non-explosive projectiles. The total habitat area reported here represents the cumulative area for which stressors will exceed Service thresholds (i.e., the sum of all individual areas of effect). Based on the density of marbled murrelets in the offshore area where projectiles will be fired, we expect that a total of 7.1 groups of marbled murrelets to be within that area and therefore exposed to stressors.

10.4.5.4.1.1.4 Response: All Non-Explosive Projectiles

Small-caliber non-explosive projectiles can kill or injure marbled murrelets by directly striking birds. Medium-caliber non-explosive projectiles may strike birds and may also cause auditory injury or barotrauma from the projectile shock waves (sound/pressure waves) of supersonic projectiles. Large-caliber non-explosive projectiles can result in the same effects as medium-caliber projectiles, and can also cause auditory injury or barotrauma from the muzzle blast.

The expected number of groups of marbled murrelets that will be exposed to stressors associated with projectile firings may overestimate the number of birds that will actually be injured. The number of groups of marbled murrelets exposed to stressors is the result of applying the density of marbled murrelets in the offshore area affected to the area of exposure of each type of projectile firing. There are several reasons why the areas in which birds would be injured could be smaller than the calculated areas of effect:

- Projectiles may travel higher than typical marbled murrelet surface habitat (water surface to 20 m above the surface);
- Projectiles may travel a shorter distance then estimated; or
- Some medium- and large-caliber projectiles may be slower or not supersonic for part or all of their flights.

The area of injury will also be smaller than the area of exposure due to the shape of the sound pressure waves. Projectile shock waves are cone-shaped and trail behind supersonic projectiles. Also, muzzle blast noise spreads away from guns spherically. For our exposure analysis, we used the maximum extent of the area where sound will be above the 140 dBA peak re: 20 μPa injury threshold. Depending on the height of the projectile, a smaller area of typical surface habitat may actually be exposed to injurious levels of sound. Furthermore the area of exposure for muzzle blasts includes areas (such as the deck of the ship firing its guns) where birds are unlikely to be present. While the area of injury may be smaller than the analyzed area of exposure, we are unable to quantify how these factors would influence the expected number of birds exposed when trying to determine the number of birds that would be injured (Figure 16).

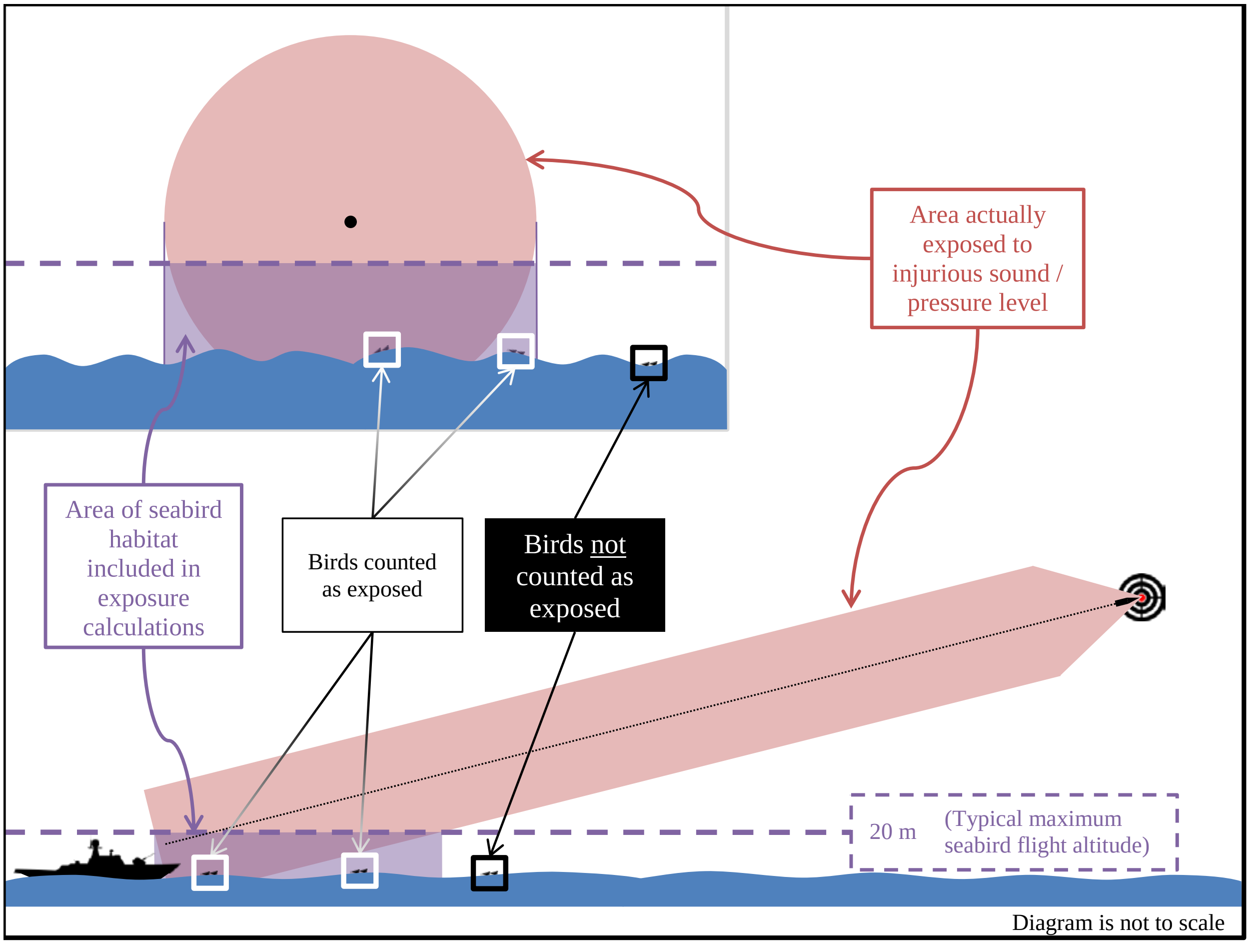

Figure 16: Estimation of seabird exposure to stressors associated with projectiles.

Our quantitative analysis also illustrated that the actual number of birds exposed to stressors could be larger than the expected numbers reported earlier.

- The expected number of marbled murrelet groups exposed to small-caliber projectile stressors is 1.17. There is a 33 percent probability that more than one pair of marbled murrelets will be exposed, and there remains a 12 percent probability that more than two groups of marbled murrelets will be exposed to small-caliber projectile stressors.

- The expected number of marbled murrelet groups exposed to medium-caliber projectile stressors is 9.1. There is a 43 percent probability that more than 9 groups of marbled murrelets will be exposed, and a 31 percent probability that more than 10 groups of marbled murrelets will be exposed to small-caliber projectile stressors.

- The expected number of marbled murrelet groups exposed to large-caliber projectile stressors is 7.1. There is a 43 percent probability that more than 7 groups of marbled murrelets will be exposed, and there remains a 30 percent probability that more than 8 groups of marbled murrelets will be exposed to small-caliber projectile stressors.

10.4.5.4.1.1.5 Conclusion

We expect that 17.4 groups or 34.9 marbled murrelets (assuming 2 birds per group) within 1,843.6 km^2 (537.5 nm^2) of habitat will be exposed to potentially injurious effects from non-explosive projectile firings over the 20 year life of the proposed action. The habitat areas reported here represent the cumulative area for which stressors will exceed Service thresholds (i.e., the sum of all individual areas of effect). We used an exposure model to estimate the number of marbled murrelets that may be affected by this stressor. Our model includes explicit assumptions regarding the seasonal distribution of marbled murrelets and the extent of the potential effects. Given the tremendous variability in the distribution and density of marbled murrelets in the marine environment, we are limited in our ability to accurately correlate the expected exposure to the actual number of marbled murrelets that may be injured by these activities. While the actual number of marbled murrelets that are reasonably certain to be affected by this stressor is unknown, we are able to reliably quantify the area of habitat affected. We believe that the expected values from our probability analysis represent a reasonable estimate of the number of marbled murrelets that may be affected.

10.4.5.4.2 Effects of Non-Explosive Projectiles on the Short-tailed Albatross in the Offshore Area

Use of non-explosive projectiles (small-caliber, medium-caliber, and large-caliber) is expected only in the Offshore Area.

10.4.5.4.2.1.1 Exposure: Small-caliber Non-Explosive Projectiles

Physical strike is the only stressor associated with small-caliber projectiles; therefore the area of exposure for small-caliber projectiles is defined by the projectile's path. Since many weapons that use small-caliber ammunition fire the projectiles in short successions, we assumed that small caliber projectiles will be fired in bursts of five. We therefore divided the total number of small-caliber projectiles fired in the proposed action by five to determine the number of instances when albatross could be struck by small-caliber projectiles.

Projectile firings are only proposed in the offshore area further than 20 nm from the shore. Short-tailed albatross can occur anywhere within the testing and training area beyond 20 nm from shore. Considering that small-caliber projectiles will be fired in bursts and that all projectile firings are proposed within short-tailed albatross habitat, we determined that there will be a total of 24,240 instances (121,200 projectiles) per year when short-tailed albatross habitat will be exposed to stressors associated with firing small-caliber projectiles.

Each one of those instances has an area of exposure of 0.011 km^2 (0.0032 nm^2). Over the 20 years of the proposed action a total of 5,319.4 km^2 (1,550.88 nm^2) of short-tailed albatross habitat will be exposed to stressors associated with small-caliber projectiles. The total habitat area reported here represents the cumulative area for which stressors will exceed Service thresholds (i.e., the sum of all individual areas of effect). Based on the density of short-tailed albatross in these areas, we expect 0.79 albatross to be exposed to physical strike from small-caliber projectiles over the 20 years of the proposed action.

10.4.5.4.2.1.2 Exposure: Medium-caliber Non-Explosive Projectiles

Due to their size and velocity, medium-caliber projectiles have the potential to affect short-tailed albatross both by physically striking the birds and through the shock wave and elevated SPLs associated with the projectile shock wave of the supersonic projectile. The area of exposure for medium-caliber projectiles is therefore defined by the projectile shock wave extending out from projectile paths. Since many weapons that use medium-caliber ammunition fire the projectiles in short succession, we assumed that medium-caliber projectiles will be fired in bursts of five. We therefore divided the total number of non-explosive medium-caliber projectiles fired in the proposed action by five to determine the number of instances when albatross could be adversely affected by medium-caliber projectiles.

Projectile firings are only proposed in the offshore area further than 37 km (20 nm) from the shore. Short-tailed albatross can occur anywhere within the testing and training area beyond 37 km (20 nm) from shore. Considering that medium-caliber projectiles will be fired in bursts and that all projectile firings are proposed within short-tailed albatross habitat, we determined that there will be a total of 8,636 instances (43,180 projectiles) per year when short-tailed albatross habitat will be exposed to stressors associated with firing medium-caliber, non-explosive projectiles.

As stated earlier, the area of exposure to stressors associated from medium-caliber projectiles is the extent to which the projectile shock wave overlaps with where short-tailed albatross are likely to be present (the surface of the ocean to 20 m above). The size of the projectile determines the size of its projectile shock wave when it is supersonic. The “medium-caliber” category is defined by the projectiles being smaller than 57 mm, and the most common sizes of medium-caliber projectiles are 20, 25, and 40 mm (Navy 2015a, p. 2-23). Without knowing the whole range of sizes for medium-caliber projectiles we assumed a fourth size (56 mm) just smaller than the upper limit of the medium-caliber category. We used those four sizes (20, 25, 40, and 56 mm) to model the impacts of medium-caliber projectiles. Without knowing the proportions of different sized projectiles used for training, we assumed equal proportions of each projectile size. Our model of medium-caliber projectile impacts is therefore comprised of 25 percent 20 mm projectiles, 25 percent 25 mm projectiles, 25 percent 40 mm projectiles, and 25 percent 56 mm projectiles. The areas of exposure for the different sizes of medium-caliber projectiles are summarized below in Table 42.

Over the 20 years of the proposed action, a total of 13,833.8 km^2 (4033.3 nm^2) of short-tailed albatross habitat will be exposed to stressors associated with medium-caliber non-explosive projectiles. The total habitat area reported here represents the cumulative area for which stressors will exceed Service thresholds (i.e., the sum of all individual areas of effect). Based on the density of short-tailed albatross in the offshore area where projectiles will be fired, the area of effect of each burst of fire, and the number of projectiles used, we expect that a total of 2.1 short-tailed albatross to be within that area and therefore exposed to stressors.

Table 42. Areas of exposure for stressors associated with medium-caliber non-explosive projectiles for short-tailed albatross.

	Surface-to-Air				Surface-to-Surface			
	20 mm	**25mm**	**40 mm**	**56 mm**	**20 mm**	**25mm**	**40 mm**	**56 mm**
Length of trajectory in m and *(nm)*[1]	1,100 *(0.594)*	1,189 *(0.642)*	2,217 *(1.20)*	3,352 *(1.81)*	3,660 *(1.97)*	3,660 *(1.97)*	3,660 *(1.97)*	3,660 *(1.97)*
Radius of projectile shock wave in m and *(nm)*	6.20 *(3.346 x 10^{-3})*	8,35 *(4.51 x 10^{-3})*	13.6 *(7.37 x 10^{-3})*	19.4 *(0.0105)*	6.20 *(3.346 x 10^{-3})*	8,35 *(4.51 x 10^{-3})*	13.6 *(7.37 x 10^{-3})*	19.4 *(0.0105)*
Area of effect for single instance in km^2 and *(nm^2)*	0.0136 *(3.98 x 10^{-3})*	0.0198 *(5.79 x 10^{-3})*	0.0605 *(0.0176)*	0.130 *(0.0379)*	0.0453 *(0.0132)*	0.0610 *(0.0176)*	0.0998 *(0.0291)*	0.142 *(0.0414)*
Instances per year	484	484	484	484	1,675	1,675	1,675	1,675
Total short-tailed albatross habitat exposed over 20 years in km^2 and *(nm^2)*	132 *(38.5)*	192 *(56)*	586 *(171)*	1260 *(367)*	1520 *(443)*	2,050 *(596)*	3,340 *(975)*	4,760 *(1,390)*

[1] The length of the projectile's trajectory is the maximum distance projectiles can travel for surface-to-air projectiles or the distance between the ship and the target (4,000 yards) for surface-to-surface projectiles. For surface-to-air projectiles, the length of trajectory also accounts for the projectiles traveling upward (based on the minimum target altitude of 500 ft) so that at a point stressors associated with the projectile no longer impact the surface of the water or altitudes where marbled murrelets are likely to be flying.

10.4.5.4.2.1.3 Exposure: Large-caliber Non-Explosive Projectiles

Since they travel faster than the speed of sound, large-caliber projectiles have the potential to affect short-tailed albatross by physically striking the birds and by shock waves and elevated SPLs associated with the supersonic projectile. Firing large-caliber projectiles also produces muzzle blast noise which can affect short-tailed albatross. The area of exposure for large-caliber projectiles is therefore determined by adding the area of the projectile shock wave extending from projectile paths, and the area of the shock wave and injurious sound around the muzzle blast. As we did with the other categories of non-explosive projectiles, we assumed that large-caliber projectiles will be fired in bursts of five. We therefore divided the total number of non-explosive large-caliber projectiles fired in the proposed action by five to determine the number of instances when albatross could be adversely affected by large-caliber projectiles.

Projectile firings are only proposed in the offshore area further than 20 nm from the shore. Short-tailed albatross can occur anywhere within the testing and training area beyond 20 nm from shore. Assuming that large-caliber projectiles will be fired in bursts, and considering that all projectile firings are proposed within short-tailed albatross habitat, we determined that there will be a total of 560 instances per year when short-tailed albatross habitat will be exposed to stressors associated with firing large-caliber, non-explosive projectiles.

We assumed that the most common large-caliber projectiles (5-inch diameter) (Navy 2015a, p. 2-24) would be used for all large-caliber projectile firings. The areas of exposure for large-caliber projectiles are summarized below in Table 43.

Table 43. Areas of exposure for stressors associated with large-caliber non-explosive projectiles

	Surface-to-Air	**Surface-to-Surface**
Length of trajectory in m and *(nm)*[1]	5,240 *(2.83)*	11,112 *(6)*
Radius of projectile shock wave in m and *(nm)*	41.6 *(0.0224)*	41.6 *(0.0224)*
Radius of muzzle blast in m and *(nm)*	79.7 *(0.043)*	79.7 *(0.043)*
Area of exposure for single instance in km^2 and *(nm^2)*	0.456 *(0.132)*	0.944 *(0.275)*
Instances per year	16	544
Total short-tailed albatross habitat exposed over 20 years in km^2 and *(nm^2)*	146 *(42.5)*	10,300 *(2990)*

[1] The length of the projectile's trajectory is the distance between the ship and target (Navy 2015b, pp. 5-41, 5-70). For surface-to-air projectiles, the length of trajectory also accounts for the projectiles traveling upward (based on the minimum target altitude of 500 ft) so that at a point stressors associated with the projectile no longer impact the surface of the water or altitudes where marbled murrelets are likely to be flying.

Over the 20 years of the proposed action, a total of 10,413.8 km^2 (3,036.2 nm^2) of short-tailed albatross habitat will be exposed to stressors associated with large-caliber non-explosive projectiles. The total habitat area reported here represents the cumulative area for which stressors will exceed Service thresholds (i.e., the sum of all individual areas of effect). Based on the density of short-tailed albatross in the offshore area where projectiles will be fired, the area of effect of each burst of fire, and the number of projectiles to be used, we expect that a total of 1.6 short-tailed albatross to be within that area and therefore exposed to stressors.

10.4.5.4.2.1.4 Response: Non-Explosive Projectiles

Small-caliber non-explosive projectiles can kill or injure short-tailed albatross by directly striking birds. Super-sonic, medium-caliber non-explosive projectiles may strike birds and may also cause auditory injury from the projectile shock waves. Super-sonic large-caliber non-explosive projectiles can result in injury in the same ways as medium-caliber projectiles, and the muzzle blast from large projectiles can also cause auditory injury.

The actual number of short-tailed albatross exposed, and ultimately, injured, is difficult to estimate. Our quantitative analysis may both overestimate and underestimate the exposure and number of birds as detailed below.

The expected number short-tailed albatross exposed to stressors associated with projectile firings may overestimate the number of birds that will actually be injured. The number of groups of albatross exposed to stressors is the result of applying the density of short-tailed albatross in the offshore area to the area of exposure of each type of projectile firing. There are several reasons why the areas in which birds would be injured could be smaller than the areas of exposure:

- Projectiles and projectile shock waves may travel higher than typical short-tailed albatross surface habitat (water surface to 20 m above the surface);

- Projectiles may travel a shorter distance than estimated; and

- Some medium- and large-caliber projectiles may be slower or not supersonic for part or all of their flights.

The actual area of injury will also be smaller than the area of exposure due to the shape of the sound pressure waves. Projectile shock waves are cone-shaped and trail behind supersonic projectiles. Also, muzzle blast noise spreads away from guns spherically. For our exposure analysis, we used the maximum extent of the area where sound will be above the 140 dBA peak re: 20 μPa injury threshold for short-tailed albatross. Depending on the height of the projectile or guns, a smaller area surface habitat may actually be exposed to injurious levels of sound. Furthermore, the area of exposure for muzzle blasts encompasses non-habitat areas where birds are very unlikely to occur, such as the decks of ships. While the actual area of injury may be smaller than the analyzed area of exposure, we are unable to quantify how much these factors would influence the expected number of birds exposed, and consequently, the number of birds injured.

Our quantitative analysis also illustrated that the actual number of birds exposed to stressors could be larger than the expected numbers reported earlier as follows:

- The expected number of short-tailed albatross exposed to small-caliber projectile stressors is 0.79. There is a 55 percent probability that one or more short-tailed albatross will be exposed, and there remains a 19 percent probability that more than one short-tailed albatross will be exposed to small-caliber projectile stressors.

- The expected number of short-tailed albatross exposed to medium-caliber projectile stressors is 2.1. There is a 36 percent probability that more than two albatross will be exposed and a 17 percent probability that more than three albatross will be exposed to medium-caliber non-explosive projectile stressors.

- The expected number of short-tailed albatross exposed to large-caliber projectile stressors is 1.6. There is a 46 percent probability that more than one short-tailed albatross will be exposed and a 21 percent probability that more than two short-tailed albatross will be exposed, and there remains a 30 percent probability that more than 8 short-tailed albatross will be exposed to large-caliber non-explosive projectile stressors.

10.4.5.4.2.1.5 Conclusion

We expect that 4.5 short-tailed albatross associated with 29,567.0 km^2 (8,620.4 nm^2) of habitat will be exposed to potentially injurious effects from non-explosive projectile firings over the 20 year life of the proposed action. The total habitat area reported here represents the cumulative area for which stressors will exceed Service thresholds (i.e., the sum of all individual areas of effect). We used an exposure model to estimate the number of short-tailed albatross that may be affected by this stressor. Our model includes explicit assumptions regarding the extent of the potential effects. Given the tremendous variability in the distribution and density of short-tailed albatross in the marine environment, we are limited in our ability to accurately correlate the expected exposure to the actual number of short-tailed albatross that may be injured by these activities. While the actual number of albatross that may be affected by this stressor is unknown, we are able to reliably quantify the area of habitat affected. We believe that the expected values from our probability analysis represent a reasonable estimate of the number of albatross that may be affected.

10.4.5.5 Other Non-Explosive Practice Munitions (Bombs and Missiles)

Non-explosive practice bombs and missiles could injure or kill seabirds directly or cause auditory injury or barotrauma due to the shockwave and sound created when practice bombs or missiles hit the water surface. Practice bombs and missiles can create a large impulse of sound as the objects transfer their kinetic energy to the water (Navy 2015a, p. 3.0-35).

10.4.5.5.1 Effects of Non-Explosive Practice Munitions on the Marbled Murrelet

10.4.5.5.1.1 Effects of Non-Explosive Practice Bombs and Missiles on the Marbled Murrelet in the Offshore Area

Use of non-explosive practice bombs and missiles is expected only in the Offshore Area.

10.4.5.5.1.1.1 Exposure: Non-Explosive Practice Bombs

In order for marbled murrelets to be exposed to stressors associated with non-explosive practice bombs, those bombs need to occur in marbled murrelet habitat, while marbled murrelets are present. We estimated marbled murrelet exposure to non-explosive practice bombs based on the number of bombs proposed for use and assuming an even distribution in time and space. We then reduced that number of bombs proportional to those that will be used in the summer because marbled murrelets will not be in the exposure area (which begins 20 nm from shore) during that time. For the "reasonably certain" scenario, we also reduced the number of bombs proportional to the number fired in the area greater than 50 nm from shore (because we are not reasonably certain that murrelets occur greater than 50 nm offshore).

The marbled murrelet exposure analysis for stressors associated with non-explosive practice bombs was divided at the water's surface. Underwater, marbled murrelets could be affected by the underwater sound from practice bombs hitting the surface of the water. We estimated the peak underwater sound level using the equation given by McLennan (1997, p. 2), and assuming that the practice bomb was falling at terminal velocity along its short axis. We then calculated the radius to an injury threshold of a peak SPL of 237 dB re: 1 μPa, assuming spherical spreading. These calculations resulted in a radius to effect of 32 m and an area of effect of 3,217 m^2 (9.38 x 10-4 nm^2). We calculated the probability of exposure under the assumptions of the "reasonable worst-case" scenario, and determined that there is a less than ten percent probability of marbled murrelet exposure to the underwater sound of a non-explosive practice bomb striking the water. Therefore, we consider marbled murrelet exposure to this stressor to be discountable.

Above water, marbled murrelets could be physically struck by a practice bomb or affected by the in-air sound from practice bombs hitting the surface of the water. We estimated the peak in-air sound level by subtracting 62 dB from the peak underwater sound level to account for the differences between underwater and in-air sound measurements and transmission (Finfer et al. 2008, pp. 464-466). We then calculated the radius to an injury threshold of 155 dB (corresponding to the injury threshold of 140 dBA, as discussed above in the section on non-explosive projectiles). These calculations resulted in a radius to effect of 310 m and an area of effect of 0.302 km^2 (0.088 nm^2).

Based on the area of effect, number of non-explosive bombs used, and density of marbled murrelets, we calculated the probability of exposure and the number of marbled murrelets expected to be exposed. Under the assumptions of the "reasonable worst-case" scenario, there was a 95 percent probability of exposure over 20 years. Therefore, marbled murrelet exposure to this stressor is not discountable. Under the assumptions of the "reasonably certain" scenario, the expected number of marbled murrelet groups exposed is 0.46, and the cumulative amount of habitat we expect to be exposed (i.e., the sum of all individual areas of effect) is 48.3 km^2 (14.1 nm^2). However, there was a 63 percent chance in the "reasonably certain" scenario that no marbled murrelet groups would be exposed, so we are not reasonably certain that marbled murrelets will be struck or exposed to injurious levels of in-air sound from non-explosive practice bombs striking water.

10.4.5.5.1.1.2 Response: Non-Explosive Practice Bombs

Marbled murrelets struck by non-explosive practice bombs will be injured and killed. Murrelets may also experience auditory injury or barotrauma if they are exposed to the in-air or underwater sound created when practice bombs hit the surface of the water.

10.4.5.5.1.1.3 Conclusion: Non-Explosive Practice Bombs

Marbled murrelet exposure to injurious levels of underwater sound associated with non-explosive practice bombs hitting the water is discountable. Marbled murrelet exposure to the in-air sound and strike by non-explosive practice bombs is not discountable, but is also not reasonably certain to occur.

10.4.5.5.1.1.4 Exposure: Non-Explosive Practice Missiles

Our analysis of the potential effects of underwater and in-air sound associated with non-explosive practice missiles followed the same outline described above for our analysis for non-explosive practice bombs. The radii to effect for underwater and in-air sounds were, respectively, 9 m and 108 m, corresponding to areas of effect, respectively, of 254 m^2 (7.42 x 10-5 nm^2) and 36,644 m^2 (0.0107 nm^2).

10.4.5.5.1.1.5 Response: Non-Explosive Practice Missiles

Based on our analysis of a "reasonable worst-case" scenario, we found that over the 20 years of the proposed action there was a less than ten percent probability that any marbled murrelets would be exposed to strike and in-air sound from non-explosive practice missiles. Similarly, we found that there was a less than ten percent chance that any marbled murrelets would be exposed to injurious levels of underwater sound from non-explosive practice missiles.

10.4.5.5.1.1.6 Conclusion: Non-Explosive Practice Missiles

The strike, in-air noise, and underwater noise effects of non-explosive practice missiles are discountable for the marbled murrelet.

10.4.5.5.2 Effects of Non-Explosive Practice Munitions on the Short-tailed Albatross

10.4.5.5.2.1 Effects of Non-Explosive Practice Bombs and Missiles on the Short-tailed Albatross in the Offshore Area

Use of non-Explosive practice bombs and missiles is expected only in the Offshore Area.

10.4.5.5.2.1.1 Exposure: Non-Explosive Practice Bombs

Our analysis of the potential effects to short-tailed albatross of underwater and in-air sound associated with non-explosive practice bombs followed the same outline described above for the effects of these stressors to marbled murrelets. Our analysis of a "reasonable worst-case" scenario, showed that there is a less than ten percent chance that any short-tailed albatross will be exposed to injurious levels of underwater sound caused by non-explosive practice bombs striking the water. This means that short-tailed albatross exposure to this underwater stressor is discountable. Our analysis of the "reasonable worst-case" scenario also showed a 41 percent chance of short-tailed albatross exposure to injurious levels of in-air sound or direct strike by a non-explosive practice bomb. Under the assumptions of the "reasonably certain" scenario, 0.12 short-tailed albatross are expected to be exposed over 20 years to the in-air stressors associated with non-explosive practice bombs, and a total of 664 km^2 (194 nm^2) of short-tailed albatross habitat (i.e., the sum of all individual areas of effect) is expected to be exposed. However, there was an 89 percent chance in the "reasonably certain" scenario that no short-tailed albatross individuals would be exposed, so we are not reasonably certain that short-tailed albatross will be struck or exposed to injurious levels of in-air sound from non-explosive practice bombs striking water.

10.4.5.5.2.1.2 Response: Non-Explosive Practice Bombs

Short-tailed albatross struck by non-explosive practice bombs could be injured and killed. Albatross may also experience auditory injury or barotrauma if they are exposed to the in-air or underwater sound created when practice bombs hit the surface of the water.

10.4.5.5.2.1.3 Conclusion: Non-Explosive Practice Bombs

Short-tailed albatross exposure to injurious levels of underwater sound associated with non-explosive practice bombs hitting the water is discountable. Short-tailed albatross exposure to the in-air sound and strike by non-explosive practice bombs is not discountable, but is not reasonably certain to occur.

10.4.5.5.2.1.4 Exposure: Non-Explosive Practice Missiles

Our analysis of the potential effects of underwater and in-air sound associated with non-explosive practice missiles followed the same outline described above for our analysis for non-explosive practice bombs. The radii to effect for underwater and in-air sounds were, respectively, 9 m and 108 m, corresponding to areas of effect, respectively, of 254 m^2

(7.42×10^{-5} nm^2) and 36,644 m^2 (0.0107 nm^2). Based on our analysis of a "reasonable worst-case" scenario, we found that over the 20 years of the proposed action there was a less than 10 percent probability that any short-tailed albatross would be exposed to any stressors (strike, in-air sound, and underwater sound) from non-explosive practice missiles.

10.4.5.5.2.1.5 Response: Non-Explosive Practice Missiles

Short-tailed albatross exposure to stressors associated with non-explosive practice missiles is considered discountable; therefore, responses are not anticipated.

10.4.5.5.2.1.6 Conclusion: Non-Explosive Practice Missiles

We have determined that the effects of non-explosive practice missiles are discountable for short-tailed albatross.

10.4.5.6 Vessel Noise

10.4.5.6.1 Bull Trout, Marbled Murrelet, Short-tailed Albatross

Navy vessels (ships, small craft, and submarines), as well as some unmanned underwater vehicles, have combustion engines which produce low-frequency, broadband underwater sound. The Navy's NWTT FEIS states that Navy ships contribute approximately 1 percent of the broadband noise generated by large military and non-military vessels in the project area (Navy 2015, p. 3.0-35). The Navy stated the noise from the largest Navy ship is similar to a large oil tanker. McKenna et al. (2012, p. 96) studied underwater radiated noise from commercial vessels and found the highest broadband source level originated from a 54,000 gross ton container ship at 188 dB re 1 µPa@1m (rms assumed). We do not expect injurious effects from exposure to this type of continuous, broadband sound because exposure durations that are long enough for exposure to result in auditory damage will not occur. While the sound levels originating from operation of Navy vessels may be detectable by short-tailed albatross, marbled murrelets, and/or bull trout, these sounds are transient and of a relatively short duration such that measurable effects are not anticipated. Therefore, effects of vessel noise on short-tailed albatross, marbled murrelet, and bull trout are considered insignificant.

10.4.5.7 Aircraft Noise

10.4.5.7.1 Effects of Aircraft Noise on the Marbled Murrelet

The use of jet aircraft over the Olympic MOAs will introduce increased levels of sound into the action area throughout the year, including flights during the marbled murrelet nesting season (April 1 through September 23). The sound level of jet aircraft can be extremely loud at close distances. Because jet aircraft fly at high rates of speed (≥ 250 km/hour), the onset of exposure to loud noise from a jet overflight can be rapid. In some situations, jets can be flying so fast that a person or animal on the ground will not hear them approaching until they passing directly overhead. The rapid onset of the sound can be startling, and the combined auditory and visual stimuli of low altitude jet overflights have the potential to disturb or disrupt marbled murrelet nesting behaviors if the flights coincide with the marbled murrelet nesting season, and occur at a low altitude over areas of marbled murrelet nesting habitat.

10.4.5.7.1.1 Evaluation Criteria

We have previously completed analyses of the potential for noise and visual disturbance to marbled murrelets (e.g., USFWS 2003, pp. 265-285; USFWS 2006, entire; USFWS 2013, pp. 101-110). Potential marbled murrelet responses to disturbance can range from minor behavioral responses, such as scanning or head-turning, or increased vigilance for short periods, to more severe responses such as flushing. Under certain scenarios, exposure to noise or visual disturbance could result in a disruption of normal nesting behaviors. In these analyses, we have identified specific behavioral responses as indicators of severity of disturbance. Behavioral responses indicating a significant disruption of normal nesting behaviors include: (1) an adult marbled murrelet flushing from a nest or perch within the vicinity of a nest site, including delay or avoidance in nest establishment, and (2) an adult marbled murrelet aborting one or more feedings of nestlings. These behavioral responses are considered significant because they create a likelihood of injury to exposed individuals due to the potential for reduced hatching success, fitness, or survival of nestlings. For example, escape or avoidance behaviors may increase probability of detection by predators, expose chicks or eggs to inclement weather, or reduce feeding of young.

For aircraft overflights, we used the following evaluation criteria to assess potential risk for disturbance to nesting marbled murrelets:

- Aircraft noise exceeding 92 dBA SEL at an active nest site, or aircraft approach within a distance of 110 yards.

There is no direct research on marbled murrelets that indicates that exposure to very loud sounds will cause a marbled murrelet to flush from a nest. The 92 dBA SEL threshold is derived from research on other bird species. Mexican spotted owls exposed to helicopter noise did not flush from their roosts until the noise from helicopters exceeded 92 dBA SEL, and the helicopters were within a distance of 105 m (Delaney et al. 1999, pp. 66-68). Subsequent research with Mexican spotted owls has found that distance to aircraft is a better predictor for potential disturbance because there was no significant relationship between aircraft sound levels and Mexican spotted owl behavioral responses (U.S. Air Force 2012, p. 3-99).

While exposure to a specific sound level may not be a strong predictor for behavioral responses in Mexican spotted owls, there is evidence from other bird species that indicates that exposure to high-amplitude sounds can be disruptive. Hillman and others (2015, p. 1196) observed that 1 of 8 least terns (*Sternula antillarum*; 12.5 percent) exposed to military jet aircraft noise that exceeded a maximum 1-second equivalent average sound level of 90 dBA (MaxLEQ) flushed in response to the aircraft overflights, but it is not clear if the birds were responding to sound levels or visual stimuli of overhead aircraft. Most studies of avian responses to aircraft have been limited to raptors and waterfowl. Even within these groups, responses have differed widely, depending on reproductive state, activity, age, exposure frequency, and species. A literature review by Efroymson et al. (Efroymson et al. 2000, p. 56-62) reported response thresholds for sound levels in the range of 89 to 105 dBA MaxLEQ for bird species, coupled with response thresholds for slant distance (distance from aircraft to the bird) ranging from 315 ft (96 m) to > 6,500 ft (2 km) (Efroymson et al. 2000, p. 52).

Given the range of responses observed in various bird species, we expect the combined auditory and visual stimuli of low altitude jet flights pose a risk of disturbance to marbled murrelets. We expect sounds from aircraft will either need to be of very high amplitude (more than 90 dBA SEL) or have a highly visible approach for marbled murrelets to respond. For this analysis, we are relying on our previously-defined sound threshold of 92 dBA SEL to evaluate whether marbled murrelets are likely to be exposed to potential disturbance effects from aircraft overflights in the Olympic MOAs.

10.4.5.7.1.1.1 Exposure

In this analysis, we use exposure of marbled murrelet nesting habitat as an indicator of the potential for exposure of marbled murrelets. Audio-visual surveys for marbled murrelets conducted on various ownerships within the MOAs have documented both marbled murrelet presence detections and occupancy behaviors at many locations within the MOAs, indicating nesting habitat throughout the MOAs may be occupied by marbled murrelets.

Aircraft operating in the Olympic MOAs will exceed the defined noise disturbance threshold of 92 dBA SEL re: 20 μPa during some of the training exercises. Whether or not the noise from the aircraft will exceed the disturbance threshold in habitat depends on two factors: the aircraft's power setting and the distance the aircraft is from habitat. The Navy provided SEL information for the EA-18G, which is the aircraft used for over 98 percent of the proposed training flights that will occur in the Olympic MOAs. Other aircraft (including the P-3C/EP-3 and P-8A) will be used in training events. Intelligence, surveillance and reconnaissance missions, which will be performed by P-3C/EP-3 aircraft, will only occur at high altitudes (higher than 10,000 ft above MSL) over the Olympic MOAs. Since those aircraft (which are similar to the Lockheed L-188 Electra) are significantly quieter than the jets used for training (Federal Aviation Administration 2002, p. 9T) and they will be flown at high altitudes, we consider noise from P-3C/EP-3 aircraft at high altitude likely to have an insignificant on marbled murrelets.

The data provided by the Navy gives modeled sound levels at a range of altitudes above ground level (AGL) that will result from operating the EA-18G at three different power settings (78, 85, and 93 percent power) (Navy 2015a, p. 3.6-60). Unfortunately, none of the power settings in the proposed action (80, 82, and 89 percent power) were included in the modeled SEL data. To estimate the SELs for the power settings in the proposed action, we plotted lines of the modeled SELs and power settings by altitude and then determined the SELs and associated altitudes for the proposed power settings from where the proposed power settings intersected the plotted lines (Figure 17).

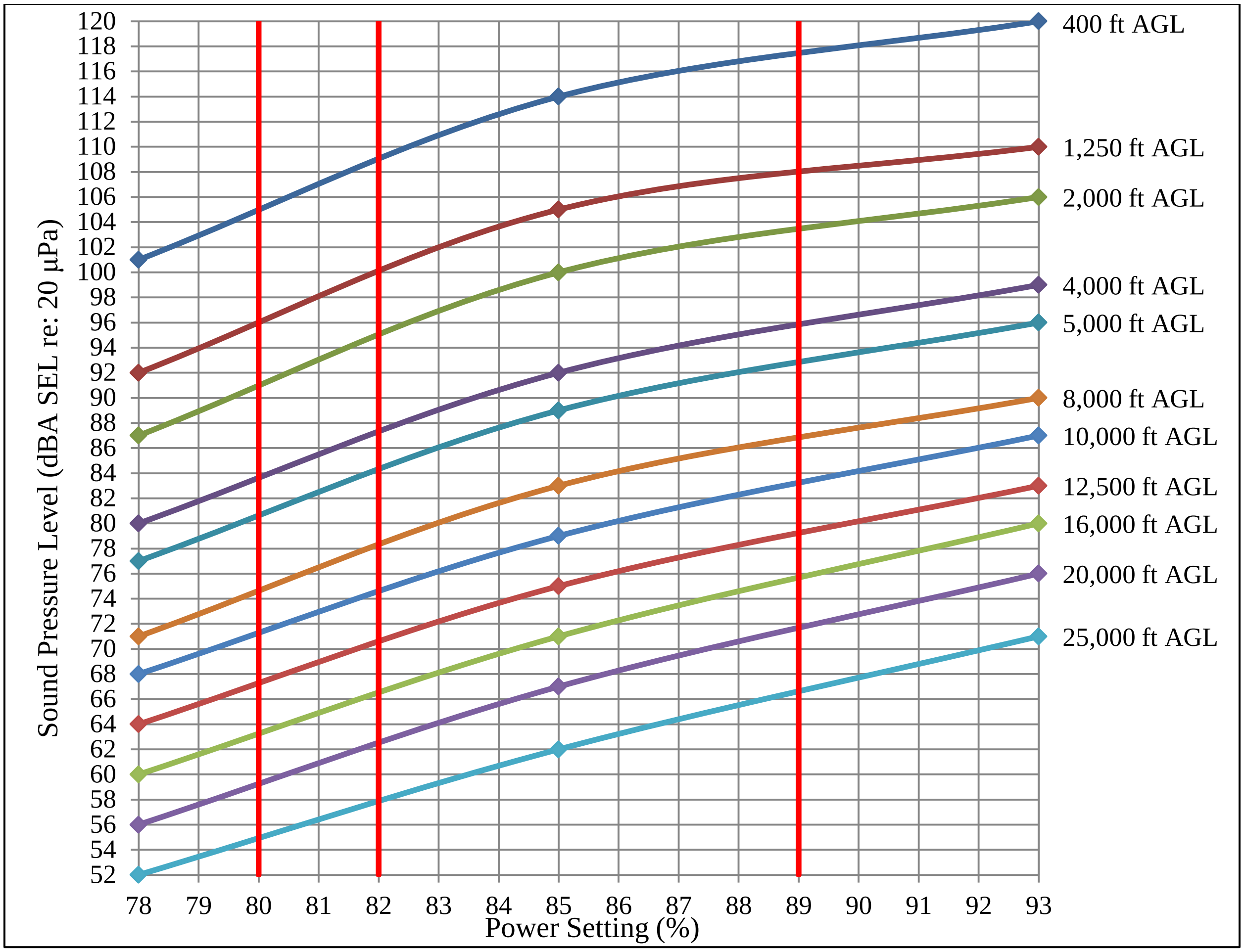

Figure 17. Estimation of SELs for proposed power settings using the SELs of modeled power settings.

We then estimated the distances at which SPLs from aircraft operating at the proposed power settings would exceed the 92 dBA SEL re: 20 µPa disturbance threshold. To estimate the distances to the threshold for each proposed power setting, we plotted the estimated SPLs for each proposed power setting relative to altitude AGL then estimated the altitude at which those lines intersected the 92 dBA SEL re: 20 µPa disturbance threshold (Figure 18). In determining the distances to the threshold for the proposed power settings, we conservatively rounded up to the nearest thousand feet. We found that marbled murrelet nesting habitat would be exposed to noise exceeding the 92 dBA SEL re: 20 µPa disturbance threshold within:

1. 6,000 ft of jets flying under 89 percent power,
2. 3,000 ft of jets flying under 82 percent power, and
3. 2,000 ft of jets flying under 80 percent power[3].

[3] The noise from a jet operating under 80 percent power is expected to be 91 dBA SEL 2,000 ft from the jet, but rounding up to the nearest thousand feet resulted in the same distance for disturbance threshold.

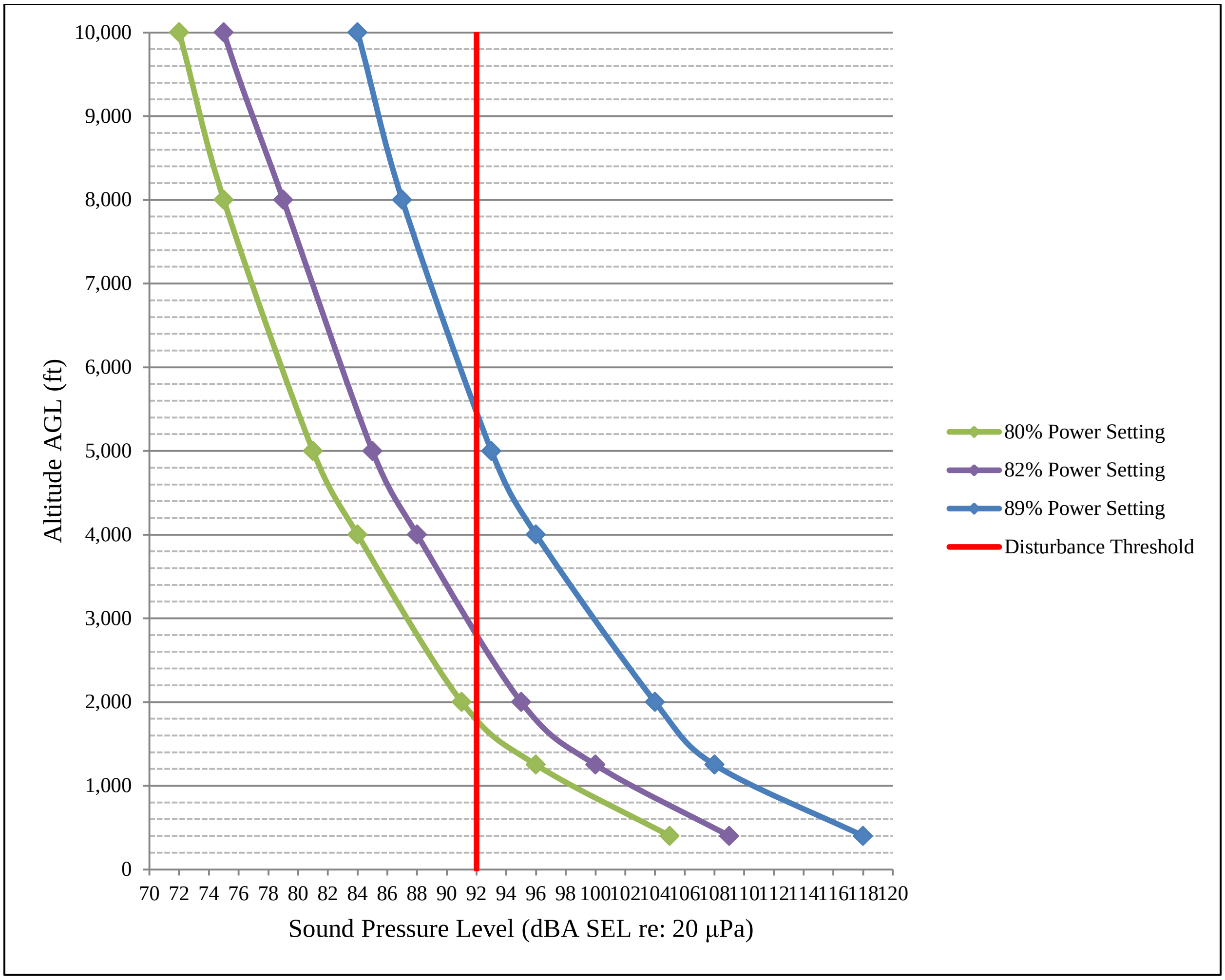

Figure 18. Estimation of distance to disturbance threshold using estimated SPLs for proposed power settings.

We refer to these distances as "Distance To Disturbance Thresholds," abbreviated DT^2, for the remainder of this section. The Navy proposes that EA-18G jets will also operate at a 75 percent power setting, but we did not calculate SELs or DT^2 for jets under that power setting. Estimating SELs for a power setting that was not between provided data points would require extrapolation and introduce an unacceptable amount of error. Instead of estimating the noise associated with a 75 percent power setting, we used the provided modeled data for EA-18G jets under 78 percent power. The SEL provided by the Navy along with our estimated sound levels is shown in Table 44.

Table 44. Navy-provided and Service-estimated sound exposure levels (SELs) in dBA at different altitudes for the EA-18G operating at various power settings.

Flight Altitude (ft AGL)	Power Setting					
	78	80	82	85	89	93
400	101	*105*	*109*	114	*118*	120
1,250	92	*96*	*100*	105	*108*	110
2,000	87	*91*	*95*	100	*104*	106
3,000			*92*			
4,000	80	*84*	*88*	92	*96*	99
5,000	77	*81*	*85*	89	*93*	96
6,000					*92*	
8,000	71	*75*	*79*	83	*87*	90
10,000	68	*72*	*75*	79	*84*	87
12,500	64	*68*	*71*	75	*80*	83
16,000	60	*64*	*67*	71	*76*	80
20,000	56	*60*	*63*	67	*72*	76
25,000	52	*55*	*58*	62	*67*	71

Note: Estimated data are shaded in green, data provided by the Navy (Navy 2015a, p. 3.6-60) are unshaded.

On the Olympic Peninsula, marbled murrelet nesting habitat generally ranges between 0 and 4,000 ft above MSL in elevation (Davis et al. 2011; Raphael et al. 2015). As long as the ground elevation is below 4,000 ft, aircraft overflights that approach within the DT^2 of the ground could expose nesting habitat to noise levels that are disruptive to marbled murrelets. The following discussion is supplemented by Table 45. The Navy includes four types of training missions for EA-18G jets over the Olympic Peninsula in the proposed action:

1. Entering and exiting the Olympic MOAs,
2. Suppressing enemy air defenses,
3. Electronic warfare close air support, and
4. Advanced air combat tactics.

When entering into and exiting from the Olympic MOAs, jets will operate at 75 percent power for which the DT^2 is 1,250 ft. During this training component, jets will fly only between 14,000 and 16,000 ft above MSL. There is marbled murrelet habitat within the DT^2 of the altitudes proposed for this training component.

When conducting this training, jets will operate at an 80 percent power setting resulting in a DT^2 of 2,000 ft. The lowest altitude that jets will fly at for these training missions is 6,000 ft above MSL. When jets fly at that lowest altitude over the highest-elevation marbled murrelet nesting habitat there will be 2,000 ft between the jet and habitat. Since jets will not fly closer than the DT^2 to habitat, we do not expect marbled murrelet behavior to be disturbed by these training missions.

For these training missions, jets will operate at an 82 percent power setting which has a DT^2 of 3,000 ft. During two percent of time spent performing these missions, jets will fly between 6,000 and 8,000 ft above MSL. Consequently, potential marbled murrelet nesting habitat at elevations between 3,000 and 4,000 ft above MSL will be within the DT^2 of these flights. The Navy proposes 245 flights annually for this training and each flight will last an average of 90 minutes resulting in a total of 367.5 hours of flight time. Two percent of the total flights times for this training component are 7.4 hours. Therefore, electronic warfare close air support training is likely to expose marbled murrelet nesting habitat to high-level aircraft noise 7.4 hours each year.

When training in advanced air combat tactics, jets will operate at 89 percent power which has a DT^2 of 6,000 ft. At that power setting, jets flying below 10,000 ft will be within the DT^2 of habitat, and jets flying at the minimum altitude of 6,000 ft above MSL will potentially expose marbled murrelet nesting habitat at elevations ranging from 0 to 4,000 ft in elevation. Of the 741 hours of advanced air combat tactics training, 6.5 percent, or 48.2 hours, will consist of jets flying low enough to expose habitat to noise above the disturbance threshold.

In total, aircraft training flights in the Olympic MOAs will expose marbled murrelet nesting habitat to noise exceeding the 92 dBA SEL disturbance threshold 55.5 hours each year. Table 45 summarizes the data that was used to develop these estimates.

Table 45. Proposed annual training missions for EA-18G jets over the Olympic Military Operations Areas

Name/Identifier	Entry / Exit	Suppress Enemy Air Defenses (EW)	Electronic Warfare Close Air Support (EW)			Advanced Air Combat Tactics (ACM)		
# Aircraft Flights / Year	1558	572	245			741		
Avg time in Airspace/Aircraft (min)	10	90	90			60		
Total Time of Flights / Year (hrs)	259.7	858.0	367.5			741		
Avg Power Setting (% NC)	75	80	82			89		
Avg Speed (Knots indicated)	250	265	298			342		
Distance To Disturbance Threshold (DT^2)	1,250 ft	2,000 ft	3,000 ft			6,000 ft		
Altitude MSL (ft)	**Percent of total time spent at altitudes**	**Percent of total time spent at altitudes**	**Percent of total time spent at altitudes**	**Total time spent at altitudes**	**Habitat elevation within DT^2 (ft. msl)**	**Percent of total time spent at altitudes**	**Total time spent at altitudes**	**Habitat elevation within DT^2 (ft. msl)**
6,000 - 8,000		2.0%	2.0%	7.4	3,000 - 4,000	3.2%	23.7	0 - 4,000
8,000 - 10,000		2.5%	2.5%			3.3%	24.5	2,000 - 4,000
10,000 - 12,000		2.5%	2.5%			3.3%		
12,000 - 14,000		6.0%	6.0%			13.8%		
14,000 - 16,000	100.0%	6.0%	6.0%			13.8%		
16,000 - 18,000		6.0%	6.0%			13.8%		
18,000 - 20,000		6.0%	6.0%			13.8%		
20,000 - 23,000		32.0%	32.0%			17.5%		
23,000 - 30,000		32.0%	32.0%			17.5%		
30,000 - 40,000		5.0%	5.0%					
Total % Time	100.0%	100.0%	100.0%			100.0%		
Total Time exceeding noise threshold (hrs)				**7.4**			**48.2**	

Note: Number, duration, power setting, and altitudes of flights are from Table 3-7 in Appendix J of the Northwest Training and Testing Activities Final Environmental Impact Statement/Overseas Environmental Impact Statement (U.S. Department of the Navy 2015c, Appendix J, p. 14).

Marbled murrelets will not be exposed to high amplitude aircraft sounds by every aircraft flight, but only those where the aircraft are sufficiently close to habitat. Without knowing the location and flight pattern of each training flight, we assumed that the training flights will be evenly distributed throughout the Olympic MOAs. We also assumed that the proportion of the time that aircraft will disturb habitat is equal to the proportion of the training area that is habitat. Table 45 shows bands of elevation that will be within the DT^2 under different mission parameters (labeled "Habitat elevation within DT^2"). Marbled murrelet nesting habitat is not evenly distributed throughout the training area; in fact, habitat makes up a disproportionate amount of land at higher elevations. Using models of potential marbled murrelet nesting habitat developed for the Northwest Forest Plan, we determined the proportion of those elevation bands that are nesting habitat (Table 46). To determine the total annual amount of disturbance to nesting habitat, we multiplied the total time jets spent at altitudes where habitat was within DT^2 by the proportion of the elevation within DT^2 that is habitat for marbled murrelets.

Table 46. Habitat proportions of elevation bands exposed to disturbance-level aircraft noise.

Elevation bands exposed to disturbance-level aircraft noise	**Total area within Olympic MOAs**		**Marbled murrelet nesting habitat within the Olympic MOAs**	
	Total acres in MOAs	**Percent land area in MOAs**	**Acres of murrelet habitat in MOAs**	**Percent of total area within MOAs in murrelet habitat**
0 – 4,000 ft	1,367,600	100 %	370,995	27 %
2,000 – 4,000 ft	134,645	9.8 %	57,549	42.7 %
3,000 – 4,000 ft	28,688	2.1 %	3,163	11 %

Notes: Total area within the Olympic MOAs includes both land area and marine waters. Marbled murrelet habitat estimates represent approximate conditions in 2012, as depicted by map data developed for the Northwest Forest Plan monitoring program, moderate (class 3) and highest (class 4) suitability (Raphael et al. 2015, p. 121).

Exposure to high amplitude aircraft noise is likely to be the most disruptive to marbled murrelets during their nesting seasons. We therefore adjusted the amount of time that aircraft would generate noise above the disturbance threshold in habitat by the proportion of the year that represents the nesting season during which noise disturbance could have a significant impact on marbled murrelets. We then assumed that training flights will be distributed uniformly throughout the year. The nesting period for marbled murrelets in Washington is defined as April 1 through September 23 (48 percent of the year) (USFWS 2013, p. 12).

We adjusted the potential exposure to aircraft noise to account for the distribution of habitat and the temporal proportion of the nesting season. This resulted in an estimated cumulative total of 8.5 hours of exposure during the marbled murrelet nesting season each year. The marbled murrelet nesting season extends over a period of 25 weeks. If we divide 8.5 hours by 25, we get an average of 20 minutes per week. If we divide 20 minutes by 5 days (training flights will not occur on weekends or holidays), the average is 4 minutes per weekday that marbled murrelet nesting habitat may be exposed to aircraft noise that exceeds the sound threshold of 92 dBA SEL.

We calculated the extent of land area that could be exposed to aircraft noise exceeding the disturbance threshold based on the DT^2, altitude, speed, and duration of training flights. Depending on the altitude of the flights, training flights operating at the 82 percent power setting will expose between 0 and 186,300 acres (0 – 754 km^2) of the MOAs to aircraft noise that exceeds the 92 dBA SEL sound threshold each hour. Training flights operating at the 89 percent power setting will expose between 0 and 542,149 acres (0 – 2,194 km^2) of the MOAs to aircraft noise that exceeds the 92 dBA SEL threshold each hour (depending on the altitude of the flights). Figure 19 shows an example calculation of the total area exposed to disturbance-level noise per hour.

Considering the cumulative flight time over the marbled murrelet nesting season, Navy training flights have the potential to expose an area much larger than the total extent of habitat in the training area. Since the area exposed to aircraft noise is greater than the amount of habitat within the MOAs, we conclude that all marbled murrelets nesting within Olympic MOAs may be exposed to disturbance-level noise multiple times each year. Based on our analysis, training flights could expose every marbled murrelet as many as 12 times every year during nesting season. We therefore expect that all marbled murrelets throughout the habitat in the training area to potentially be exposed to aircraft noise exceeding the defined sound threshold of 92 dBA SEL.

As presented above (Table 46), the total area of marbled murrelet nesting habitat in the Olympic MOAs is approximately 370,000 acres. The Olympic MOA is located in marbled murrelet Conservation Zone 2 (Zone 2), which encompasses the western Olympic Peninsula and western Washington south to the Columbia River. Total potential marbled murrelet nesting habitat in Zone 2 is estimated at 603,777 acres (Raphael et al. 2015, p. 121), indicating over half (61 percent) of the potential nesting habitat available for marbled murrelets in Zone 2 is located within the Olympic MOA. The total number of marbled murrelets exposed to noise disturbance in any given year is unknown, because nesting marbled murrelets are not evenly distributed throughout nesting habitat, and the number of breeding adults that attempt to nest varies from year to year (McShane et al. 2004, p. 3-5).

In summary, the proposed action includes an average of 8.5 hours of aircraft training operations per day, up to 260 days per year. The aircraft proposed for use by the Navy have an estimated 92 dBA sound-contour that extends from 2,000 to 6,000 ft from the aircraft depending on power levels. The closest approach of aircraft to nesting habitat would be 2,000 ft above ground level, at the upper elevation limits of marbled murrelet nesting habitat. Most (over 99 percent) of the estimated annual flight time will occur over the Pacific Ocean, or at high altitudes that will not expose marbled murrelet nesting habitat to high-amplitude aircraft noise. For each 8.5 hours of daily aircraft flight time, there will be an average of 4 minutes (less than one percent) of flight time per day that is likely to expose marbled murrelet nesting habitat to aircraft noise that exceeds 92 dBA SEL. Because the aircraft travel at high speed, each minute of low-altitude flight can expose thousands of acres to aircraft noise, but the duration of the exposure over any single location lasts for only a few seconds. Based on this, we conclude that all marbled murrelets nesting within the Olympic MOAs are likely to be exposed to aircraft noise events that exceed 92 dBA SEL for short durations only.

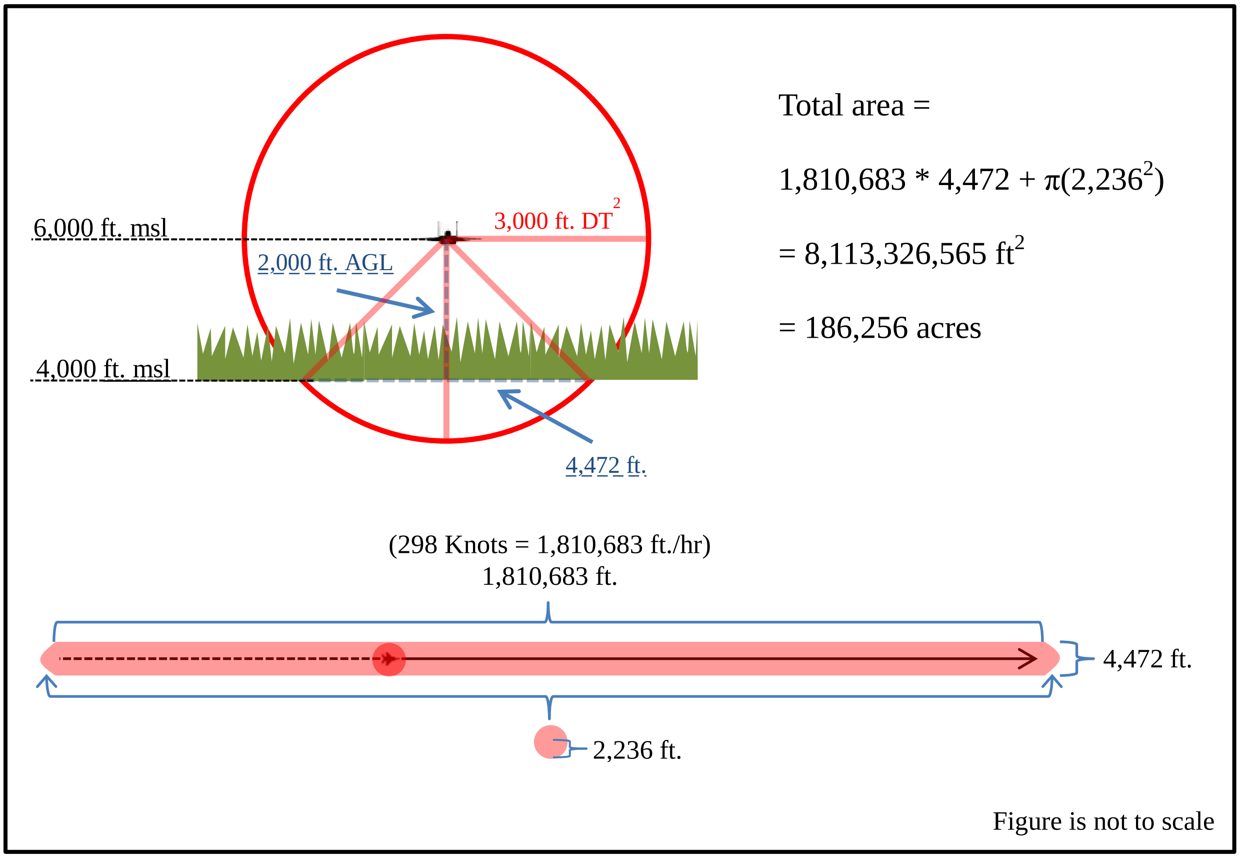

Figure 19. Diagram of total area exposed to sound each hour for a jet operating at the 82 percent power setting traveling at 298 knots at an altitude of 6,000 ft MSL over land with an elevation of 4,000 ft MSL.

10.4.5.7.1.1.2 Response

There are no experimental studies that have evaluated marbled murrelet responses to aircraft overflights. However, there are a handful of incidental observations that have been described. Long and Ralph (1998, p. 19) noted that marbled murrelets did not have an observable response to either airplanes or helicopters flying overhead, except perhaps when they passed at low altitude. One chick did not respond to an airplane passing twice within 0.25 mile at a height of about 1,000 ft, but another chick lay flat on the branch “when an aircraft passed at low altitudes” (“low altitudes” was not defined) (Long and Ralph 1998, p. 19). During a study of radio-tagged marbled murrelets in British Columbia, helicopters were used to locate the incubating adults by circling and hovering over nest sites. The hovering and circling came within distances of 100 to 300 m of the nest and lasted approximately three minutes. None of the radio-tagged adults incubating any of the nests (n = 125) flushed (R. Bradley, Univ. BC, 2002, pers. comm. in (USFWS 2003, p. 278)).

Observations of marbled murrelet responses to other sources of noise disturbance at nest sites have primarily been modifications of posture and on-nest behaviors indicating alerting, without flushing or abandoning the nest (Hebert and Golightly 2006, pp. 35-39; Long and Ralph 1998, p. 22). Hebert and Golightly (2006) monitored nesting marbled murrelets exposed to experimental bouts of chainsaw noise and the presence of people hiking on trails in Redwood National and State Parks in northern California. Adult and chick responses to chainsaw noise, vehicle traffic, and people walking on forest trails resulted in no flush responses. However, adults exposed to chainsaw noise spent more time with their head raised, and their bill raised up in a posture of alert, vigilant behavior. When undisturbed, adult marbled murrelets spent 95 percent of the time resting or motionless (Hebert and Golightly 2006, pp. 35-39).

Marbled murrelet chicks exposed to chainsaw noise also spent more time with their head raised, and their bill up during the disturbance trials, although compared to pre- and post-disturbance trials, the relationship was not statistically significant (Hebert and Golightly 2006, p. 36). The relevance of the behavioral responses seen in adults tending nests is unknown, but the behavior is similar to an adult marbled murrelet reaction to the presence of a nest predator (Hebert and Golightly 2006, p. 35). The authors suggest that marbled murrelets responding to a noise by moving or shifting position would increase the chance that it will be detected by a predator. Additionally, the energetic cost of increased vigilance to protracted disturbance could have negative consequences for nesting success (Hebert and Golightly 2006, p. 37).

Adult marbled murrelets typically feed their chicks in the early morning and in the evening. Exposure to loud noise while an adult approaches a nest to provision a chick may cause sufficient disturbance to result in abortion or delay of the feeding. Hamer and Nelson (1998, p. 9) noted that adult marbled murrelets would abort feeding attempts or flush off the nest branch during attempted food deliveries when people on the ground were visible to the birds and within a distance of 15 to 40 m, or occasionally when vehicles passed directly under a nest tree. Marbled murrelet chicks appear to be much more difficult to disturb than adults, and there are no documented instances of a nestling marbled murrelet falling due to sound or visual disturbance, including disturbances due to researchers climbing nest trees, handling young, and placing cameras close to young (USFWS 2003, p. 269).

Marbled murrelets have evolved several mechanisms to avoid predation; they have cryptic coloration, are silent around the nest, minimize movement at the nest, and limit incubation exchanges and chick feeding to occur during twilight hours (Nelson 1997, p. 14). Hebert and Golightly (2006) suggest that flushing as a result of a noise disturbance might not provide a benefit compared to the potential risk of exposure to predators. When confronted with the presence of potential predators, marbled murrelets remain on the nest in alert or defensive postures (Hebert and Golightly 2006) and are reluctant to flush unless confronted directly by a large predator such as a raven (Singer et al. 1991).

Based on the best available information concerning marbled murrelet responses to disturbance associated with noise, activity, and human presence, we conclude the following:

- Adult marbled murrelets are most likely to exhibit a flush response while attempting to deliver food to the chick at dawn or dusk. Therefore, disturbance activities that occur in close proximity to occupied nests during dawn or dusk periods can cause adult marbled murrelets to flush and abort a feeding attempt.

- Adult marbled murrelets that are incubating an egg are not likely to flush from noise disturbance alone. The only observations of flushes during incubation involved a direct approach to the nest by a researcher or a predator such as a raven.

- The normal behavior of incubating adults is to rest and remain motionless during the day. Noise disturbance can disrupt this normal behavior by causing the adults to remain vigilant and alert during a time when they are normally resting.

- Marbled murrelet chicks appear to be mostly unaffected by visual or noise disturbance. The greatest risk to marbled murrelet chicks from disturbance is the potential for missed feedings, which occur primarily during dawn and dusk periods, but do occasionally occur during mid-day hours.

Exposure to loud aircraft noise while an adult approaches a nest to feed a chick may cause sufficient disturbance to result in abortion or delay of the feeding. Aircraft noise disturbance has the potential to create an increased likelihood of injury to marbled murrelets in three ways: (1) increasing the risk of predation to adults, eggs, or nestlings; (2) increased energetic expenditure in adults who delay nest establishment activities or have to increase the number foraging trips or time inflight; or, (3) by reducing food and water intake of nestlings. We address each of these below.

Losses of eggs and chicks to avian predators have been determined to be an important cause of nest failure in marbled murrelets (McShane et al. 2004, p. 4-109). Marbled murrelets appear to be most sensitive to noise or visual disturbances when they are approaching a nest site for an incubation exchange or delivering fish to a nestling. There are several documented instances where ground-based activities caused adult marbled murrelets to abort or delay feedings of nestlings, caused adults to divert their flight paths into nesting habitat or caused marbled murrelets to vacate suitable habitat (Hamer and Nelson 1998, pp. 8-17). Disturbances that cause a marbled murrelet to flush can advertise the nest’s location, thereby creating a likelihood of predation of the eggs or nestlings (USFWS 2006, p. 27). When an adult is flushed, it can alert a predator to its location and the location of its egg or chick, thereby facilitating predation. While this has never been observed directly in marbled murrelets, it is a potential outcome of exposure to anthropogenic noise and/or visual disturbance.

Noise and visual disturbance that causes an adult marbled murrelet to abandon or delay nest establishment or abort a prey delivery to a nestling creates a likelihood of injury for the adult through an increased energy cost, and by exposing the adult to an increased risk of predation. Hull et al. (2001, p. 1036) report that marbled murrelets spend 0.3 to 3.5 hours per day (mean 1.2 ± 0.7 hours per day) commuting to nests during the breeding season. The distance traveled between the nest site and foraging areas ranged from 12 to 102 km, and is a substantial energy demand for the adults. Each flight to the nest is energetically costly, increases the risk of predation from avian predators, and detracts from time spent in other activities such as foraging (Hull et al. 2001, p. 1036). Increases in prey capture and delivery efforts by the adults results in reduced adult body condition by the end of the breeding season, and increases the predation risks to adults and chicks as more trips inland are required (Kuletz 2005, pp. 43-45).

Missed feedings can reduce the fitness of nestlings. Nestlings have minimum daily energetic demands to sustain life and development, and mortality from starvation occurs when nestlings do not receive sufficient food (Kitaysky 1999, p. 471). During chick rearing, adult marbled murrelets feed the young 1 to 8 times per day (mean = 3.2 ±1.3 SD) (Nelson and Hamer 1995, p. 61). If we assume an average of 4 feedings per day, a single aborted feeding would constitute a loss of 25 percent of that day's food and water intake for the nestling. Such a loss is considered to be a significant disruption of normal behavior given that, "Marbled murrelet chicks grow rapidly compared to most alcids, gaining 5 to 15 g/day during the first 9 days after hatching" (Nelson and Hamer 1995, p. 60). With such a fast growth rate and a low average number of daily feedings, it is reasonable to assume that missed feedings may disrupt normal growth and create the likelihood of injury by presenting a developmental risk to the chick. Young marbled murrelets that receive multiple daily feedings grow faster and fledge earlier than those with lower provisioning rates. Early fledging helps minimize nest mortality (Nelson and Hamer 1995, p. 66). Missed feedings that may occur due to anthropogenic noise or visual disturbance are considered significant, because each missed feeding represents a delay in the development of the chick, prolonging the time to fledging and increasing the risk of predation, accidental death from falling off the nest, or abandonment by the adults.

Marbled murrelets that do not visibly react or only exhibit minor behavioral responses to sound or visual disturbance may produce increased levels of stress-related hormones including GCs and corticosterone in response to the disturbance. Research with spotted owls has indicated that spotted owls nesting in close proximity to roads can have elevated levels of GCs (Hayward et al. 2011; Wasser et al. 1997). Although increased GCs can indicate stress, the interpretation of these studies is complicated by the fact there are no consistent relationships between elevated GCs and survival or reproductive success (Busch and Hayward 2009, p. 2844). Information linking elevated corticosterone levels to specific stressors (e.g., noise) and specific effects to breeding, feeding, or sheltering in birds is limited to and confounded by inconsistent correlations. At this time we are unable to determine the significance of elevated GCs to marbled murrelets, and continue to rely on behavioral responses as indicators of the severity of potential disturbance effects.

In most cases, we expect exposure to loud aircraft noise will result in either no response from adults or chicks, or minor behavioral responses such as head-turning, increased vigilance, or brief startle responses resulting in flattening on a branch. The effect of increased vigilance and alerting may increase energetic demands to adults, but this is likely to be most significant for individuals that are exposed to prolonged disturbances over a period of days. Aircraft overflights represent brief disturbance events that are most likely to result in increased vigilance for a short period (minutes).

As described above, all marbled murrelets nesting within the Olympic MOAs have the potential to be exposed to aircraft noise disturbance from multiple jet overflights during the nesting season. Potential exposure of nesting habitat to high-level aircraft noise does not automatically lead us to conclude that all marbled murrelets using the habitat exposed to aircraft noise will be negatively-affected. In order for a disturbance event to be disruptive to marbled murrelets, the aircraft overflight must approach within the disturbance threshold distance of an active nest site, and the aircraft overflight must coincide with an event (such as a prey delivery to a chick) where the marbled murrelet is most likely to experience a biologically-significant response (e.g., flushing, aborted feedings of chicks).

In the preceding analysis, we determined that all available nesting habitat, and therefore, potentially all marbled murrelets nesting within the Olympic MOAs are likely to be exposed to brief bouts of aircraft noise disturbance, multiple times each year. We think this over-estimates the number of marbled murrelets likely to be disturbed because training flights are not evenly distributed across the MOAs, some high-use areas within the MOAs are likely to be exposed multiple times, and still other areas within the MOAs may never be exposed to noise that exceeds the disturbance threshold criteria because natural topographic features that block aircraft sound. Likewise, not all marbled murrelets exposed to aircraft noise exceeding the potential disturbance thresholds are likely to respond in a biologically-significant way. For example, the likelihood of an overflight event (at any one location) co-occurring with the moment that a marbled murrelet is delivering prey to a chick is very low, but is not entirely discountable due the fact that even one minute of a low-altitude flight can expose thousands of acres to high amplitude noise.

Marbled murrelets may exhibit a range of responses to aircraft overflights. Hillman et al. (2015, p. 1196) observed that only 1 of 8 least terns (12.5 percent), flushed during incubation when exposed to military jet aircraft noise that exceeded a maximum 1-second equivalent average sound level of 90 dBA (MaxLEQ). Contrary to their expectations, the authors noted "even if the loudest overflights affected incubation behavior, the effect size was minimal and the effect was not likely to influence demographic rates, particularly as the effect was not towards reduced time incubating during an overflight, but towards more time incubating after an overflight" (Hillman et al. 2015, p. 1196).

Similarly, Derose-Wilson et al. (2015, p. 1256) evaluated the effects of military aircraft overflights to incubating Wilson's plovers (*Charadrius wilsonia*). This study evaluated vigilance behavior, incubation rate, and heart rates before, during, and after overflights (Derose-Wilson et al. 2015, p. 1249). Wilson's plovers were alert and scanned more during overflights, but heart rates and incubation rates did not change in response to overflights (Derose-Wilson et al. 2015,

p. 1250). The authors noted that because Wilson's plovers rely primarily on secrecy and cryptic coloration to protect their nests from predators, they may not incubate less because of overflights, even if they perceive them as threatening (Derose-Wilson et al. 2015, p. 1252). The authors concluded that although the transient increase in vigilance observed during these flights was not likely to directly influence fitness, it did indicate that incubating Wilson's plovers perceive and react to overflights under some conditions (Derose-Wilson et al. 2015, p. 1252).

Rojek and others (2007, p. 61) noted that from 4 to 31 percent of low-elevation aircraft flyovers caused some common murres (*Uria aalge*) to flush during nesting. Aircraft flights in this study were both non-military fixed-wing and helicopters, and low-elevation flights were defined as an altitude of less than 1,000 ft (305 m). Flush rates varied widely by colony, with individuals in some colonies flushing more frequently than in others. No sound information was reported for the aircraft overflights. Brown (1990, p. 591) subjected crested terns (*Sterna bergii*) to high-amplitude simulated aircraft noise and noted that about 8 percent of terns flushed in response to the noise.

We cite these examples to illustrate that the responses to aircraft noise can vary widely between different species, and response can also vary between individuals within a species exposed to the same stressor. The studies cited above are from bird species that nest in open habitats with little or no vegetation to absorb sound energy or provide a visual screen between the birds and distant aircraft. Because marbled murrelets nest in a forested environment, they may be shielded to some degree by forest cover over their nests. The most comparable studies of aircraft disturbance to forest-nesting birds are for Mexican spotted owls. Mexican spotted owls typically respond to aircraft overflights by orienting or alerting towards the aircraft. More severe responses such as movements or flushing are rare, and only occurred when aircraft approached at close range (Delaney et al. 1999, p. 68; U.S. Air Force 2012, p.3-99).

The weight of evidence indicates that marbled murrelet responses to the type and duration of aircraft overflights proposed by the Navy are likely to be brief periods (minutes) of increased vigilance and alerting behaviors. This is due to the fact that over 99 percent of training flights will be spent at high altitudes where marbled murrelet habitat will not be exposed to high-amplitude aircraft noise. Risk of direct visual disturbance to nesting marbled murrelets from aircraft overflights is low, because marbled murrelets nest within the live crowns of trees which provide canopy cover. Also, the closest approach of aircraft to marbled murrelet nesting habitat will be at 2,000 ft or greater above ground level.

All incidental observations of flush responses in marbled murrelets have been associated with ground-based disturbances that occurred within direct visual range of the birds. The species relies on cryptic behavior to avoid detection of predators, so a flush response is likely to be a rare event. We do not expect marbled murrelets to flush in response to aircraft noise unless the disturbance event coincides directly with a prey delivery to a chick. While this is a potential outcome of aircraft noise disturbance, we are not reasonably certain that this will occur, due to the limited duration of training flights at lower altitudes. For each 8.5 hours of daily flight time, we estimated that there would be an average of approximately 4 minutes (less than one percent) of flight time per day that is likely to expose marbled murrelet nesting habitat to aircraft noise that exceeds 92 dBA SEL. At any one location, exposure to high-amplitude aircraft noise is a brief event lasting only a few seconds, so the risk of an overflight coinciding directly with a marbled murrelet prey delivery is low.

10.4.5.7.1.1.3 Conclusion

When evaluating effects to listed species, the Service considers whether the effects of a proposed action are beneficial, insignificant, or wholly discountable (USFWS and NMFS 1998, p. 3-12). Discountable effects are defined as effects that are extremely unlikely to occur, while insignificant effects are defined as effects that a reasonable person would not be able to meaningfully measure, detect, or evaluate. Nesting marbled murrelets within the Olympic MOAs are likely to be exposed to aircraft noise that exceeds the defined sound disturbance threshold of 92 dBA SEL. In most cases, exposure to aircraft noise is expected to result in only minor behavioral responses, such as head turning, a sudden movement such as flattening, or short periods of increased vigilance which we consider to be insignificant effects. Aircraft noise does a pose a potential risk of more severe disturbance effects (e.g., flushing from a nest), but due to the limited duration of training flights at lower altitudes, these potential effects are speculative, and are not reasonably certain to occur. Because the potential effects of aircraft noise are not insignificant or entirely discountable, we conclude exposure to aircraft noise may adversely affect marbled murrelets, but we do not anticipate these effects will result in a significant disruption of nesting behaviors or result in direct injury to marbled murrelets.

10.4.6 Ingestion of Debris

The proposed activities will introduce debris into the ocean that could exacerbate threats to seabirds through direct ingestion of plastics/debris, indirect ingestion via prey, or bioaccumulation of toxins through the food chain. The materials and devices used by the Navy will either sink or float. Limited information was available to discern quantities that would sink or float, nor the rate with which they do so. Some of these materials may stay at the surface or within the diving depths that marbled murrelets and/or short-tailed albatross forage for an unknown amount of time.

We believe that munitions, fragmented bombs and torpedoes, guidance wires/fiber optic cables used for missiles and torpedoes, and sonobuoys and their components will not float on the surface or in the water column long enough to be a significant ingestion threat to marbled murrelets or short-tailed albatross. Effects from exposure to these materials are expected to be extremely unlikely and are therefore discountable. However, other materials that will float at or near the surface of the water could pose a threat to marbled murrelets and short-tailed albatross.

Unrecovered materials from the Navy's training and testing activities that that could float at or below the surface include chaff fibers, plastic end caps and pistons from flares, plastic end caps and pistons from chaff cartridges, fragments of missiles (rubber, carbon, or Kevlar fibers), (Navy 2015a, pp. 3.1-61, 3.4-299 - 300), and fragments of targets. Plastic end caps and pistons from flares and chaff cartridges may float for some period of time (Navy 2015a, pp. 3.1-61, 3.5-66).

In total, the proposed action includes the firing of 824 flares and 5,000 chaff cartridges in the offshore area annually (Navy 2015a, pp. 3.3-28 - 29) over 20 years. These end caps and pistons from flares and chaff cartridges will contribute 116,480 additional pieces of plastic to the marine environment. Also, 42 high-explosive and non-explosive missiles will be fired each year in the Offshore Area (Navy 2015a, p. 3.0-45), but the Navy did not provide any information on how many fragments are likely to result from these events over 20 years. Targets struck with ordnance will release target fragments (Navy 2015a, p. 2-33) contributing additional pieces. The Navy will use 458 targets for munitions training and testing in the offshore area each year (approximately 10,000 targets over 20 years) (Navy 2015a, p. 3.0-46), but did not provide any estimate of how many floating fragments would be created.

It is difficult to determine how much debris the proposed action will add to the marine habitat relative to the amount of debris that already exists especially since we do not know how many pieces of debris is the direct result of Navy activities within the proposed action. At the southern end of the training area (where debris would be carried by summer currents), researchers performing transects have found between 0 and 15,222 pieces of floating debris per km^2 (Titmus and Hyrenbach 2011, p. 2500). North of the training area (where debris would be carried by winter currents) researchers performing transects within Queen Charlotte Sound, British Columbia found between 0.91 and 2.27 pieces of floating debris per km^2 (Williams et al. 2011, p. 1308). Neither of these studies attempted to determine the sources of the observed debris.

Ocean currents will change the destination of floating debris left by the Navy’s activities. In the winter, debris is likely to enter the Pacific subarctic gyre flowing north up the coast of North America, running along and through the Aleutian Islands, then turning around near the Kamchatka Peninsula and returning to the northeast Pacific Ocean (Avery-Gomm et al. 2012, p. 1778). Once in the Pacific subarctic gyre, debris may continue to circulate for as many as 31 years or could exit the subarctic gyre to drift south along North America and join the Pacific subtropical gyre (Ebbesmeyer et al. 2007, pp. 1, 4-5).

This debris will accumulate, and although we are unable to quantify the actual number of pieces introduced into marine waters by Navy activities, it represents a quantity that we expect to be measurable above the baseline. We expect these plastics to persist in the environment for a long time because plastic doesn’t actively decompose, but only breaks down into smaller and smaller fragments.

10.4.6.1 Effects of Ingestions of Debris in the Marbled Murrelet

10.4.6.1.1.1.1 Exposure

Marbled murrelets may ingest plastic because debris may either resemble prey or may be in close proximity to prey; however we have no evidence of this occurring (D. Lynch, pers. comm. 2015). In one study, 82 marbled murrelets were examined along with other seabirds and none of the marbled murrelets showed evidence of ingested plastic; even though other pursuit-diving seabirds did, including murres, auklets, and puffins (Robards et al. 1997, p. 74). Others have also found no evidence of plastic ingestion in marbled murrelets (Avery-Gomm et al. 2013, in press, p. 1). While there may be a small risk that marbled murrelets will accidentally ingest debris, we expect that it is extremely unlikely to occur, and therefore, is discountable.

Marbled murrelets rely solely on marine fish as prey and likely consume fish with bioaccumulation of plastic contaminants. There is evidence that seabirds ingest prey contaminated by plastics and associated contaminants. Plastics degrade into smaller and smaller pieces that are ingested by fish and birds. Upon ingestion, microscopic plastic fragments can translocate into the tissues (Rochman et al. 2013, p. 1). Persistent, bioaccumulative, and toxic substances are found on recovered plastic debris globally (Hirai et al. 2011), bioaccumulate in foodwebs (Teuten et al. 2009), and are linked with several adverse effects including endocrine disruption (Guillette et al. 1994), decreased fish populations (McKinley and Johnston 2010), and reduced species evenness and richness (Johnston and Roberts 2009). Changes in prey abundance, availability, and quality are all identified as threats to marbled murrelets in the Service's 5-year status of the species review (USFWS 2009a, pp. 39-42, 45).

10.4.6.1.1.1.2 Response

Direct ingestion of plastics has not been identified as a threat to the marbled murrelet. Marbled murrelets typically feed by diving for prey, rather than skimming the surface, which may reduce the risk of ingestion. However, based on studies of another pursuit diving seabird (e.g., murres) (Bond et al. 2013), there is a potential risk of ingestion. The highest prevalence of ingested plastics in seabirds is in surface feeders, such as fulmars, some shearwaters, petrels, and phalaropes (Robards et al. 1997, p. 71). Blight and Burger found plastics in the stomachs of surface-feeding seabirds, but not in pursuit dive-feeding seabirds, including marbled murrelets (1997, p. 323). Others found that 7 percent of pursuit-dive feeding murres had ingested plastic (Bond et al. 2013, p. 192) and 11 percent of murres had plastic debris in their gastrointestinal tracts (Provencher et al. 2010, p. 1406).

The majority of plastic debris that litters aquatic habitats globally is microscopic, less than 1 mm (Rochman et al. 2013, p. 1). Plastic particles are reported in the gut content of several species of fish globally including from pelagic habitats, estuaries, and bays (Rochman et al. 2013, p. 2). Fish fed fragments of polyethylene, a common component of plastic and chemical pollutants absorbed from the marine environment, bioaccumulated these chemical pollutants and suffered liver toxicity and pathology (Rochman et al. 2013, p. 1). Rochman and others (2013, p. 5) concluded that polyethylene ingestion is a vector for the bioaccumulation of persistent, bioaccumulative, and toxic substances in fish, and that toxicity resulting from plastic ingestion is a consequence.

10.4.6.1.1.1.3 Conclusion

Given the information regarding the degradation of plastic in the oceanic environment and the bioaccumulation of associated contaminants through the marine food web, we conclude that marbled murrelets are likely exposed to these contaminants. Given the information presented above, this exposure can adversely affect individuals. However, at this time, there is insufficient information to determine whether the effects of this exposure would result in fitness consequences to individuals.

10.4.6.2 Effects of Ingestion in the Short-tailed Albatross

The Service does not concur with the Navy that the effects of debris resulting from training and testing activities in the offshore area are “not likely to adversely affect” the short-tailed albatross. The best available information is insufficient to support the Navy’s determination that the introduction of debris into the marine environment is “not likely to adversely affect” short-tailed albatross.

10.4.6.2.1.1.1 Exposure

At any given time approximately 75 to 95 percent of the short-tailed albatross population will be at sea (Finkelstein et al. 2010, pp. 327-328). Once they fledge from the breeding colonies in the central and west Pacific Ocean, juvenile short-tailed albatross disperse widely throughout their range. Short-tailed albatross observed along the west coast of the United States are primarily juvenile and sub-adults (Suryan et al. 2007, p. 456; USFWS 2014, pp. 12-14). Outside of the breeding season, adult and juvenile short-tailed albatross appear to spend the largest proportion of their time near Alaska (Suryan et al. 2007, p. 454). During the breeding season (October through June), short-tailed albatross older than 5 years of age may return to breeding colonies (USFWS 2014, p. 10). However up to 25 percent of breeding-age adults may not return to breeding colonies and instead remain in foraging areas with juvenile short-tailed albatross (H. Hasegawa pers. comm. 2002 cited in USFWS 2014, p. 10).

We expect the proposed action to produce some amount of floating plastic debris and other debris that will persist in the environment for a long time. It is unclear how much will be produced and how much that will contribute to floating debris present in the action area. We expect that short-tailed albatross will be exposed to debris resulting from the proposed action, both near the training and testing activities, and elsewhere within the range of the species where debris will be carried by ocean currents. We expect that the number of short-tailed albatross exposed to plastic debris to increase over the duration of the proposed action due to anticipated increases in the short-tailed albatross population, the persistence of plastic in the environment, and repeated contributions of plastics from all sources.

10.4.6.2.1.1.2 Response

Plastics are a threat to short-tailed albatross (USFWS 2008b, p. 26; USFWS 2014, p. 25), and research has shown that plastics pose a similar threat to black-footed albatross in areas with high concentrations of marine debris (Titmus and Hyrenbach 2011, p. 2505). Short-tailed albatross are likely to ingest floating plastic either because the debris resembles typical prey, or because the debris is the substrate to which flying fish eggs are attached (Pettit et al. 1981, p. 840). Ingestion of plastics may cause starvation, suppressed appetite and reduced growth, depressed weight at fledging, decreased fat deposition, increased assimilation of toxins including polychlorinated biphenyls and organochlorides, and obstruction in the gut (Auman et al. 1997, p. 242). Ingestion of sharp plastic pieces has resulted in internal injury or mortality to birds, and large volumes of ingested plastic has resulted in a reduction of gut volume available for food and water absorption, leading to malnutrition and dehydration (Sievert and Sileo 1993, p. 216).

Ingested plastics generally do not pass through the intestines of seabirds; most adults have the ability to regurgitate at least some plastic (Laist 1987, p. 321). If seabirds do not regurgitate it, plastic can remain in their stomachs for up to two years (Ryan and Jackson 1987, p. 218). Due to the length of time plastics can persist within birds, plastics ingested by adults elsewhere in the North Pacific can be carried to nesting colonies (Auman et al. 1997, p. 243). Short-tailed albatross at breeding colonies on Torishima commonly regurgitate large amounts of plastic debris (Hasegawa, H. pers. comm. 2002 in USFWS 2009b, p. 49). Adult short-tailed albatross can regurgitate plastics when feeding chicks (Blight and Burger 1997, p. 323; Laist 1987, p. 321; Pettit et al. 1981, p. 840), and young birds may be particularly vulnerable to potential effects of plastic ingestion prior to developing the ability to regurgitate (Fefer in litt. 1989 in USFWS 2009b, p. 49). Addition of plastic to the marine environment within the range of short-tailed albatross could affect any age of short-tailed albatross. Juveniles and sub-adults feeding off the coast of North America could ingest plastic debris while feeding and adults feeding near the Aleutian Islands could ingest plastic and carry to breeding colonies where they may regurgitate it when feeding chicks.

Abdominal adipose tissue of short-tailed shearwaters (*Puffinus tenuirostris*) had higher concentrations of chemicals found in plastic, which were not present in the natural prey (pelagic fish) of the birds, suggesting that the transfer of plastic-derived chemicals from ingested plastics to tissues occurs (Tanaka et al. 2013, p. 1). Evidence from observational studies has found that birds with plastic in their stomachs have greater concentrations of polychlorinated biphenyls (PCBs) in their tissue than those that not have plastics in their stomach (Yamashita et al. 2011-12).

10.4.6.2.1.1.3 Conclusion

The proposed action is likely to adversely affect short-tailed albatross through the introduction of plastic debris in the action area. Short-tailed albatross are likely to be present where debris will be introduced and accumulate, and the ingestion of plastics could occur. Once ingested, debris can injure short-tailed albatross. The possible effects to short-tailed albatross from plastic ingestion range from benign (if the individual quickly regurgitates the debris) to death (resulting from the debris physically injuring the individual). The likelihood that Navy-produced plastics will directly or indirectly injure short-tailed albatross is difficult to predict. The rates at which plastic ingestion directly or indirectly injures short-tailed albatross are unknown, and also impossible to predict without knowing the size and shape of the debris that birds swallow. For these reasons, the Service is not reasonably certain that short-tailed albatross will be directly or indirectly injured by the additional debris from the proposed action.

10.4.7 Effects of Electromagnetic Energy, Lasers, and Electromagnetic Radiation on the Marbled Murrelet

The Navy identified electromagnetic energy and low energy lasers as the only energy stressors potentially affecting bull trout, marbled murrelets and short-tailed albatross within the Offshore Area and Inland Waters. Bull trout would not be exposed to these stressors in the Offshore Area as the stressors occur outside 3 nm from shore where bull trout will not be found. Electromagnetic radiation is the only energy stressor located in the Olympic MOA.

10.4.7.1 Offshore Area and Inland Waters

Electromagnetic energy is used in mine neutralization systems using towed or unmanned mine warfare devices that mimic a vessel passing through the water (Navy 2015, p. 3.0-40). The electromagnetic devices put out both electrical current and magnetic fields. The Navy states that the electrical current and magnetic fields are both very small. Because the conductivity of saltwater is higher than the conductivity of a fish, and the electrical fields provided by the Navy's system are so small, the electricity goes around the fish instead of through it and therefore, the fish is not affected (Smith-Root 2015). The Service does not expect marbled murrelets and short-tailed albatross would be exposed to electromagnetic energy in both the Offshore Area or Inland Waters as the energy is released from a towed or unmanned device and marbled murrelets and short-tailed albatross would flush away from these devices, which avoids or minimizes any potential exposure.

The Navy identified the highest potential level of exposure from low energy lasers would be from an airborne laser beam directed at the ocean's surface. As the laser penetrates the water, 96 percent of a laser beam is absorbed, scattered, or otherwise lost (Ulrisch 2004, as cited by Navy 2015, p. 3.0-41). The Navy stated that an animal's eye would have to be exposed to the laser for at least 10 seconds or longer to sustain any injury. Since the low energy lasers originate from a moving source, the Service does not expect that a marbled murrelet or short-tailed albatross would be exposed to the laser for more than one second.

Based on the above analysis, and the limited exposure to electromagnetic energy and low energy lasers, the Service does not expect measureable effects to short-tailed albatross, marbled murrelet, and bull trout within the Offshore Area and Inland Waters. As such, the potential effects are considered insignificant.

10.4.7.2 Olympic MOAs

EW training in the Olympic MOAs utilizes aircraft and ground-based vehicles that contain the MEWTS. The effects of aircraft overflights are analyzed in the Aircraft Noise section above. Electromagnetic radiation (EMR) and ground-based noise and visual disturbance associated with the MEWTS on National Forest lands in the Olympic National Forest are analyzed below for their effects on marbled murrelets. The analysis of these effects to the spotted owl was previously addressed in the Concurrence section.

There are no published studies that document the effects of EMR on marbled murrelets. There are studies showing that EMR can be correlated with physiological and developmental changes (For example: Fernie and Bird 2000; Fernie and Reynolds 2005), and behavioral changes (e.g., Balmori 2005; Rejt et al. 2007) in birds. More generally, lower frequency (50 Hz to 1.1GHz) EMR has been correlated with altering the function of cellular calcium channels (Pall 2013; Rao et al. 2008), while high energy EMR between 100kHz and 300 GHz can cause tissue heating (burns) when exposure lasts over a period of minutes (Health Canada 2015). However, the range of potential effects of EMR exposure varies with energy level, range of wavelengths, and duration of exposure. For this analysis, we focused our review of the research to evaluate exposures to EMR in similar frequencies as those described in the proposed action (4 to 8 GHz).

For their EW training, the Navy proposes to use three MEWTS which are utility trucks modified with two vehicle-mounted mobile emitters. The mobile emitters with which MEWTS will be outfitted are summarized in Table 47. The MEWTS will operate from 15 sites within the Olympic MOAs. These sites consist of existing pull-outs or turnarounds which have already been cleared or have natural features (e.g., a cliff or ridgeline) that provide an unobstructed line of sight to the west. The MEWTS will not be parked at training sites overnight, but travel to sites each day from Naval Station Everett Annex Pacific Beach using existing roads. Once on sites, MEWTS will operate between 8 and 16 hours each day for 260 days each year (Navy 2014). Emitters are expected to be energized, emitting signals at 90-300 watts, about 45 minutes of every hour that the MEWTS are on site (Mosher, pers. comm. 2015; Navy 2014).

Table 47. Summary of mobile electromagnetic (EM) emitters in electronic warfare training.

Emitter type	Range of EM wave frequencies (GHz)	Shape of EM signal	Dimensions of EM Signal	Radiation Hazard Minimum Safe Separation Distance
Traveling Wave Tube Amplifier	4 - 8	Cone	8.1 degrees	30.8 m / 101.1 ft
Magnetron	6.7 – 7.4	Wedge	9 degrees horizontal 27 degrees vertical	8.9 m / 29.3 ft

(Mosher, pers. comm. 2015; Navy 2014, pp. 3.1-4 - 5)

10.4.7.2.1.1.1 Exposure

We evaluated the proposed training sites within the Olympic MOAs to determine their proximity to known occupied marbled murrelet nesting stands and potential nesting habitat for marbled murrelets. Of the 15 proposed emitter sites identified by the Navy, three sites are located within close proximity to potential marbled murrelet nesting habitat (sites 5, 8, and 15), and six sites (sites 3, 5, 9, 12, 13, and 14) are located a distance of one mile or less from known occupied marbled murrelet stands located on the Olympic National Forest or lands managed by the Washington Department of Natural Resources. We consider potential marbled murrelet nesting habitat to be forest that contains structural features (e.g., trees with platform branches) capable of providing nesting habitat for marbled murrelets, but is not known to be occupied by the species. There is a cumulative total of approximately 6 acres of potential marbled murrelet nesting habitat located within close proximity (defined as a 100-m radius) of three emitter sites on the Olympic National Forest (sites 5, 8, and 15), but occupancy status at these sites is unknown due to a lack of surveys.

There are several aspects of EW training that will limit the exposure of wildlife to EMR. The emitter antennas will be extended 14 ft above the MEWTS and the directional beams produced by the emitters will be aimed to allow unobstructed signal transmission (taking advantage of clear lines of sight to the west) so that there is no potential for wildlife on the ground or in the tree canopy to be exposed to the signal (Mosher, pers. comm. 2015). Therefore, only birds in flight over the forest canopy have the potential to intersect beams and become exposed to EMR from the training.

Marbled murrelets are likely to be intermittently exposed to EMR during flight. During the nesting season, marbled murrelets transit daily between foraging areas in marine waters and inland nesting sites, often flying well above the forest canopy at heights of greater than 200 m above ground level (Stumpf et al. 2011, p. 125). Marbled murrelets also visit inland sites during the winter months (O'Donnell et al. 1995, p. 117), so there is a potential for exposure of marbled murrelets in flight to EMR throughout most of the year. Marbled murrelet flight heights likely vary with topography, distance to the ocean, weather, and other factors, but generally marbled murrelets do not fly at or below the forest canopy level unless they are in close proximity to a nest site (Paton 1995, p. 115).

The six emitter sites located within a mile of known occupied marbled murrelet stands include multiple marbled murrelet presence detections in the general vicinity of these stands (i.e., marbled murrelets heard or seen flying over the forest canopy). Based on these observations, we are reasonably certain that marbled murrelets that are flying to inland nesting sites are likely to be exposed to EMR signals from EW training. Considering the flight behavior of marbled murrelets and the general proximity of proposed MEWTS sites to known occupied marbled murrelet nesting habitat, we expect low numbers of marbled murrelets are likely to be intermittently exposed to EMR. When marbled murrelets are exposed to EMR we expect exposure to be over a matter of seconds as the birds fly through directional EM fields.

10.4.7.2.1.1.2 Response

Biological responses to EMR depend on many factors including the density and duration of the exposure, the species, and conditions of individuals. EM waves can "cause different, and even contrary effects, depending on their frequency, intensity, modulation, pulses or time of exposure" (Balmori 2005, p. 110; Redlarski et al. 2015, p. 2).

Due to the range of energy waves that fall into the category of EMR (which includes ranges of microwaves and radar), and the variability of species and life histories, it is difficult to predict the effect that a broad spectrum of EMR will have on birds. There is research showing that exposure to EMR does have the potential to adversely affect birds, and that is summarized below. The challenge is determining which results and observations are useful to predict the effects of the Navy's proposed action. For our analysis of the effects of EW training on marbled murrelets, we surveyed available research for methods that closely resembled the specific frequencies included in the Navy's proposed action.

Cucurachi et al. (2013, pp. 210-211) found that most studies of EMR exposure in birds have been laboratory experiments largely focused on embryonic chicken and Japanese quail development. While laboratory studies found both significant and insignificant effects, the proposed EW training actions avoid exposure of nests to EMR. Field studies in which juvenile and adult birds were exposed are more likely to be applicable to the Navy's proposed action. While they discovered that most effects were adverse, Fernie and Reynolds (2005) found that birds can have positive, neutral, or negative responses in reproductive success to EM fields produced by electric transmission lines.

Another study found evidence that pigeons can sense EMR from a radio transmitter between 6 and 17.5 MHz, that birds unaccustomed to the presence of EMR will take longer to fly to their roosts, and that birds tend to fly at a lower altitude, but do not alter their direction when flying toward a source of EMR (Steiner and Bruderer 1999). However, research on the effects of EM fields associated with electric transmission lines has very limited applicability to the Navy's proposed action. The EM energy associated with electric transmission lines is typically characterized by persistent fields of EM waves with frequencies around 60 Hz (Fernie and Bird 2000, p. 462). In contrast, the Navy's EW emitters produce signals between 4 and 8 GHz (4 to 8 billion Hz), a much higher frequency than EMR from transmission lines or the radio signals studied by Steiner and Bruderer (1999, p. 167).

Other field research studied responses to EMR with frequencies closer to the range the Navy will use for EW training. White storks nesting within 200 m of cellular antennas emitting EMR at 900 MHz and 1.8 GHz had significantly lower productivity than storks nesting further than 300 m from the antenna, suggesting that chronic exposures to EMR in these frequencies may affect stork nesting success. The productivity measured beyond 300 m was close to the total productivity measured in the area before the cellular antennas were installed (Balmori 2005, p. 114). The results of this study suggest that the EMR from cellular antennas may cause deleterious effects at least out to 200 m from the antennas.

Closer to the frequencies proposed for EW training, Rejt et al. (2007, entire) examined the effects of military radar emitting signals between 1.2 and 3 GHz on nesting blue and great tits over 45 days. The only significant correlation the researchers found was that competitively dominant great tits seemed to show a significant preference for nesting in areas exposed to lower radiation levels, leaving the higher radiation sites to be disproportionately inhabited by blue tits. Neither species showed any significant difference related to EM radiation in terms of their breeding success (Rejt et al. 2007, pp. 237-238). Although these studies examined EMR that is similar to the energy parameters proposed by the Navy, they studied conditions where birds were continuously exposed, while exposure to the Navy's proposed training will be intermittent. Assuming that all three MEWTS are deployed every day of the 260 (annual) fly days and that the 15 sites are used equally, each site will be used 1 of every five days. Within each of those days, the emitters will be energized about 45 minutes of every hour, for 8 to 16 hours.

Of the available information, we found the following research to be the most applicable to understanding the Navy's proposed action because the EMRs in the study used a similar frequency and exposure duration. Bruderer et al. (1999, pp. 1016-1017) aimed the ex-military tracking radar emitter "Superfledermaus" at birds in flight to determine if the birds altered their behavior when the emitter was energized and when it was not. "Superfledermaus" emits EMR directionally at approximately 9 GHz, making the EM energy similar to that proposed by the Navy. It can also be steered to track birds through their flight paths. The researchers found that the radar provoked no measurable changes in the behavior of the birds in terms of flight direction or vertical speed (Bruderer et al. 1999, pp. 1018-1019).

10.4.7.2.1.1.3 Conclusion

Since the emissions are directional and pointed skyward, marbled murrelets will only be exposed when their flight paths intersect with a beam of EMR. The EMR emitters will be energized intermittently, and produce EMR with frequencies between 4 and 8 GHz. The best-available commercial and scientific information indicates that the effects of brief, intermittent exposures to EMR frequencies in the range of 4 to 8 GHz are likely to be insignificant to birds in flight. Physical effects, such as tissue heating or burns, are considered to be discountable, because an exposure lasting a few seconds (as is the case with a bird in flight) would be too brief to manifest these effects. Based on this analysis, the Service agrees with the Navy's determination that use of the mobile emitters for EW training will have insignificant effects on marbled murrelets.

10.4.8 Ground-Based Noise and Visual Disturbance

10.4.8.1 Evaluation Criteria

The use of motorized equipment in close proximity to marbled murrelet habitat can disrupt normal marbled murrelet nesting behaviors. The Service has previously completed analyses for noise and visual disturbance to marbled murrelets (USFWS 2013, pp. 101-110). In these analyses, we concluded that normal marbled murrelet nesting behaviors may be disrupted by above-ambient sounds or visual disturbances that occur in close proximity to an active nest or when the activity occurs within the line-of-sight of a nesting marbled murrelet. For ground-based activities, we use a threshold distance of 110 yards (100 m) to evaluate if marbled murrelet habitat will be exposed to potentially disruptive activities.

10.4.8.1.1.1.1 Exposure

For their EW training, the Navy proposes to use three MEWTS, which are utility trucks modified with two vehicle-mounted mobile emitters. The use of this ground-based equipment in the Olympic MOAs will potentially expose marbled murrelets to noise and visual disturbances. However, the risk of exposure to these stressors may be discountable if suitable habitat is not located within the immediate vicinity of the training sites. We evaluated the proposed training sites within the Olympic MOAs for proximity to known occupied marbled murrelet stands and potential nesting habitat for marbled murrelets. Of the 15 proposed emitter sites identified by the Navy, three sites are located within close proximity to potential marbled murrelet nesting habitat (sites 5, 8, and 15), and six sites (sites 3, 5, 9, 12, 13, and 14) are located with a distance of one mile or less from known occupied marbled murrelet stands located on the Olympic National Forest or state lands managed by the Washington Department of Natural Resources. Potential marbled murrelet nesting habitat is forest that contains structural features (e.g., trees with platform branches) capable of providing nesting habitat for marbled murrelets, but is not known to be occupied by the species. There is a cumulative total of approximately 6 acres of potential marbled murrelet nesting habitat located within close proximity (defined as a 100-m radius) of three emitter sites on the Olympic National Forest (sites 5, 8, and 15), but occupancy status at these sites is unknown because of the lack of surveys.

10.4.8.1.1.1.2 Response

The Service considers the use of vehicles on open forest roads to be a low-intensity activity that poses a low risk of disturbance to marbled murrelets (USFWS 2013, pp. 103-104). Upon arrival at a training site, the mobile emitter crew will determine the need for establishing a safety zone. Sites requiring a safety zone will be posted with a radiation hazard sign and the crew will mark the perimeter of the hazard zone with removable warning tape. While conducting training operations, the crew will use a small generator to power the equipment. The generators selected to power the mobile emitters have specifications that meet National Park Service sound level requirements (60 dBA at 50 ft) for National Park use. The generators will be encased in steel and have mufflers on the exhaust, both of which offer an increased level of sound attenuation to create a corresponding drop in noise levels to approximately 42 dBA at 50 ft (Navy 2014, p. 3.2-24), indicating low-level generator noise will be associated with the mobile emitter sites. This level of generator noise is not expected to be disruptive to marbled murrelets. Low-level mechanical sounds that are detectable to marbled murrelets may result in minor behavioral responses, such as scanning or head-turning behaviors, or increased vigilance for short periods. Such minor behavioral responses are considered to have insignificant effects on nesting marbled murrelets.

The primary risk associated with the mobile emitters is the visual disturbance associated with the presence of people on the ground outside of the parked vehicle. Once the vehicle is parked, crew members will briefly exit vehicles to set up equipment and establish safety zones, etc. Marbled murrelets have been observed flushing in response to people walking on a road near a nest site (Hamer and Nelson 1998, p. 9). The intensity, frequency, duration, and magnitude of a disturbance event are all important factors the Service considers when evaluating the likelihood and magnitude of effects. In general, we consider low intensity, short-duration actions (e.g., less than 1 day at a site) to be of much lower risk for a measurable effects to nesting marbled murrelets when compared to prolonged actions that require several days or weeks at a site to complete (e.g., major construction). Effects to marbled murrelets are limited to short-term exposures of generally one day or less at any particular emitter site, and the presence of people outside of vehicles will be limited to a few minutes each day during set-up and take-down of the safety-zone perimeter. Considering the limited duration of this activity in any given location, and the limited amount of potential nesting habitat located in close proximity to emitter sites, the likelihood of significantly disrupting marbled murrelet nesting behaviors is considered to be discountable. Other minor behavioral responses such as alert behaviors or increased vigilance in response to distant sounds or activity may occur, but these are also considered to be insignificant behavioral responses.

10.4.8.1.1.1.3 Conclusion

The effect of motor-vehicle use on open, public-access roads within the Olympic MOAs is considered to be insignificant to marbled murrelets.

10.4.9 Physical Disturbances and Strike

The physical disturbances and strike stressors include vessel strikes, in-water devices, seafloor devices, divers and swimmers, military expended materials (and their fragments), physical disturbances from helicopters, and aircraft strikes.

10.4.9.1 Vessel Strikes

10.4.9.1.1 Effects of Vessel Strike on the Marbled Murrelet and the Short-tailed Albatross

Navy vessels include ships, small craft, and submarines. Navy ships generally operate at speeds in the range of 10 to 15 knots, submarines operate at 8 to 13 knots, and small craft have variable speeds based on the activity (Navy 2015b, p. 3.0-42). Maximum speeds are slightly faster.

10.4.9.1.1.1.1 Exposure

We are not aware of any records of ships striking a short-tailed albatross or a marbled murrelet (or any other alcid species), or of either species colliding with a ship and being injured. There are numerous reports of seabirds landing on the decks of vessels during bad weather. These are most likely weary individuals actively searching for large floating platforms to land on.

10.4.9.1.1.1.2 Response

Marbled murrelets are fast fliers (up to 60 mph), capable of maneuvering through trees and landing on branches in dim lighting conditions. At sea, they frequently dive and sometimes take to the air to avoid approaching vessels. Short-tailed albatross spend their lives on the ocean and adapt to the harsh conditions and can be found flying around vessels. Based on our knowledge of these species and the available data, it is our best professional judgment that marbled murrelets and short-tailed albatross are capable of avoiding vessels. Due to the low densities of both species offshore and their ability for flight, the Service considers the likelihood of vessel strikes to be discountable for short-tailed albatross and marbled murrelets.

10.4.9.1.1.1.3 Conclusion

The likelihood of either a marbled murrelet or a short-tailed albatross striking a Navy vessels is considered extremely unlikely and is therefore discountable.

10.4.10 <u>In-Water Devices</u>

10.4.10.1 Effects to the Bull Trout, the Marbled Murrelet, and the Short-tailed Albatross From In-water Devices

In-water devices include unmanned vehicles, such as remotely operated vehicles, unmanned surface vehicles, unmanned undersea vehicles, and towed devices. Similar to Vessel Strikes described above, the typical speed of in-water devices is similar to Navy vessels: towed devices at10 to 40 knots, and unmanned underwater vehicles and unmanned surface vehicles at one to 15 knots.

10.4.10.1.1.1.1 Exposure

Unmanned surface vehicles have the same cumulative probability of striking a marbled murrelet or short-tailed albatross, as described above in Vessel Strikes. The Service considers the likelihood of exposure to in-water devices to be extremely unlikely.

10.4.10.1.1.1.2 Response

As exposure is considered extremely unlikely, we do not anticipate any responses by bull trout, marbled murrelets, or short-tailed albatross.

10.4.10.1.1.1.3 Conclusion

Effects from exposure to in-water devices are considered extremely unlikely and are therefore discountable.

10.4.10.2 Seafloor Devices

Seafloor items are deployed onto the seafloor. These items include moored mine shapes, anchors, bottom placed instruments, and robotic vehicles referred to as “crawlers.” Crawlers are slow-moving devices that crawl along the seafloor. Some seafloor devices like moored mines are deployed by fixed-wing aircraft. The mine enters the water and impacts the seafloor, where it becomes partially buried. Upon impact, the mine casing separates and the semi-buoyant mine floats up through the water column until it reaches the end of the mooring line. Other seafloor devices are positioned manually and are allowed to sink to the bottom.

10.4.10.2.1.1.1 Exposure

Seafloor devices may result in localized, temporary increases in turbidity and suspended solids and a slight reduction in prey abundance due to mortality of macroinvertebrates. However, neither the bull trout, the marbled murrelet, or the short-tailed albatross spend the majority of their life history on the seafloor, which limits direct exposure to these stressors. The potential area of habitat affected by seafloor devices is small in comparison to the habitat available. Most seafloor devices occur in deeper water where bottom substrates are soft and do not provide habitat for bull trout, marbled murrelet, or short-tailed albatross prey species. Some activities, such as precision anchoring, involve repeated disturbance to the same area of seafloor. These areas have been highly impacted from past disturbance and are not expected to impact prey species habitat or impact habitat sufficiently to result in measurable effects to prey.

10.4.10.2.1.1.2 Response

Seafloor devices will not degrade habitat functions that are important to the bull trout, the marbled murrelets or the short-tailed albatross, including diminishing forage fish or other prey resources. These effects will be intermittent and limited in physical extent and duration.

10.4.10.2.1.1.3 Conclusion

Based on the relatively localized, temporary impacts associated with these devices, as well as the limited use of seafloor habitat by the bull trout, marbled murrelet and short-tailed albatross, we do not anticipate any measureable effects. As such, the effects of seafloor devices as considered insignificant to bull trout, marbled murrelets, and short-tailed albatross.

10.4.11 Effects to the Bull Trout and the Marbled Murrelet from In-water Disturbance in Inland Waters

10.4.11.1 Divers and Swimmers (In-water Disturbance)

Navy training and testing activities that involve divers may disturb bull trout and marbled murrelets when they occur in the Inland Waters Subunit. In-water disturbance may result in alarm responses and temporary disruption of normal bull trout and marbled murrelet behaviors such as abandonment or avoidance of habitat and decreased foraging effectiveness. These effects will be intermittent and limited in physical extent and duration.

10.4.11.1.1.1.1 Conclusion

We expect that bull trout and marbled murrelets will quickly resume normal activities following any disturbance associated with the Navy's use of divers and swimmers for training activities. Therefore, we consider the effects of in-water disturbance from divers and swimmers to be insignificant to bull trout and marbled murrelets.

10.4.11.2 Strike by Military Expended Material and Their Fragments

Military expended materials include a variety of devices, equipment, and munitions. We evaluated the potential that they, or their fragments, may strike and injure or kill a bull trout, marbled murrelet, or short-tailed albatross. Some military expended materials were also analyzed under other stressors such as ingestion and entanglement. This section only addresses the potential for listed species to be struck by military expended material.

Military munitions, devices, equipment, and materials that are used and expended by the Navy include sonobuoys, expendable targets, drones, flares, chaffs, projectile casings, and weights. The cumulative probability of flares and sonobuoys striking short-tailed albatross and marbled murrelets is shown in Appendix A. The cumulative probability of a flare or sonobuoy striking a marbled murrelet or a short-tailed albatross was less than ten percent for each species.

Most military expended material in Inland Waters will occur in areas where bull trout occurrence is low. Sonobuoys and expendable targets are either floating on the surface or moving, so the likelihood of their striking a bull trout is extremely low. Other material, such as drones, flares, and chaff, is expended in the air and some (like flare casings) would slowly sink through the water column, with a very low probability of striking a bull trout. Projectile casings and weights may fall through the water column faster but are still unlikely to strike a bull trout.

10.4.11.2.1.1.1 Conclusion

Based on the low probabilities of exposure shown in Appendix A, the Service considers the potential of a sonobuoy striking either a short-tailed albatross or a marbled murrelet to be extremely unlikely, and therefore discountable. The Service also expects that short-tailed albatross or marbled murrelets would not be struck by other materials such as expendable targets. The Service considers the effects of military expended materials striking a short-tailed albatross or marbled murrelet, except for those related to non-explosive practice munitions (addressed above), to be discountable. The likelihood of these materials striking a bull trout is also considered discountable.

10.4.12 <u>Effects of Helicopter Use to Marbled Murrelets in Inland Waters</u>

10.4.12.1.1.1.1 Exposure

Stressors associated with helicopter use include rotor strikes, elevated SPLs, water plumes, flying debris, and rotorwash (downdraft). Exposure to these stressors can result in injury, mortality, displacement, missed feedings, disturbance, and reduced fitness.

Helicopters (rotary-wing aircraft) will be used for four activities in Inland Waters. Helicopters produce lower-frequency sound and vibration at a higher intensity than fixed-wing aircraft (Richardson et al. 1995). Helicopter sounds contain dominant tones from the rotors that are generally below 500 Hz (the lower hearing range of marbled murrelets, at approximately 480 Hz). Helicopters often radiate more sound forward than backward (Navy 2015a, p. 3.0-37). Helicopter use is typically limited to approximately four-hour durations due to fuel capacity; therefore, the total hours described for each activity are expected to be intermittent based on the limited capacity of helicopter use and the inherent travel time associated with their departures/arrivals from where they are stored.

Maritime Homeland Defense/Security Mine Countermeasures Integrated Exercises are conducted at various ports and harbors to support homeland defense/security. Helicopters are used to tow mine sweeping/detecting devices at any time of year, for up to 24 hours over a several day period. Based on the information provided by the Navy, we estimate that marbled murrelets may be exposed to stressors related to helicopter use in the Inland Waters for 1 event every other year, for a total of 24 hours of helicopter flight time per event, for 20 years.

Naval Special Warfare Personnel Insertion/Extraction (Non Submersible) training exercises are conducted at Crescent Harbor and Navy 7 (R6701) to train personnel to approach or depart using various means. Training personnel are inserted into the water via low, slow-flying helicopters from which personnel jump. These activities occur year round, for 2 to 8 hours, at any time of day. Based on the information provided by the Navy, we estimate that marbled murrelets may be exposed to stressors related to helicopter use in Crescent Harbor and Navy 7 (R6701) for 5 events per year, for 8 hours per event, for 20 years.

Search and Rescue operations are conducted in Crescent Harbor and at Navy 7 training areas. Helicopters fly below 3,000 ft elevation to train in rescuing personnel. These activities occur year round, for 2 to 3 hours, at any time of day. Based on the information provided by the Navy, we estimate that marbled murrelets may be exposed to stressors related to helicopter use in Crescent Harbor for a total of 5,700 hours over a 20-year period (95 events per year, for 3 hours per event). We estimate that marbled murrelets may be exposed to stressors related to helicopter use in Navy 7 (R6701) for 5 events per year, for 3 hours per event, for 20 years.

Mine Warfare/Mine Neutralization – Explosive Ordnance Disposal operations are conducted in Crescent Harbor and Hood Canal EOD Training Range site. Helicopters are used to support mine detection and classification and for countermeasure and neutralization testing. During airborne neutralization testing, a previously located mine is destroyed or rendered nonfunctional using a helicopter-based system. Based on information provided by the Navy we estimate that marbled murrelets may be exposed to stressors related to helicopter use in Crescent Harbor and Hood Canal EOD Training Range site for 12 events per year, for 4 hours per event, for 20 years.

For EOD detonations, training events in Crescent Harbor will occasionally involve the use of helicopters. The majority only involve the use of boats. When helicopters are used, they take off from Ault Field on Whidbey Island, flying at approximately 500 ft elevation (152 m). They approach Crescent Harbor from the north and fly around the harbor at approximately 70 to 80 knots searching for a float mark that identifies a simulated mine. The helicopter slows to less than 1 knot and hovers at about 10 to 20 ft (3.0 to 6.1 m) above the water while releasing swimmers. The helicopter then flies to the survival area (NW shoreline of the Seaplane Base) where it waits for the charge to be set. After setting the charges, the swimmers are then removed by helicopter.

For all other exercises involving helicopter use, we expect that helicopters will be used similarly as described above for EOD detonations in Crescent Harbor. Although the maximum duration of use is approximately four hours, we expect the maximum duration that a helicopter would remain hovering in a particular area would be less than two hours. We expect helicopters would likely deploy from the nearest Navy air field, travel to the activity area, perform the exercise and return to the air field, or temporary waiting location, and would only remain within a particular area for only as much time as it would take to complete the exercise.

Based on best available information regarding marbled murrelet occurrence in Inland Waters (Falxa et al. 2015; Pearson in litt. 2015), murrelets are likely to be present in areas of helicopter use.

10.4.12.1.1.1.2 Response

Marbled murrelets are expected to be exposed to stressors from helicopter use in Inland Waters (Puget Sound and Strait of Juan de Fuca). These stressors include rotor strikes, elevated SPLs, water plume, flying debris, and helicopter rotor wash (downdraft). Exposure to these stressors can result in injury, mortality, displacement, missed feedings, disturbance, and reduced fitness.

We expect that murrelets will perceive an approaching helicopter as an aerial threat and their primary response will be to dive. The length and distance of the murrelet dive may not be sufficient to completely evade helicopter downwash as the craft hovers. Depending on how long the helicopter hovers, the murrelet may dive and re-surface several times to evade the downwash. The area of effect where murrelets may be exposed is based on the assumption that rotor downwash extends three times the diameter of the rotor length (Federal Aviation Administration 2014, p. 7-3-6), which yields an area of effect of approximately 0.02 km^2 each time. We assume that a total of 110 events per year will include helicopters. Over 20 years, we expect that a cumulative total of 26.8 km^2 (i.e., the sum of all individual areas of effect) of marbled murrelet habitat within the Inland Waters will be exposed to helicopter downwash. We expect that marbled murrelets exposed to helicopter downwash may not always be able to evade it and may experience a significant disruption of their normal behaviors.

We expect that when murrelets are exposed to helicopters, their foraging bouts and resting attempts will be interrupted. They are likely to abandon use of these areas until the helicopters are no longer present. We anticipate murrelet energy expenditure will be increased above normal when they flush, relocate out of the area, increase their diving effort to replace lost foraging opportunities, and escape from perceived predators (i.e., helicopters). Given that murrelets have high energetic demands and must consume a large percentage of their body weight every day, we expect that these responses in the context of the duration, frequency, and affected areas represent a significant disruption of normal behaviors that creates a likelihood of injury.

We do not expect marbled murrelets will collide with, or be struck by, helicopters. Collision is extremely unlikely because marbled murrelets are expected to flush or dive, to avoid being struck. Additionally, pre-detonation surveys will reduce exposure in Crescent Harbor and Hood Canal EOD Training Range sites.

10.4.12.1.1.1.3 Conclusion

In Inland Water areas, such as Navy 7, and ports and harbors where Maritime Homeland Defense/Security Mine Countermeasures Integrated exercises occur, marbled murrelets will be exposed to downwash from helicopters. The area of exposure is approximately 0.02 km^2 for each instance. Over 20 years, we expect that a cumulative total of 26.8 km^2 (i.e., the sum of all individual areas of effect) of marbled murrelet habitat within the Inland Waters will be exposed to helicopter downwash. Given the location and number of events using helicopters and the area of effect explained above, and the densities of marbled murrelets in these locations, we are reasonably certain that 6.6 groups of two birds (13.2 birds) will be exposed over 20 years. Exposed marbled murrelets are expected to respond by diving repeatedly and or by vacating the area. Based on the high energetic demands of marbled murrelets, coupled with the duration of this exposure, we expect that this disruption of normal behaviors will result in reduced foraging efficiency to the extent that there are measureable effects to individuals that create a likelihood of injury.

10.4.13 Effects of Helicopter Use to Marbled Murrelets and Short-tailed Albatross in the Offshore Area

10.4.13.1.1.1.1 Exposure

To evaluate the potential exposure of short-tailed albatross and marbled murrelets to rotor wash from hovering helicopters and unmanned rotary-winged aircraft in the Offshore Area, we considered the area of effect for hovering helicopters to be a circle 161 feet in radius, three times the rotor diameter of the MH-60 helicopter. For unmanned rotary-winged aircraft, we assumed the area of effect to be a circle with a radius of 82.5 ft (25.1 m), three times the rotor diameter of a Fire Scout MQ-8B unmanned rotary-wing aircraft. The cumulative probability for short-tailed albatross being exposed to the rotor wash of hovering aircraft was less than ten percent. Therefore, we considered short-tailed albatross exposure to the physical disturbances associated with helicopters to be discountable. For marbled murrelets, in the “reasonable worst-case” scenario, there was a 12 percent chance of exposure to hovering helicopters and unmanned rotary-winged aircraft, so marbled murrelet exposure to this stressor is not discountable. However, in the “reasonably certain” scenario, the probability of exposure is less than ten percent. Therefore, we are not reasonably certain that such exposure will occur.

10.4.13.1.1.1.2 Conclusion

There is a discountable chance of exposure to short-tailed albatross from helicopter use in the Offshore Area. We expect a 12 percent chance of marbled murrelet exposure in the Offshore Area. However, our analysis of a “reasonably certain” scenario indicated that exposure probability is less than ten percent, which is considered discountable.

10.4.14 Aircraft Strikes

10.4.14.1 Effects of Aircraft Use to the Marbled Murrelet over the Olympic MOAs

The Navy proposes aircraft flights over the Olympic MOAs regardless of whether the Forest Service issues a special-use permit allowing the ground-based MEWTS vehicle-mounted emitters to operate on National Forest lands. The proposed action includes 1,558 fixed-wing aircraft flights in the Olympic MOAs each year (Navy 2015c, Appendix J, p. 14).

10.4.14.1.1.1.1 Exposure

Aircraft participating in training missions in the Olympic MOAs will operate higher than 6,000 ft above mean sea level and will remain at least 1,200 ft above ground level when flying over higher elevation lands (Navy 2015c, Appendix J, p. 4). The proposed aircraft flights will fly at the lowest altitudes of 6,000 to 8,000 ft above mean sea level during only five percent of the total proposed annual flight time over the Olympic Peninsula (Navy 2015c, Appendix J, p. 14). Marbled murrelet nesting habitat on the Olympic Peninsula extends up to 4,000 ft above mean sea level (Raphael et al. 2011), so aircraft will never be less than 2,000 ft above murrelet habitat.

10.4.14.1.1.1.2 Response

In order for marbled murrelets to be struck by aircraft, the birds would need to fly at the same altitude as the aircraft. Murrelet flight heights have been measured using radar surveys at several sites in the Pacific Northwest. Mean murrelet flight altitudes ranged from 93 m (300 ft) (Sanzenbacher et al. 2014, p. 169) to 308 m (1,010 ft) (Hamer Environmental 2009, p. 37) above ground level. At typical flight altitudes, marbled murrelets would not fly high enough to be struck by the lowest-flying aircraft. The highest recorded flight altitude of a marbled murrelet we found in our review is 819 m (~2,700 ft) above ground level (Hamer Environmental 2009, p. 37). It is therefore possible that a murrelet could be struck by aircraft if the murrelets are flying near the maximum recorded flight altitude over land areas that are at least 3,300 ft in elevation (i.e., an aircraft flying no lower than 6,000 ft above mean sea level would be 2,700 ft above ground level).

While it is in the realm of possibility that a murrelet could be struck by an aircraft, there are a number of factors that indicate this is not a likely scenario. As described in the Effects of Aircraft Noise, we expect less than one percent of training flights over the MOAs would occur at lower elevations that approach within a distance of 3,000 ft above ground level over murrelet nesting habitat. Additionally, murrelets occur at low densities and are widely dispersed within the Olympic MOAs, so the probability of an aircraft striking a murrelet is extremely low. Most (74 percent) aircraft bird strikes occur in the vicinity of airports where aircraft traffic volume is high, and the aircraft are flying at lower elevations (less than 500 ft above ground level) where the likelihood of encountering birds is much higher (Dolbeer 2006, p. 1346). Therefore, it is extremely unlikely that marbled murrelets will be struck by aircraft.

10.4.14.1.1.1.3 Conclusion

All aircraft training operations will occur at altitudes that exceed 6,000 ft above mean sea level, indicating the closest approach of aircraft to potential murrelet nesting habitat will be 2,000 ft above ground level. Marbled murrelets typically fly at elevations of less than 1,000 ft above ground level, and occur at low densities throughout the Olympic MOAs. Given that most training flights will occur at altitudes that exceed 10,000 ft above mean sea level, we consider the risk of aircraft strikes to be discountable.

10.4.14.2 Effects of Aircraft Use to the Marbled Murrelet and Short-tailed Albatross in the Offshore Area

Various training and testing activities will involve fixed-wing, rotary-wing, and unmanned aerial vehicles in the offshore area.

10.4.14.2.1.1.1 Exposure

Short-tailed albatross and marbled murrelets will be present in the offshore area during training and testing activities, although they will be in very low densities and spending the majority of their time on the surface of the water. When short-tailed albatross and marbled murrelets do fly over the ocean, they usually fly low, within a few meters of the water surface.

10.4.14.2.1.1.2 Response

At times aircraft will fly at low altitudes, although it will be extremely rare that aircraft will be close enough to the water to strike a short-tailed albatross or marbled murrelet. We expect that the threat of aircraft strikes to short-tailed albatross and marbled murrelet is discountable due to the wide distribution of short-tailed albatross and marbled murrelets in the offshore area and the behaviors that will separate the birds from the altitudes used by the great majority of the aircraft flights.

10.4.14.2.1.1.3 Conclusion

Marbled murrelet and short-tailed albatross exposure to potential aircraft strikes in the Offshore Area is expected to be extremely unlikely and is therefore discountable.

10.4.15 Effects of Entanglement on the Bull Trout, the Marbled Murrelet, and the Short-tailed Albatross

The Service analyzed the potential risk of marbled murrelets, short-tailed albatross, and bull trout entanglement in military expended material such as decelerators/parachutes, guidance wires, or fiber optic cables.

10.4.15.1.1.1.1 Exposure

For short-tailed albatross and marbled murrelet, we determined that the cumulative probability for each species becoming entangled by military expended materials in the Offshore Area was less than 10 percent (Appendix A). Our analysis of exposure risk in the Inland Waters reflects our understanding of bull trout and marbled murrelet distribution and estimated occurrence of expended materials.

Fiber optic cables and guidance wires are used for torpedo testing and Unmanned Underwater Vessel activities which occur in the Offshore Area and DBRC and Keyport Range Site in the Inland Waters. Expendable parachutes are used for the deployment of sonobuoys and are only used in the Offshore Area. Most are used greater than 12 nm from shore. Fiber optic cables, guidance wires, and parachutes are all used on devices that are moving (torpedoes and Unmanned Underwater Vessels) and this reduces the risk of exposure to bull trout, marbled murrelets, and short-tailed albatross. It is likely that these moving objects would be avoided.

The properties of fiber optic cables and guidance wires make them less susceptible to entanglement. Guidance wires and fiber optic cables are single, straight strands of material that do not easily form loops or a web-like structure, such as a gill net or fishing net. Once deployed and used, the guidance wires and fiber optic cable sink and do not remain or float in the water column for an extended period of time. Decelerators and parachutes have weights and metal clips attached to them that facilitate their descent to the seafloor and minimize the time when entanglement could occur.

10.4.15.1.1.1.2 Response

Short-tailed albatross only dive to shallow depths when foraging. Because expendable parachutes are used during the deployment of sonobuoys, and guidance wires and fiber optic cables are used during torpedo testing and Unmanned Underwater Vessel activities, it is extremely unlikely that marbled murrelets and short-tailed albatross would become entangled by these expended materials. The parachutes, guidance wires, and fiber optic cables would rapidly sink upon use, decreasing exposure risk to marbled murrelets and short-tailed albatross.

In the Inland Waters, the use of fiber optic cables and guidance wires are used at DBRC and Keyport Range Sites, which are located in Hood Canal and south Puget Sound where bull trout occurrence is rare or extremely unlikely. The use of fiber optic cables and guidance wires are also used in deep water. Bull trout have been found to migrate over deep water, but are more dependent on shallow water for migration and foraging.

10.4.15.1.1.1.3 Conclusion

Based on a low cumulative probability of entanglement and the properties of the military expended materials, the Service expects the likelihood of entanglement with decelerators/parachutes, guidance wires, and fiber optic cables is discountable for bull trout, short-tailed albatross, and marbled murrelets.

10.4.16 Effects of Air Pollutants on the Bull Trout, Marbled Murrelet, and Short-tailed Albatross

Air pollutants are emitted during the Navy's use of aircraft, vessels, ordnances, powered targets, and a variety of other items such as chaff, flares and smoke targets. Criteria pollutants are the six major air pollutants of concern: carbon monoxide, sulfur dioxide, nitrogen dioxide, ozone, suspended particulate matter, and lead. The U.S. Environmental Protection Agency regulates 187 substances as hazardous air pollutants known to cause or suspected of causing cancer or other serious health effects. Criteria and hazardous air pollutants are generated by the combustion of fuel by surface vessels and aircraft and by combustion of explosives and propellants in various types of munitions. Pollutant levels are based on location, altitude, number of aircraft, vessels, explosives, etc. used, and length of activity.

10.4.16.1.1.1.1 Exposure

Emission of pollutants occurs throughout the action area. Air pollutants emitted above 3,000 ft elevation are above the atmospheric mixing height and do not affect ground-level air quality (USEPA 1992 as cited by Navy 2015, p. 3.2-7). Many of the Navy aircraft, munitions, and powered targets occur over 3,000 ft. Ninety percent of emissions are released more than 12 nm from shore (Navy 2014, p. 3.2-28). We expect that atmospheric dispersion will quickly reduce potential impacts of the Navy emissions of air pollutants. Emissions of increased air pollutants will be intermittent and limited in physical extent and duration.

Greenhouse gasses are another class of air pollutants generated by the proposed action and linked to climate change. While climate change is a significant threat to listed species, we do not anticipate measurable effects from contributions of the proposed action in the context of existing and predicted global climate conditions.

10.4.16.1.1.1.2 Conclusion

The release of these criteria and hazardous air pollutants is not expected to result in measureable effects to bull trout, marbled murrelets, and short-tailed albatross. As such, we consider the effects of increased air pollutants on these listed species to be insignificant.

10.4.17 Effects of Sediment and Water Quality on the Bull Trout, the Marbled Murrelet, the Short-tailed Albatross

The sediments and water quality within the action area are affected by explosives and explosion byproducts, metals, chemicals other than explosives (solid fuel, liquid fuel, PCBs, seafloor devices (crawlers and items placed on the seafloor) and other materials (marine markers, chaff, flares, target materials [glass, carbon fibers, plastics]). Impacts to sediment and water quality may occur from the following: 1) releasing materials into the water that subsequently disperse, react with seawater, or dissolve over time; 2) depositing materials into the water column or directly on the ocean bottom that subsequently interact with sediments, or the accumulation of materials over time; 3) depositing materials or substances on the ocean bottom that subsequently interact with the water column; and 4) depositing materials on the ocean bottom that subsequently disturb those sediments or that suspend them in the water column (Navy 2015b, pp. 3.1-28, 29).

10.4.17.1.1.1.1 Exposure

Military expended material, as it settles on the marine substrate, results in chemical, physical, and biological changes in sediment and water quality. The debris breaks down slowly leaching chemicals into the water and sediments. These impacts are localized, are contained within a small area surrounding the debris, but may last for a long time. Within the water column, released chemicals and metals are expected to dilute rapidly. Biologically, the increased contaminants surrounding the debris on the seafloor will impact macroinvertebrates, which are prey for forage fish and bull trout. Military expended materials will enter waters throughout the action area.

In-water devices, especially unmanned underwater vehicles, also may come in contact with the substrate. In-water devices, when contacting the substrate, will result in localized, temporary increases in turbidity and suspended solids and may result in a slight reduction in prey abundance due to mortality of macroinvertebrates.

10.4.17.1.1.1.2 Response

We do not expect that in-water devices will measurably degrade habitat functions that are important to bull trout or marbled murrelets or their prey resources.

10.4.17.1.1.1.3 Conclusion

The effects of increased sediment contamination and decreased water quality are expected to be insignificant to bull trout, marbled murrelets, and short-tailed albatross.

10.5 Summary of Effects to Bull Trout, Marbled Murrelets, and Short-tailed Albatross

The following table (Table 48) provides a summary of the stressors analyzed above and the estimated number of bull trout, marbled murrelets, and short-tailed albatross injured or killed per year, and the total area where adverse effects will occur for the different activities conducted by the Navy.

Table 48. Summary of all groups/individual bull trout, marbled murrelet, or short-tailed albatross where adverse effects are reasonably certain to occur.

Sonar						
Inland	**Bull Trout**	**km^2**	**Marbled Murrelet Groups**	**m^2**	**Location**	**Activity / Exercise**
MF8	0	n/a	1.2	435,840	Bangor and Keyport	Acoustic Component Test - Pierside Integrated Swimmer Defense (boat or pierside) & Shipboard Protection Systems and Swimmer Defense Testing - Pierside Integrated Swimmer Defense
Helicopter rotor wash						
Inland	**Bull Trout**	**km^2**	**Marbled Murrelet Groups**	**km^2 / nm^2**	**Location**	**Activity / Exercise**
All	0	n/a	6.6	26.8/7.8	Hood Canal and Crescent Harbor Ranges, Navy 7, and various locations in Puget Sound	Mine Neutralization – EOD, Search and Rescue, Personnel Insertion and Extraction – Non-Submersible, and Maritime Homeland Defense/ Security Mine Countermeasures Integrated Exercises
Explosions (Underwater)						
Inland	**Bull Trout**	**km^2**	**Marbled Murrelet Groups**	**km^2 / nm^2**	**Location**	**Activity / Exercise**
< E1	60	3			Crescent Harbor Range	Mine Neutralization – EOD
E3	60	13			Crescent Harbor Range	Mine Neutralization – EOD
E3			3.2	25.5/7.4	Bangor-Hood Canal and Crescent Harbor Ranges	Mine Neutralization – EOD
Total	**120**	**16**	**3.2**	**25.5/7.4**		

Table 48. Summary of all groups/individual bull trout, marbled murrelet, or short-tailed albatross where adverse effects are reasonably certain to occur.

Offshore	**Bull Trout**	**km^2 / nm^2**	**Marbled Murrelet Groups**	**km^2 / nm^2**	**Short-tailed Albatross**	**km^2 / nm^2**	**Activity / Exercise**
E3	0	n/a	1.08	115 / 33.5	0	n/a	Explosive sonobuoy for Maritime Patrol Aircraft (Sound Underwater Signal)
E4	0	n/a	2.77	293 / 85.5	0	n/a	Explosive sonobuoy for Maritime Patrol Aircraft (Improved Extended Echo Ranging)
Total	**0**	**n/a**	**3.85**	**408 / 119**	**0**	**n/a**	
Explosions (In-air, including all stressors from explosive projectiles)							
Offshore	**Bull Trout**	**km^2 / nm^2**	**Marbled Murrelet Groups**	**km^2 / nm^2**	**Short-tailed Albatross**	**km^2 / nm^2**	**Activity / Exercise**
E1	0	n/a	18.8	1,988 / 580	5.5	30,437 / 8,874	Med-caliber explosive projectiles from Surface-to-Air and Surface-to-Surface Gunnery Exercises
E5 / E3	0	n/a	4.8	508 / 148	1.3	7,409 / 2,160	Lg-caliber explosive projectiles from Surface-to-Air and Surface-to-Surface Gunnery Exercises
Total	**0**	**n/a**	**23.6**	**2,496 / 728**	**6.8**	**37,846/ 11,034**	

Table 48. Summary of all groups/individual bull trout, marbled murrelet, or short-tailed albatross where adverse effects are reasonably certain to occur.

Non-explosive Projectiles							
Offshore	**Bull Trout**	**km^2 / nm^2**	**Marbled Murrelet Groups**	**km^2 / nm^2**	**Short-tailed Albatross**	**km^2 / nm^2**	**Activity / Exercise**
In-air	0	n/a	1.17	124 / 36	0.79	5,319 / 1,551	Sm-caliber projectiles for Surface-to-Surface Gunnery Exercises
In-air	0	n/a	9.1	965 / 281	2.1	13,834 / 4,033	Med-caliber projectiles for Surface-to-Air and Surface-to-Surface Gunnery Exercises
In-air	0	n/a	7.1	754 / 220	1.6	10,414 / 3,036	Lg-caliber projectiles for Surface-to-Air and Surface-to-Surface Gunnery Exercises
Total	**0**	**n/a**	**17.4**	**1,844 / 538**	**4.5**	**29,567 / 8,620**	

Summary Table							
Inland & Offshore	**Bull Trout**	**km^2**	**Marbled Murrelet Groups**	**km^2 / nm^2**	**Short-tailed Albatross**	**km^2 / nm^2**	**Activity / Exercise**
All Total	**120**	**16**	**55.9**	**4,801 / 1,400**	**11.3**	**67,413 / 19,654**	**All combined over 20 years**

Note that the habitat areas listed here are the total cumulative habitat areas affected over 20 years (i.e., the sum of all individual areas of effect), and the number of individual fish or birds listed is the number of individuals we expect to be exposed cumulatively over 20 years.

11 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 Opinion. Future federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Within Puget Sound, all State, tribal, local, and private actions are required to obtain a U.S. Army Corps of Engineers permit for work conducted in, over, or under navigable waters under the authority of Section 10 of the Rivers and Harbors Act and/or for the discharge of dredged or fill material under Section 404 of the Clean Water Act. Therefore new actions will require section 7 consultation with the Service.

However, bull trout and marbled murrelets will continue to be affected by ongoing activities within Puget Sound and along rivers and streams draining into Puget Sound. Threats to Puget Sound habitat quality include population growth, shoreline development and armoring, urbanization that increases the amount of impervious surfaces, pressures on water supplies, filling of wetlands, and water and air pollution (Washington Department of Ecology 2015). Within the next 5 years, the population in the Puget Sound region is estimated to grow by 700,000 people.

Population increases results in higher levels of toxic chemicals entering Puget Sound from surface runoff, groundwater discharges, and municipal and wastewater outfalls. These contaminants include oil, grease, PCBs, and heavy metals. Many areas surrounding Puget Sound are highly urbanized with development spreading to the surrounding areas and converting agriculture and forested lands to impervious surfaces. Degraded water quality results in metabolic stress; avoidance responses which prevent or discourages free movement, reduced locomotor performance, and impaired olfactory responsiveness which may compromise growth, long-term survival, and reproductive potential.

Within the Olympic MOAs, non-federal lands are managed primarily for timber production. Some non-federal lands have no restrictions on harvest of suitable marbled murrelet habitat. Therefore, a landowner could harvest timber (habitat) without a pre-harvest survey, potentially resulting in the loss of suitable habitat for marbled murrelets.

Marbled murrelets and short-tailed albatross in the Offshore Area are threatened by continued overfishing, pollution, shipping, and oil and gas development (World Wildlife Federation 2015). Many of these actions are currently present, but are expected to increase in the future. Approximately 90 percent of the world’s fisheries are already overfished threatening the ocean life and habitat. The shipping industry is increasing the size of ships carrying containers and cargo goods increase oil spills, dumping of rubbish ballast water, and oily waste. Oil and gas exploration poses a major threat to sensitive marine habitats and species. The Offshore Area and the oceans are dumping grounds for all the sewage, garbage, pesticides, plastics, and other pollutants that threaten short-tailed albatross and marbled murrelets.

For short-tailed albatross, contaminants and floating plastics and debris will continue to pose a threat to their recovery as both affect survival through reduced growth, decreased reproduction, and egg and chick survival, thereby limiting their population growth. Bull trout and marbled murrelets will continue to have direct and indirect effects to the species and their designated critical habitat from human population growth and its associated urbanization and development through habitat degradation, fragmentation, degraded water quality, and impacts to marine forage fish. These effects, especially in the Puget Sound area, will likely adversely influence reproduction and abundance of murrelets, and the distribution and abundance of bull trout.

12 INTEGRATION AND SYNTHESIS

The Integration and Synthesis section is the final step in assessing the risk posed to listed resources as a result of implementing the proposed action. In this section, we consider the significance of the effects of the proposed action, taken together with cumulative effects, relative to the status and conservation needs of listed resources and the conservation role of the action area. This analysis informs our biological opinion as to whether the proposed action is likely to appreciably reduce the likelihood of both survival and recovery of the species in the wild by reducing its numbers, reproduction, or distribution.

12.1 Bull Trout

In the Environmental Baseline, Status of the Species, Effects of the Action, and Cumulative Effects sections of the Opinion, we established that the effects of past and ongoing activities in the Crescent Harbor and Naval Base Everett action area would maintain the existing habitat conditions. Residential development, urbanization, and degradation or elimination of nearshore marine and estuarine habitats are the main threats to bull trout in the nearshore marine environment. The marine waters of Puget Sound are critical in supporting the bull trout anadromous life history form that is not found in any other Recovery Unit.

Bull trout present in the Crescent Harbor and Naval Base Everett action area are believed to be from the Lower Skagit River, Stillaguamish River, and the Snohomish/Skykomish River core areas. The Lower Skagit River core area consists of 20 local populations and has the highest abundance of these three core areas with the number of adults ranging between 5,000 and 10,000 (USFWS 2008a). The Lower Skagit core areas is considered at “low risk” of extirpation due to habitat degradation and population declines from upland/riparian land management, flood control, agriculture practices, residential development, urbanization, climate change, and fish passage issues. The Snohomish/Skykomish River core area has four local populations and approximately 1,000 to 2,500 adults (1/10th the population of the Skagit River core area). The population trend has been decreasing over the past five years and there is a potential risk for extirpation from threats such as flood control measures (bank armoring, levees), recreational mining, residential development, urbanization, and fish passage issues. The Stillaguamish River core area consists of three local populations and has an even smaller population with fewer than 250 adults. The population trend is declining and the overall status is at risk for extirpation due to upland/riparian land management, recreational mining, forest management, residential development, urbanization, fish passage issues, and genetic drift.

The overall condition of the environmental baseline at Crescent Harbor and Naval Base Everett is influenced by on-going activities that occur within watersheds that drain into Puget Sound. Navy activities at NAS Whidbey Island have resulted in some of the shorelines along Crescent Harbor at the installation being armored and modified. 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 contribute sediments to the beaches around Crescent Harbor.

Crescent Harbor is highly influenced by the Skagit River and becomes stratified during the summer with surface waters ranging between 10 °C to 13 °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 (less than 5 mg/L). A variety of habitats are found throughout the action area including shallow subtidal bays, mud flats, and open mixed-coarse beaches.

Naval Base Everett is located within a highly urbanized area and its entire shoreline is riprapped and contains seawalls. No aquatic vegetation is located in or around Naval Station Everett, and the aquatic habitat is significantly degraded due to the presence of riprap, seawalls, and overwater structures.

12.1.1 Effects to Bull Trout Populations

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

Because the Lower Skagit River core area is directly connected to the action area, and supports more bull trout than either of the other two core areas, most bull trout exposed to < E1 and E3 detonations in Crescent Harbor are likely to be from the Lower Skagit River core area. Some of the bull trout exposed may also be from the Snohomish/Skykomish or Stillaguamish River core areas. However, very few bull trout from the Stillaguamish or the Snohomish/Skykomish core areas are expected to be in Crescent Harbor based on the much lower abundance of bull trout in those core areas and greater distances from the EOD site.

Bull trout exposed to mid-frequency sonar at Naval Base Everett that exceeds 221 dB SEL re: 1 Pa2-sec would be injured if exposure occurred for a sufficient duration. The Service is not reasonably certain such exposure will occur and, as a result, we do not anticipate population-level effects.

We expect that up to six bull trout will be injured or killed per year due to detonations of <E1 and E3 charges within Crescent Harbor. The loss of six bull trout per year will not lead to an appreciable reduction in the likelihood of survival and recovery of the species in the Puget Sound region of the Coastal RU because: 1) the majority of bull trout likely to be in the action area and exposed to high SPLs are expected to be from the Skagit core area; 2) the Skagit River core area currently has a robust, self-sustaining population (5,000 to 10,000 adults), an increasing population trend, and is the largest population in Washington; and 3) given the low populations and distance from the project site, we expect few bull trout from the Snohomish/Skykomish or the Stillaguamish River core areas to be present in the Crescent Harbor action area.

The three core populations of bull trout in the action area are considered to be sufficiently resilient to the loss of three individuals per year, such that we do not expect an appreciable reduction in the likelihood of persistence at either the core area or the RU scale. Therefore, the effects of the proposed action, in consideration of the cumulative effects, are not expected to appreciably reduce the likelihood of survival and recovery of the bull trout through a reduction in reproduction, numbers, or distribution, at the scale of the core area and RU. Based on the same reasoning, we do not anticipate the proposed action to appreciably reduce the likelihood of persistence of the unique anadromous life history component that is vital to this RU.

12.2 Marbled Murrelet

12.2.1 Range-wide Status Summary

Murrelet populations have declined at an average rate of 1.2 percent per year since 2001. The most recent population estimate for the entire Northwest Forest Plan area in 2013 was 19,700 murrelets (95 percent CI: 15,400 to 23,900 birds) (Falxa and Raphael 2015, p.7). While the overall trend estimate is negative (-1.2 percent per year), this trend is not conclusive because the confidence intervals for the estimated trend overlap zero (95 percent CI:-2.9 to 0.5 percent), indicating the murrelet population may be declining, stable, or increasing at the range-wide scale (Falxa and Raphael 2015, pp. 7-8).

Murrelet population size and marine distribution during the summer breeding season is strongly correlated with the amount and pattern (large contiguous patches) of suitable nesting habitat in adjacent terrestrial landscapes (Falxa and Raphael 2015, p. 156). Monitoring of murrelet nesting habitat within the Northwest Forest Plan area indicates nesting habitat has declined from an estimated 2.53 million acres in 1993 to an estimated 2.23 million acres in 2012, a total decline of about 12.1 percent (Falxa and Raphael 2015, p. 89). The largest and most stable murrelet subpopulations now occur off the coast of Oregon and northern California, while subpopulations in Washington have experienced the greatest rates of decline (-5.1 percent per year; 95 percent CI: -7.7 to -2.5 percent) (Falxa and Raphael 2015, p. 8-11). Rates of nesting habitat loss have also been highest in Washington, primarily due to timber harvest on non-Federal lands (Falxa and Raphael 2015, p. 124), which suggests that the loss of nesting habitat continues to be an important limiting factor for the recovery of murrelets.

Factors affecting murrelet fitness and survival in the marine environment include: reductions in the quality and abundance of murrelet forage fish species through overfishing and marine habitat degradation; murrelet by-catch in gillnet fisheries; murrelet entanglement in derelict fishing gear; oil spills; and high levels of underwater sound pressure generated by pile-driving and underwater detonations (USFWS 2009a, pp. 27-67). While all of these factors are recognized as stressors to murrelets in the marine environment, the extent that these stressors affect murrelet populations is unknown (USFWS 2012b). As with nesting habitat loss, marine habitat degradation is most prevalent in the Puget Sound area where anthropogenic activities (e.g., shipping lanes, boat traffic, shoreline development) are an important factor influencing the marine distribution and abundance of murrelets in Conservation Zone 1 (Falxa and Raphael 2015, p. 163).

12.2.2 Threats to Murrelet Survival and Recovery

Since it was listed under the ESA, the murrelet population has continued to decline in portions of its range as a result of poor reproduction and recruitment. The Recovery Implementation Team for the murrelet identified the following major factors that appear to be contributing to this decline (USFWS 2012b, pp. 10-11):

- Ongoing and historic loss of nesting habitat;
- Predation on murrelet eggs and chicks in their nests;
- Changes in marine conditions that affect the abundance, distribution, and quality of murrelet prey species;
- Post-fledging mortality (e.g., due to predation, entanglement in gill-nets, and exposure to oil-spills); and
- Cumulative and synergistic effects of various factors affecting individuals and populations.

Climate change is also considered to be a threat to murrelet survival and recovery. Although seabirds, such as the murrelet, have life-history strategies adapted to variable marine environments, ongoing and future climate change could present changes at a frequency and scope that exceeds their capacity to adapt in a timely and effective manner (USFWS 2009a, p. 46).

12.2.3 Murrelet Conservation Needs

Reestablishing an abundant supply of high quality murrelet nesting habitat is a vital conservation need given the extensive removal of that habitat during the 20th century. Much of the federal lands managed under the Northwest Forest Plan that currently do not support murrelet nesting habitat are expected to transition into mature and older-forest habitat over the next few decades (Raphael et al. 2011, p. 44). In addition to increasing nesting habitat, there are other conservation imperatives. Foremost among those is increasing murrelet reproductive success and productivity (i.e., fecundity) by increasing the number of breeding adults, improving murrelet nest success (due to low nestling survival and low fledging rates), and reducing anthropogenic stressors in marine and terrestrial habitat that reduce individual murrelet fitness or lead to mortality.

General criteria for murrelet recovery and delisting are established under the murrelet recovery plan. More specific delisting criteria are expected to be developed in the future to address population, demographic, and habitat-based recovery criteria (USFWS 1997b, p. 114-115). The general criteria include:

- Documenting stable or increasing population trends in population size, density, and productivity in four of the six Conservation Zones for a 10-year period; and

- Implementing management and monitoring strategies in the marine and terrestrial environments to ensure protection of murrelets for at least 50 years.

Thus, increasing murrelet reproductive success and reducing the frequency, magnitude, or duration of any anthropogenic stressor that directly or indirectly affects murrelet fitness or survival in the marine and terrestrial environments are the priority conservation needs of the species. The Service estimates recovery of the murrelet will require at least 50 years (USFWS 1997b).

12.2.4 Summary of the Environmental Baseline in the Action Area

12.2.4.1 Inland Waters of Puget Sound and the Strait of Juan de Fuca

Most of the training and testing activities proposed to occur in the inland waters of Puget Sound/Strait of Juan de Fuca are focused in specific areas that have been used by the Navy as training areas for decades. These specific training areas (e.g., Bangor, Keyport, Everett, etc.) are characterized by high vessel traffic and extensive shoreline developments from naval piers and facilities. They occupy a relatively small area within the larger Puget Sound/Strait of Juan de Fuca marine system and provide marine foraging habitat for murrelets. These areas support relatively low densities of murrelets during the summer months, and increased densities during the winter months as result of the seasonal migration of murrelets from British Columbia to the inland waters of Puget Sound (Speich and Wahl 1995, p. 325).

The Service previously consulted with the Navy on various activities in these areas and concluded that low numbers of murrelets were likely to be injured or killed by excessive sound pressure levels caused by underwater explosives and marine pile-driving projects. The murrelet population in Conservation Zone 1 has declined over the past two decades due to multiple environmental and anthropogenic stressors that reduce murrelet productivity and survival. As the population has declined, average densities of murrelets within the training areas have declined as well. The population estimate for Zone 1 in 2015 was 4,290 murrelets (95 percent CI: 2,783 – 6,942), with a -5.3 percent average annual rate of decline for the 2001 – 2015 period (Lance and Pearson 2016, p. 4).

12.2.4.2 Offshore Areas

The proposed offshore testing and training areas extend west along the Pacific coastlines of Washington, Oregon, and northern California from a distance of 22 km to 463 km (12 nm to 250 nm) off the coastline. This is a vast area that encompasses a marine surface area of approximately 160,500 square miles (415,693 km^2/121,197 nm^2). These waters occur outside of murrelet conservation zones, which were defined as encompassing marine waters within a distance of 1.2 miles (2 km/1.1 nm) of the shoreline (USFWS 1997b, p. 135). While the summer distribution of murrelets is well documented as occurring primarily in nearshore waters, the winter distribution of murrelets is poorly documented but does include a few observations of murrelets in offshore areas. Based on the best available information, we are reasonably certain that murrelets occur in low densities in the offshore waters out to a distance of 92.6 km (50 nm) from shore, and that murrelets that occur in these waters during the fall/winter seasons likely represent a mixed population originating from multiple Conservation Zones.

The factors affecting murrelets in offshore waters are largely driven by climate and oceanographic conditions that drive patterns of ocean upwelling, sea-surface temperature, and productivity of marine food webs (Becker and Beissinger 2003a, p. 2003). These factors are affected by climate change, and strong climatic events such as El Nino are expected to negatively affect murrelet reproduction and survival due to a reduction in marine productivity (USFWS 2009a, pp. 40-45). While the Navy has conducted training activities in these offshore waters for decades, the Service has not previously considered the impacts of those activities on the murrelet due to a lack of information on murrelet occurrence in these offshore waters. At this time, it is not possible to distinguish the extent to which these ongoing training activities have contributed to the observed trends in murrelet Conservation Zone populations since 2001. Based on best available information, the primary factors influencing the condition of the murrelet at the range-wide population scale are the loss of suitable breeding habitat, nest predation, declines in marine prey species, and degradation of the marine environment in nearshore marine waters caused by oil spills, murrelet entanglement in gill nets, and derelict fishing gear. Past Navy training activities have not been considered a significant factor influencing the reproduction, numbers, and distribution of the murrelet.

12.2.5 Summary of the Effects of the Proposed Action on Murrelets

Individual murrelets that are exposed to explosions and elevated sound pressure levels may be killed or injured depending on their proximity to the source of these stressors. Possible injuries include loss in hearing sensitivity (TS), scarred or ruptured eardrums, or gastrointestinal tract lesions. Although affected murrelets may survive their exposure to these and other stressors, they are likely to have a reduced level of fitness and reproductive success and have a higher risk of predation. Exposed individuals may also experience: lethal injuries that occur instantaneously or over time; direct mortality; lung hemorrhaging; ruptured livers; hemorrhaged kidneys; ruptured air sacs; and/or coronary air embolisms.

Murrelets that experience TS are expected to have damaged hair cells in their inner ears and, as a result, may not be able to detect biologically relevant sounds such as approaching predators or prey, and/or hear their mates or young attempting to communicate. Murrelets that lose their hearing sensitivity are at increased risk of predation and reduced foraging efficiency. Some affected murrelets may regain some or all of their hearing sensitivity; however, they are still temporarily at risk while experiencing TS.

Murrelets that are exposed to other stressors caused by training activities such as exposure to helicopter rotor wash, but do not experience TS, are likely to experience interrupted foraging bouts or resting attempts, which creates a likelihood of injury by significantly disrupting normal behaviors (as a result of their diving repeatedly or vacating the area). Foraging efficiency is likely to be reduced, and energy expenditures are likely to be increased above normal when they flush and/or relocate out of the area. Murrelets are also likely to increase their diving efforts in response to these lost foraging opportunities, or to replace prey dropped or swallowed, or to escape from perceived predators (i.e., helicopters and boats). In the Olympic MOAs, nesting murrelets are likely to be exposed to various levels of aircraft noise caused by the proposed training activities. Murrelets are likely to exhibit periods of increased vigilance and alerting behavior in response to aircraft sound and presence, but exposure to distant aircraft overflights is not likely to cause a disruption of normal murrelet nesting behaviors or result in fitness consequences.

In the analyses presented above in the Effects of the Action section, the estimated areas of exposure encompass the full range of adverse effects, from temporary TS to direct mortality. We then used models to estimate probabilities of murrelet exposure to stressors generated by training activities based on the area of effect, estimated number of training events, and assumed densities of murrelets, which vary by season and decline over time. Table 49 summarizes our estimates of the cumulative amount of marbled murrelet habitat that will be affected (i.e., the sum of all individual areas of effect), and the estimated number of murrelets exposed to stressors caused by the proposed action over 20 years.

Table 49. Summary of estimated marine habitat areas within Inland Waters and Offshore Areas where marbled murrelets may be exposed to stressors causing injury, mortality, or other significant adverse effects, the expected numbers of individuals that may be exposed, and the expected numbers of individuals reasonably certain to be exposed (according to "reasonably certain" scenario).

Stressors	**Cumulative estimated area of marine habitat exposed to adverse effects over 20 years**		**Estimated numbers of murrelets expected to be exposed over 20 years**	
Stressors in Inland Waters	nm^2	km^2	(exposure is reasonably certain)	(exposure is not discountable, regardless of whether exposure is reasonably certain)
Sonar (MF1 and MF8)*	2	7	2 (MF8 only)	3 (MF1 and MF8)
Explosives (underwater)**	9	31	7 (E3 only)	8 (SWAG and E3)
Helicopters	8	27	13	13
Inland Waters – Totals	11	38	22	24
Stressors in Offshore Areas (12 to 50 nm from shore)				
Explosives (underwater)	123	422	8	8
Explosive projectiles (in-air)	728	2,496	47	47
Projectiles (non-explosive)	537	1,842	35	35
Non-explosive practice bombs	14	48	n/a	1
Offshore Waters Totals	1,398	4,795	90	91

* Effects of these stressors are expected to affect the same small habitat areas repeatedly. Each effect is counted separately in the cumulative habitat estimate.

** Effects of these stressors are expected to be geographically confined to approximately 5 km^2 (1.5 nm^2) at Crescent Harbor and 1 km^2 (0.3 nm^2). Each effect is counted separately in the cumulative habitat estimate, and most or all portions of the geographic areas will be affected repeatedly.

12.2.5.1 Effects to Murrelet Populations

The 1997 Recovery Plan for the Marbled Murrelet (USFWS 1997b) identified six Conservation Zones throughout the range of the listed species. Recovery zones are the functional equivalent of recovery units as defined by Service policy (USFWS 1997b, p. 115). The murrelet subpopulations in each Zone are not discrete. There is some movement of murrelets between Zones as indicated by radio-telemetry studies (e.g., Bloxton and Raphael 2006, p. 162), but the degree to which murrelets migrate between Zones is unknown. For the purposes of consultation, the Service treats each of the Conservation Zones as separate sub-populations of the listed murrelet population.

In this analysis, we associate the effects of the proposed action in the inland waters to the murrelet population in Conservation Zone 1, while the effects in the offshore areas are associated with murrelet populations in Conservation Zones 2 through 6.

12.2.5.1.1 Inland Waters of Puget Sound and the Strait of Juan de Fuca - Conservation Zone 1

The subpopulation estimate for Zone 1 in 2015 was 4,290 murrelets (95 percent CI: 2,783 – 6,942) (Lance and Pearson 2016, p. 4). Due to the nature of the survey protocol and seasonal variation in the distribution of murrelets, there is a high level of variation in the annual population estimates (Figure 20). Despite this annual variation, the monitoring surveys indicate the murrelet population in Conservation Zone 1 has declined at an average rate of -5.3 percent (95 percent confidence interval -2.0 percent to -8.4 percent) per year for the period from 2001 to 2015 (Lance and Pearson 2016, p. 4) (Figure 20).

Considering the upper and lower estimates of population size and trend, the murrelet subpopulation in Zone 1 is likely to decline to a level where the population is in the range of $\geq$ 4,000 to $\leq$ 500 murrelets over the next 20 years (Figure 20).

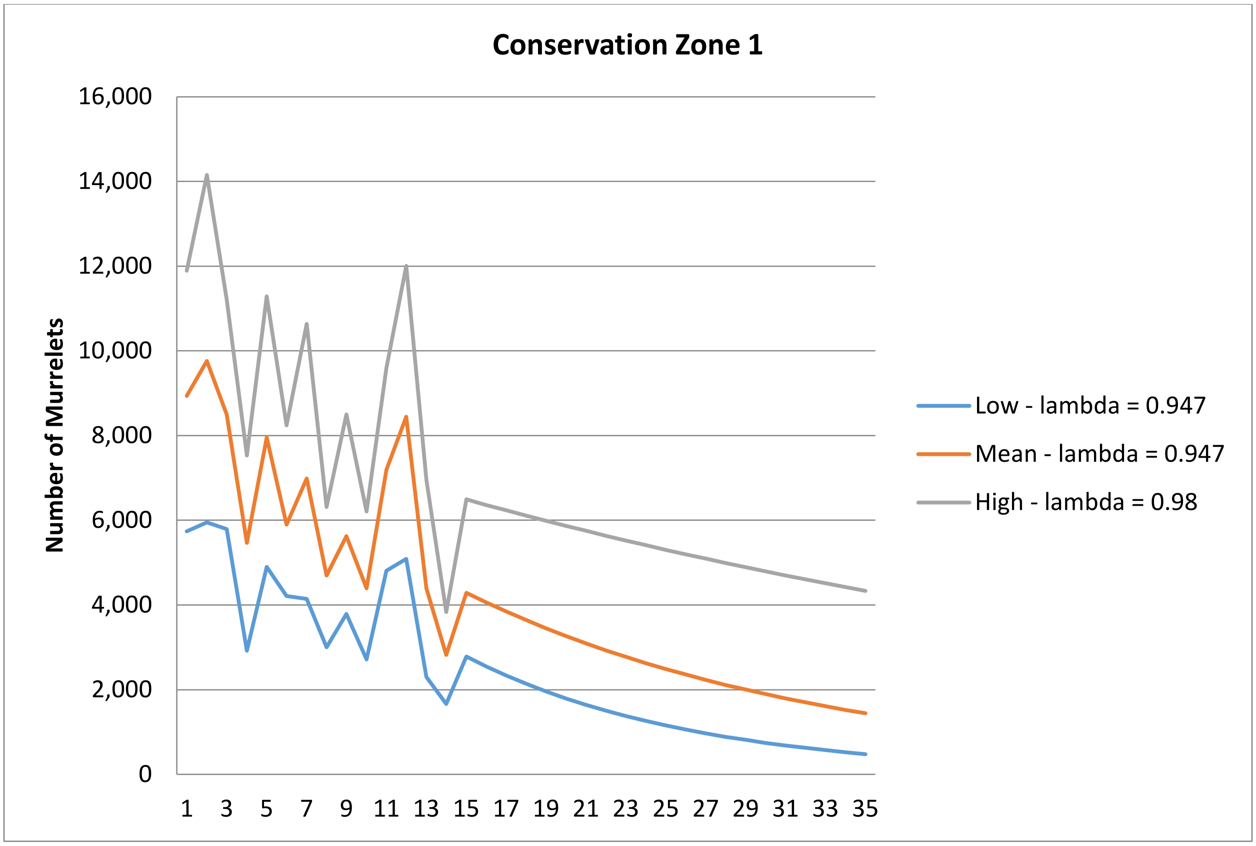

Figure 20. Summary of marbled murrelet population estimates in Conservation Zone 1 from 2001 to 2015, with mean, upper, and lower trend estimates projected through 2035.

To estimate the number of murrelets exposed to stressors caused by the proposed action, we used the average of the mean population estimates in Zone 1 for the period from 2010 to 2014, and then applied the average rate of decline to murrelet density in the action area over time. The exposure model used for the analysis of the "reasonably certain" scenario showed an expected number of approximately 11 murrelets exposed to sub-lethal or lethal injuries caused by the proposed action over a period of 20 years. Not all exposed murrelets are expected to be killed or removed from the breeding population. However, to evaluate the potential subpopulation effects at the scale of Conservation Zone 1, we applied the reasonable worst-case assumption that murrelets exposed to these injurious effects would be permanently removed from the population over the next 20 years. We expect that an additional 13 murrelets will be exposed to stressors associated with helicopters that will result in increased energetic costs, which are associated with fitness consequences and an increased likelihood of injury. However, we have not assumed that murrelets exposed to helicopters will be removed from the population. This analysis also accounts for the effects of reduced murrelet fitness and productivity that have resulted from all other past and present activities occurring in the action area because the overall rate of population change (lambda) captures all of the various population stressors that drive the population trends (annual survival, breeding rates, nesting success, immigration, emigration, etc.).

The current estimates of the mean baseline population trend indicate the murrelet population in Zone 1 is likely to decline by approximately 50 percent over the next 13 years. In the context of this declining baseline trend, the loss of up to 11 murrelets over 20 years would not appreciably influence the background trend. Using the mean estimates of current population size, (rather than upper or lower estimates), if the current trend continues, within 20 years, the estimated murrelet population in Conservation Zone 1 is likely to decline to an estimated 1,638 birds. With Navy training effects, the population is likely to decline to an estimated 1,632 birds within 20 years, a difference of six birds. This is 99.63 percent of the number of murrelets remaining compared to the average baseline trend (-0.37 percent difference) (Table 50).

Considering the high level of annual variation in Zone 1 population estimates, and the fact that our estimates of birds exposed account for seasonal emigration of birds from British Columbia into the Zone 1 population, the population-level effects at the scale of the Zone 1 population are immeasurable from the background trends.

Table 50. Simple estimates of murrelet population change in Conservation Zone 1 with a comparison of the baseline trend and the trend with murrelets removed by Navy training actions.

Year	Zone 1 murrelets with average trend (-5.3%) decline per year	Zone 1 murrelets removed per year	Zone 1 murrelet trend with birds removed from the population	Percent difference in original population over time
0	4,867	0.0	4,867	100.00%
1	4,609	0.90	4,608	99.98%
2	4,365	0.85	4,363	99.96%
3	4,134	0.81	4,131	99.94%
4	3,914	0.77	3,912	99.93%
5	3,707	0.73	3,704	99.91%
6	3,511	0.69	3,507	99.89%
7	3,324	0.65	3,320	99.87%
8	3,148	0.62	3,144	99.85%
9	2,981	0.58	2,976	99.83%
10	2,823	0.55	2,818	99.81%
11	2,674	0.52	2,668	99.80%
12	2,532	0.50	2,526	99.78%
13	2,398	0.47	2,392	99.76%
14	2,271	0.44	2,265	99.74%
15	2,150	0.42	2,144	99.72%
16	2,036	0.40	2,030	99.70%
17	1,929	0.38	1,922	99.68%
18	1,826	0.36	1,820	99.67%
19	1,730	0.34	1,723	99.65%
20	1,638	0.32	1,632	99.63%
	Total =	11		

Notes: The starting population size (n = 4,867) was derived by averaging the mean population estimates for the period from 2010 to 2014 (n = 5,448), and then applying the trend (-5.3 %) to estimate the starting population size.

To characterize the marine habitat effects of the proposed action, we modeled estimates of marine surface area within which murrelets are likely to be exposed to explosions or sound pressure levels that are likely to cause injury or death. In inland waters, the cumulative area of habitat affected annually (i.e., the sum of all areas of effect for a given year) for injury or mortality is relatively small, 1.3 km^2, and these areas are located in the vicinity of established Naval bases where there is a high background level of vessel and aircraft traffic and existing shoreline developments. Likewise, the exposure area for non-injurious disturbance effects from helicopters is also relatively small, estimated at approximately 1.34 km^2 per year. Zone 1 encompasses over 3,497 km^2 of nearshore marine waters (Falxa and Raphael 2015, p. 41) that provide foraging habitat for murrelets, so the relative area exposed to training-caused stressors at levels that are likely to kill or injure murrelets, viewed in the context of the larger Puget Sound/Straits marine system, is comparatively small. While the Navy's actions represent a continued source of impact and degradation at the scale of these existing training areas, the effects of the proposed action do not constitute a significant expansion of training areas within inland waters, or a permanent loss or degradation of marine foraging habitat. The average at-sea home range of murrelets during the summer nesting season in Zone 1 has been estimated at 700 km^2, with frequent movements of birds across large areas of the Straits and the San Juan Islands (Bloxton and Raphael 2006, p. 162). Given the murrelet's capacity to forage across large areas of marine habitat, the proposed action is not expected to affect the distribution of murrelets in Zone 1, or measurably affect the conservation role of marine waters to provide foraging habitat for murrelets within Zone 1.

In summary, we expect about 11 murrelets will be exposed to lethal or non-lethal stressors caused by the proposed action within the inland waters over the next 20 years. Although this impact is measureable in terms of those individuals, it is not likely to have an appreciable influence on reproduction, numbers, and distribution of the murrelet at the population scale at both the action area and range-wide scales. The current condition of the murrelet at both of those scales is not likely to appreciably change with implementation of the proposed action. Implementation of the proposed action is not likely to result in the loss of murrelet breeding habitat, is not likely to appreciably reduce the growth rate of the murrelet population, and is likely to have only localized adverse effects to murrelets in the marine environment.

12.2.5.1.2 Offshore Areas – Conservation Zones 2-6

Navy activities in offshore areas encompass a broad range of activities that will expose large areas of marine waters to explosives and excessive sound pressure levels. We do not know the full extent that murrelets occur in the offshore waters during the fall/winter seasons. For this analysis, we developed two exposure models. One model assumed murrelet occurrence out to a distance of 250 nm offshore (referred to above as the "reasonable worst-case" scenario), and the other model assumed murrelet occurrence out to a distance of 50 nm offshore (referred to above as the "reasonably certain" scenario). Within the listed range of the species, murrelet occurrence beyond 50 nm from shore has not been documented. Therefore, we did not rely on the "reasonable worst case" model outputs to determine the number of murrelets likely to be exposed to stressors. In the "reasonably certain" scenario model, murrelet densities are very low. Even at these low densities, the cumulative probability of exposure was high enough that we estimated four to five murrelets per year would be injured or killed, with a total cumulative estimate of approximately 91 murrelets injured and/or killed over 20 years. Not all exposed murrelets are expected to be killed or removed from the population. However, to evaluate the potential population effects, we applied a reasonable worst-case assumption that murrelets exposed to project effects would be permanently removed from the population over the next 20 years.

This analysis is useful in providing an estimate of the potential exposure of murrelets to these stressors if murrelets are dispersed throughout the offshore areas out to 50 nm. The evidence of murrelet distribution in the offshore waters is limited, but the available data suggest that murrelet densities decline with increasing distance from shore, indicating our analysis likely overestimates the number of murrelets exposed to stressors caused by the proposed training activities in the offshore waters.

For the purpose of this Section 7(a)(2) analysis, we assume that the expected number of murrelets derived from our exposure model (2) provides a reasonable basis to evaluate the effects of the proposed action to murrelet populations. The exposure analysis assumes that murrelets within the offshore waters represent a mixed population that includes all individuals from Conservation Zones 2, 3, and 4, and 10 percent of individuals from Conservation Zone 5 and Zone 6. Based on the relative distribution of the murrelet populations across Conservation Zones, over 90 percent of the exposed individuals in the offshore areas are likely to originate from Conservation Zones 3 and 4 (Oregon and northern California) (Table 51).

Table 51. Relative distribution of murrelets exposed to stressors caused by the proposed action in Offshore Areas.

Conservation Zone	2013 population estimates (mean)	Percent of Zone population in Offshore Area	Relative distribution of murrelets in Offshore Area by Zone	Expected number of murrelet exposed over 20 years	Average number of murrelets exposed per year
Zone 1	4,395	0	0	0	0
Zone 2	1,271	100 %	8 %	7	0.4
Zone 3	7,880	100 %	52 %	47	2.4
Zone 4	6,046	100 %	40 %	37	1.8
Zone 5	71	10 %	0.05%	0	0
Zone 6	628	10 %	0.4 %	0	0
Totals	20,291		100 %		4.6

Sources: Falxa and Raphael (2015); Henry and Tyler (2014).

12.2.5.1.3 Conservation Zone 2 – Washington Coast

The murrelet population in Zone 2 increased from an estimated 1,271 birds in 2013, to an estimated 3,204 birds in 2015 (Lance and Pearson 2016, p. 5), indicating that the relative distribution of murrelets in offshore areas presented above (Table 51) is likely to change over time as murrelet populations change. We do not know why there has been such a dramatic increase in the Zone 2 population, but note that as murrelets in Zone 2 have increased over the past three years, there has been a decline in the estimated murrelet population in Zone 1 over the same period. Given the observations of murrelets foraging over large marine areas in Washington, there may have been a shift in the summer distribution of birds from inland waters of Zone 1 to the outer coast of Washington during this period. With the substantial increase in the estimated murrelet population in Zone 2, the annual rate of population change (since 2001) has increased from a -6.7 percent annual decline (2013) to a -2.8 percent (2015), and the 95 percent confidence intervals for the trend (-7.6 % to +2.3) now overlap zero, indicating no clear trend in this population. The expected removal of less than one bird per year as a result of proposed Navy training activities in offshore areas would not be measurable in the context of these variable trends.

12.2.5.1.4 Conservation Zones 3 and 4 – Oregon and Northern California

The murrelet populations in Zones 3 and 4 have shown positive growth rates over the past 10 years. In 2012, the population estimate in Zone 3 was 6,359 murrelets, and the estimate in 2014 was 8,841 murrelets, indicating substantial growth or emigration. Similar patterns have been observed in Zone 4, where populations have increased from an estimated 6,046 murrelets in 2013, to 8,743 murrelet in 2015 (NWFPEMP 2016). The estimated annual rate of population change in these zones has been positive since 2001, indicating an overall cumulative change of 0.3 percent per year in Zone 3, and 2.5 percent per year in Zone 4 (Falxa and Raphael 2015). The positive trends in Zone 3 and Zone 4 are driving the upper bounds of the range-wide population estimates (+1.05 percent change per year) (Figure 21). The expected removal of approximately one to three birds per year in Zones 3 and 4 as a result of proposed Navy testing and training activities in offshore areas would not be measurable in the context of these positive population trends.

12.2.5.1.5 Conservation Zones 5 and 6 – Central California Coast

The murrelet population in Zone 5 (estimated at 71 birds in 2013) is so small that we cannot confidently predict any murrelets originating from Zone 5 will be killed or injured with implementation of the proposed action because the potential for murrelet exposure to stressors caused by the training activities is so small. In Zone 6, the estimate of the murrelet population has ranged from roughly 400 to 600 murrelets during the period from 2010 to 2014 (Henry and Tyler 2014). Although this population is larger, the number of murrelets expected to travel from Zone 6 into the areas affected by the Navy testing and training activities is so small that we cannot confidently predict that any murrelets originating from Zone 6 will be killed or injured as a result of the proposed action.

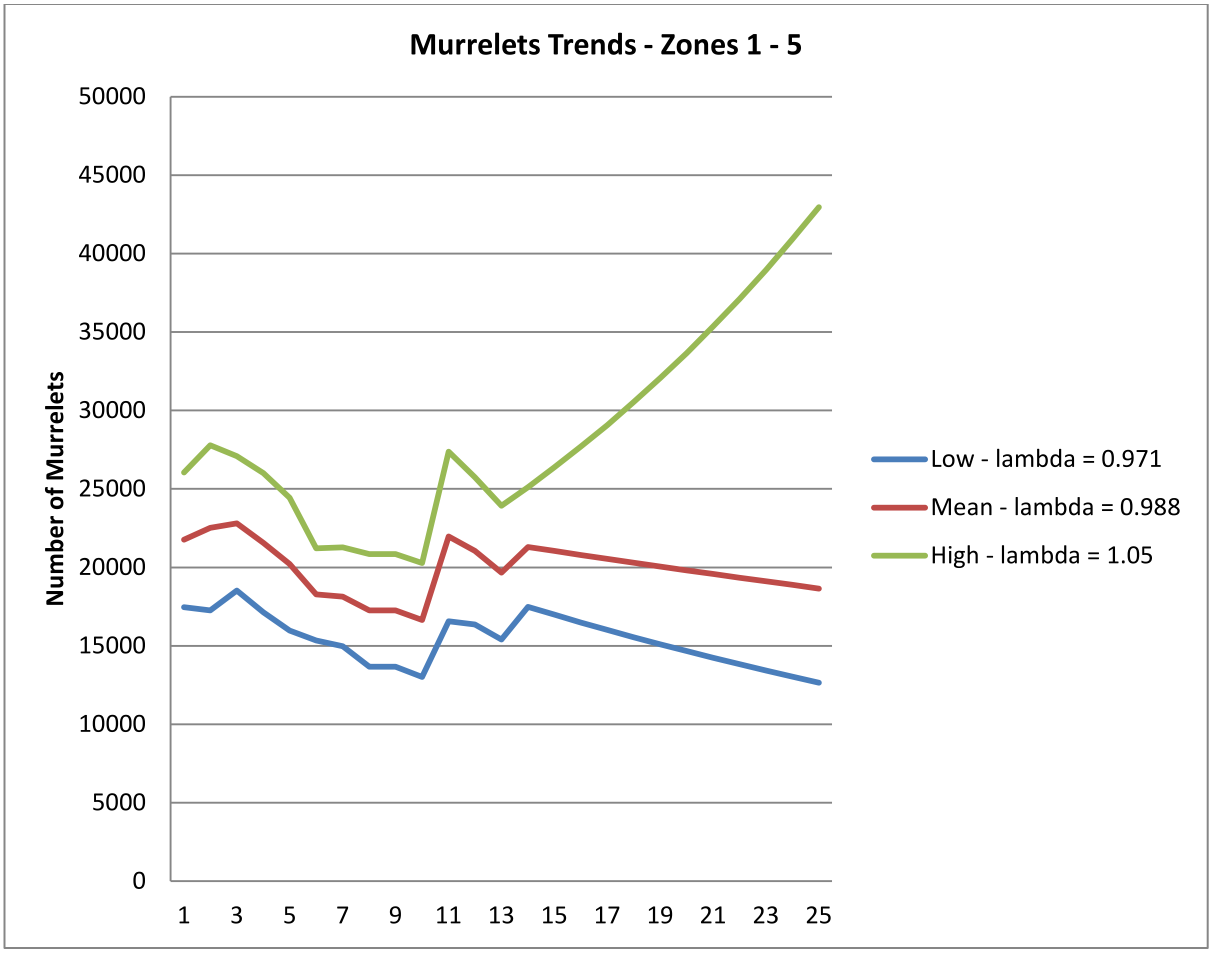

Figure 21. Summary of range-wide marbled murrelet population estimates for the Northwest Forest Plan monitoring area from 2001 to 2014, with mean, upper, and lower trend estimates projected through 2025.

Given the key assumption in our exposure model that murrelets are dispersed throughout coastal waters from 0 to 50 nm offshore during the winter, we would expect up to 91 murrelets would be killed or injured by Navy training and testing activities over the next 20 years. This equates to an annual rate of four to five murrelets killed or injured across a vast area of offshore waters from Washington to northern California. Although this impact is measureable in terms of those individuals, it is not likely to have an appreciable influence on the reproduction, numbers, and distribution of the murrelet at the population scale at both the action area and range-wide scales. The largest populations of murrelets now occur offshore of Oregon and northern California. There is strong evidence that these populations are increasing, and have the potential to double the size of the listed population over the next 20 years at the upper end of the estimated population growth rates (Figure 21). The current condition of the murrelet at the action area and range-wide scales is not likely to change with implementation of the proposed action. Implementation of the proposed action will not result in the loss of murrelet breeding habitat, is not likely to appreciably reduce the growth rate of the murrelet population, and is likely to have only localized adverse effects to murrelets in the marine environment.

12.2.6 Summary of Cumulative Effects

Most of the factors influencing the current condition of the murrelet in the action area either have a Federal nexus or are related to climate change. On that basis, the effects of the proposed action taken together with cumulative effects are not likely to have an appreciable influence on reproduction, numbers, and distribution of the murrelet at the population scale at both the action area and range-wide scales. In addition, the current condition of the murrelet at both of these scales is not likely to change with implementation of the proposed action in consideration of the cumulative effects.

12.2.7 Overall Summary of Effects of the Action on Murrelet Numbers and Reproduction Range-wide

Taking into account cumulative effects, a slight reduction in the numbers and reproduction of murrelets is anticipated with implementation of the proposed action due to the loss of individuals through direct mortality and reduced fitness of affected individuals that suffer non-lethal injuries. Injured, breeding-aged adults would incrementally reduce either the number of murrelets available for mating, the number of initiated nests, or the nesting success (fledging). The effects to the reproductive productivity of affected murrelets will vary between individuals affected by minor, recoverable injuries and those with permanent hearing loss or other injuries that reduces their capacity to survive and successfully breed. A small change is anticipated in the potential number of successfully breeding adults.

The murrelet population in Conservation Zones 1 through 5 was estimated at 19,700 murrelets in 2013, with an additional 600 murrelets estimated in Zone 6 for a total population size of roughly 20,300 murrelets. Current trend estimates indicate that murrelet populations in Oregon and northern California are growing. The current abundance of murrelets appears to be sufficiently high such that a small, incremental reduction in the future reproductive potential of the murrelet population caused by the proposed action over the next 20 years would be undetectable. The Navy's testing and training actions covered in this consultation are ongoing actions occurring in the Olympic MOAs, Puget Sound, the Strait of Juan de Fuca, and other coastal and offshore areas. The number of murrelets that would fail to contribute to the reproduction of the listed species as a result of being injured and killed by the proposed action represents a small portion of the listed population.

The expectation that some murrelets injured by the proposed action are likely to survive and continue to contribute to the breeding population, and the low numbers of murrelets likely to be killed annually and over the next 20 years as a result of the proposed action leads us to conclude that the anticipated incremental loss of murrelet numbers and reproduction as a result of the proposed action will not be detectable from background rates of population growth and/or decline observed in the Conservation Zones. Although the effect of the proposed action is measureable in terms of individuals, it is not likely to have an appreciable influence on the overall reproduction and numbers of murrelets at both the action area and range-wide scales taking into account cumulative effects.

12.2.8 Overall Summary of Effects of the Action on Murrelet Range-wide Distribution

The proposed action is not likely to affect the distribution of murrelets within the action area because it would not result in the loss of any murrelet nesting habitat, which is identified as the primary driver of the current population decline (USFWS 2012b). The essential conservation role of the Olympia MOAs to provide nesting habitat necessary for murrelet survival and recovery would not be precluded or diminished by the proposed action. The essential conservation role of marine waters to provide prey resources necessary for murrelet survival and recovery is not likely to be precluded or measurably reduced by the proposed action. Therefore, the proposed action taken together with cumulative effects is not expected to affect the distribution of murrelets in the action area or within the listed range of the species.

12.3 Short-tailed Albatross

12.3.1 Summary of the Species Status and Environmental Baseline

The range-wide population of the short-tailed albatross has been growing steadily. Based on surveys at the breeding colonies on Torishima, the three-year running average of the population growth rate between 2000 and 2013 ranges from 5.2 to 9.4 percent (USFWS 2014, p. 9). To date, conservation efforts have largely focused on addressing the threats of habitat alteration and loss due to catastrophic events and commercial fishing. Less effort has been invested to alleviate threats to short-tailed albatross from climate change, ocean regime shift, and contaminants including plastics.

Over three-quarters of the breeding population of short-tailed albatross nest on Torishima (USFWS 2014, p. 3). There have been volcanic eruptions on Torishima that have killed large numbers of birds and destroyed nesting habitat (Austin Jr 1949, p. 288). It is estimated that a volcanic eruption on Torishima in the near future could kill as much as 54 percent of the world's population of short-tailed albatross (USFWS 2008b, p. 17). Conservation strategies for short-tailed albatross emphasize the importance of establishing breeding colonies on other islands to hedge against losing a large proportion of short-tailed albatross from a single catastrophic event (USFWS 2008b). By-catch of short-tailed albatross by commercial fisheries continues to be a major conservation concern; efforts to address the threat are primarily focused on raising awareness and use of seabird deterrents in the industry (USFWS 2014, p. 15).

The training and testing area along the west coast of the United States is used by juvenile and sub-adult short-tailed albatross. As birds age they appear to spend more time in other parts of the species range, especially in the marine waters of Alaska and the Aleutian Islands. The action area does not include any current breeding habitat for short-tailed albatross.

12.3.2 Summary of the Effects of the Proposed Action, and Cumulative Effects

We estimate that 11 short-tailed albatross are likely to be killed, injured, or significantly disturbed over the 20 years of the Navy's testing and training activities. Short-tailed albatross will be injured or killed as a result of exposure to in-air explosions and other stressors associated with explosive munitions (7 short-tailed albatross over 20 years), and will also be injured or killed from being struck by non-explosive projectiles or exposed to projectile shockwaves or muzzle blast associated with non-explosive munitions (4 short-tailed albatross over 20 years). Injury from explosions and projectiles will occur within the testing and training area, and will be limited to juvenile or sub-adult birds. There is also the potential for floating debris resulting Navy's proposed activities to be consumed by short-tailed albatross, but we are not reasonably certain that actual injury will occur from such ingestion.

12.3.3 Effects to Short-tailed Albatross Survival and Recovery

It has been estimated that the population criteria for down-listing short-tailed albatross from endangered to threatened (750 breeding pairs overall) was met in 2013. Furthermore, the population standard for delisting short-tailed albatross (at least 1,000 breeding pairs and a population greater than 4,000 birds) is expected to be surpassed in 2017 (USFWS 2014, p. 3). The short-tailed albatross that will be injured or killed over the next 20 years due to the proposed action will be insufficient to noticeably alter the current population size or the increasing population trend and will therefore not appreciably affect recovery of the species. Down-listing or delisting short-tailed albatross also requires growing breeding colonies on island groups other than Torishima (USFWS 2008b, p. 41). While those standards have not been met (USFWS 2014, p. 3), the proposed action will not affect the breeding and nesting habitat available to short-tailed albatross nor will it hinder efforts to expand the nesting range of the species.

13 CONCLUSION

13.1 Bull Trout

After reviewing the current status of the bull trout, the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is the Service's Opinion that implementation of the Navy's Northwest Training and Testing Activities, as proposed, is not likely to jeopardize the continued existence of the bull trout. Critical habitat for bull trout is designated in the action area and the Service concurs with the Navy's determination that the proposed action is not likely to adversely affect designated critical habitat for the bull trout. Therefore, the proposed action is not likely to destroy or adversely modify critical habitat for the bull trout.

13.2 Marbled Murrelet

After reviewing the current status of the marbled murrelet, the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is the Service's Opinion that implementation of the Navy's Northwest Training and Testing Activities, as proposed, is not likely to jeopardize the continued existence of the marbled murrelet. While critical habitat for the marbled murrelet has been designated in the action area, no effects to the critical habitat are anticipated. Therefore, the proposed action is not likely to destroy or adversely modify designated critical habitat for the marbled murrelet.

13.3 Short-tailed Albatross

After reviewing the current status of the short-tailed albatross, the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is the Service's Opinion that implementation of the Navy's Northwest Training and Testing Activities, as proposed, is not likely to jeopardize the continued existence of the short-tailed albatross. The Service has not designated critical habitat for the short-tailed albatross.

14 INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulation pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined under section 3(19) of the ESA to mean "…harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." Harm is further defined by the Service as an act which actually kills or injures wildlife. Such an 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 ESA as an intentional or negligent act or omission that 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) of the ESA, taking that is incidental to and not intended as part of the agency action is not considered to be a prohibited taking under the ESA 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 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 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 this Incidental Take Statement pursuant to the requirements of 50 CFR 402.14(i)(3).

15 FORM AND AMOUNT OR EXTENT OF TAKE

15.1 Bull Trout

Based on the *Effects of the Action* analysis above, incidental take of the bull trout is reasonably certain to occur in the form of harm. Pursuant to the authority of section 402.14(i)(1)(i) of the implementing regulations for section 7 of the ESA, a surrogate can be used to express the amount or extent of anticipated take if the following criteria are met: the causal link between the surrogate and take is described; an explanation is provided as to why it is not practical to express the amount or extent of take or to monitor take-related impacts in terms of individuals of the listed species; and a clear standard is set for determining when the level of anticipated take has been exceeded.

As described in the effects analysis, we anticipate that the action will result in the take of 120 bull trout. However, in this case, a coextensive surrogate based on specific project components is necessary to express the extent of take of the bull trout because it is not practical to monitor take impacts in terms of individual bull trout due to the extremely low likelihood of finding dead or injured individuals in the aquatic environment. The coextensive surrogate is the direct source of the stressors causing the taking, and a clear standard for take exceedance can be established under the monitoring requirements (below) using this surrogate. On that basis, the extent of take of the bull trout covered under this Incidental Take Statement is described below by stressor category using a coextensive surrogate.

15.1.1 E3 and <E1 Detonations

- The extent of take (in the form of harm) of the bull trout is 3 E3 detonations and 18 < E1 detonations per year at the Crescent Harbor EOD Training Range site over the next 20 years.

15.2 Marbled Murrelet

Based on the *Effects of the Action* analysis above, incidental take of the marbled murrelet is reasonably certain to occur in the form of harm and harass. Pursuant to the authority of section 402.14(i)(1)(i) of the implementing regulations for section 7 of the ESA, a surrogate can be used to express the amount or extent of anticipated take if the following criteria are met: the causal link between the surrogate and take is described; an explanation is provided as to why it is not practical to express the amount or extent of take or to monitor take-related impacts in terms of individuals of the listed species; and a clear standard is set for determining when the level of anticipated take has been exceeded.

As described in the effects analysis, we anticipate that the action will result in the take of 112 marbled murrelets. However, in this case, a coextensive surrogate based on specific project components is necessary to express the extent of take because it is not practical to monitor take impacts in terms of individual marbled murrelets due to the extremely low likelihood of finding dead or injured individuals in the aquatic environment. The coextensive surrogate is the direct source of the stressors causing the taking, and a clear standard for take exceedance can be established under the monitoring requirements (below) using this surrogate. On that basis, the extent of take of the marbled murrelet covered under this Incidental Take Statement is described below by stressor category using a coextensive surrogate.

15.2.1 MF8 Sonar

- The extent of take (in the form of harm) of the marbled murrelet is 40 hours per year of MF8 sonar emissions (half in the summer, half in the winter, on overage over a 5-year period) within the Inland Waters Subunit over the next 20 years.

15.2.2 <u>E3 Detonations</u>

- The extent of take (in the form of harm) of the marbled murrelet is 6 E3 detonations (3 at each site) per year (half of each explosive class in the summer, half in the winter, on average over a 5-year period) at both the Hood Canal and the Crescent Harbor EOD sites over the next 20 years.

15.2.3 <u>Helicopter Rotor Wash</u>

- The extent of take (in the form of harass) of the marbled murrelet is 110 events per year associated with training activities conducted in Crescent Harbor and at Navy 7 training areas over the next 20 years.

15.2.4 <u>E3 and E4 Explosions</u>

- The extent of take (in the form of harm) of the marbled murrelet is 15 counts (explosive sonobuoys) per year (on average over a 5-year period) of E3 detonations within 50 nm from shore in the Offshore Area Subunit during the winter over the next 20 years.

- The extent of take (in the form of harm) of the marbled murrelet is 24 counts (explosive sonobuoys) per year (on average over a 5-year period) of E4 detonations within 50 nm from shore in the Offshore Area Subunit during the winter over the next 20 years.

15.2.5 <u>E1 Medium-caliber Projectile Explosions, Projectile Strikes, Fragment Strikes, and Projectile Shock Waves</u>

- The extent of take (in the form of harm) of the marbled murrelet is 416 E1 medium-caliber projectiles per year (on average over a 5-year period) within 50 nm from shore in the Offshore Area Subunit during the winter over the next 20 years.

15.2.6 <u>E3/E5 Large-caliber Projectile Explosions, Projectile Strikes, Fragment Strikes, Projectile Shock Waves, and Muzzle Blasts</u>

- The extent of take (in the form of harm) of the marbled murrelet is 21 E3/E5 large-caliber projectiles per year (on average over a 5-year period) within 50 nm from shore in the Offshore Area Subunit over the next 20 years.

15.2.7 <u>Small-caliber Non-Explosive Projectiles – Physical Strikes</u>

- The extent of take (in the form of harm) of the marbled murrelet is 1,697 instances (8,485 small-caliber non-explosive projectiles) per year (on average over a 5-year period) within 50 nm from shore in the Offshore Area Subunit during the winter over the next 20 years.

15.2.8 Medium-caliber Non-Explosive Projectiles – Physical Strikes and Projectile Shock Waves

- The extent of take (in the form of harm) of the marbled murrelet is 600 instances (3,000 medium-caliber non-explosive projectiles) per year (on average over a 5-year period) within 50 nm from shore the Offshore Area Subunit during the winter over the next 20 years.

15.2.9 Large-caliber Non-Explosive Projectiles – Physical Strikes, Projectile Shock Waves, and Muzzle Blasts

- The extent of take (in the form of harm) of the marbled murrelet is 41 instances (205 large-caliber non-explosive projectiles) per year (on average over a 5-year period) within 50 nm from shore in the Offshore Area Subunit during the winter over the next 20 years.

15.3 Short-tailed Albatross

Based on the *Effects of the Action* analysis above, incidental take of the short-tailed albatross is reasonably certain to occur in the form of harm. Pursuant to the authority of section 402.14(i)(1)(i) of the implementing regulations for section 7 of the ESA, a surrogate can be used to express the amount or extent of anticipated take if the following criteria are met: the causal link between the surrogate and take is described; an explanation is provided as to why it is not practical to express the amount or extent of take or to monitor take-related impacts in terms of individuals of the listed species; and a clear standard is set for determining when the level of anticipated take has been exceeded.

As described in the effects analysis, we anticipate that the action will result in the take of 11 short-tailed albatross. However, in this case, a coextensive surrogate based on specific project components is necessary to express the extent of take of the short-tailed albatross because it is not practical to monitor take impacts in terms of individual short-tailed albatross due to the extremely low likelihood of finding dead or injured individuals in the aquatic environment. The coextensive surrogate is the direct source of the stressors causing the taking, and a clear standard for take exceedance can be established under the monitoring requirements (below) using this surrogate. On that basis, the extent of take of the short-tailed albatross covered under this Incidental Take Statement is described below by stressor category using a coextensive surrogate.

15.3.1 E1 Explosions, Projectile Strikes, Fragment Strikes, and Projectile Shock Waves

- The extent of take (in the form of harm) of the short-tailed albatross is 6,368 E1 medium-caliber projectiles per year within the Offshore Area Subunit over the next 20 years.

15.3.2 E5 Explosions, Projectile Strikes, Fragment Strikes, Projectile Shock Waves, and Muzzle Blasts

- The extent of take (in the form of harm) of the short-tailed albatross is 310 E5 (E3/E5) larger-caliber projectiles per year within the Offshore Area Subunit over the next 20 years.

15.3.3 Small-caliber Non-Explosive Projectiles – Physical Strike

- The extent of take (in the form of harm) of the short-tailed albatross is 24,240 instances (121,200 small-caliber non-explosive projectiles) per year within the Offshore Area Subunit over the next 20 years.

15.3.4 Medium-caliber Non-Explosive Projectiles – Physical Strike and Projectile Shock Wave

- The extent of take (in the form of harm) of the short-tailed albatross is 8,636 instances (43,180 medium-caliber non-explosive projectiles) per year within the Offshore Area Subunit over the next 20 years.

15.3.5 Large-caliber Non-Explosive Projectiles – Physical Strike, Projectile Shock Wave, and Muzzle Blast

- The extent of take (in the form of harm) of the short-tailed albatross is 560 instances (2,800 large-caliber non-explosive projectiles) per year within the Offshore Area Subunit over the next 20 years.

16 EFFECT OF THE TAKE

16.1 Bull Trout

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

16.2 Marbled Murrelet

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

16.3 Short-tailed Albatross

In the accompanying Opinion, the Service determined that this level of anticipated take is not likely to result in jeopardy to the short-tailed albatross.

17 REASONABLE AND PRUDENT MEASURES

The Service believes the following reasonable and prudent measures (RPMs) are necessary and appropriate to minimize the impacts of the taking on the bull trout, marbled murrelet, and the short-tailed albatross.

1. Monitor implementation of the proposed action and report the results of that monitoring program to insure that the level of take exemption provided under this Incidental Take Statement is not exceeded.

2. Minimize the harm-related, death and injury impacts of the Navy's taking on the marbled murrelet in Conservation Zone 1 through removal of derelict fishing gear in Puget Sound and/or the Straits of Juan de Fuca that may kill or injure entangled marbled murrelets.

3. Minimize the harm-related, death and injury impacts of the Navy's taking on the short-tailed albatross in the Offshore Area by instituting a program of marine debris removal.

18 TERMS AND CONDITIONS

In order to be exempt from the prohibitions of section 9 of the ESA, the Navy must comply with the following terms and conditions, which implement the RPMs described above and outline required reporting/monitoring requirements. These terms and conditions are non-discretionary.

1. To implement RPM 1, the Navy shall submit a monitoring report by February 15 of each year providing monitoring information on Navy training and testing activities implemented in the previous year. The monitoring report shall include at a minimum, the following information for each listed species by training and testing stressor identified above under the *Form and Amount or Extent of Take section*:

   a. Stressor/activity name

   b. Date and location where the stressor/activity occurred

   c. Number and size of projectiles used, number and size of detonations, hours of MF8 sonar emissions, and explosive sonobuoy counts.

2. To implement RPM 2, the Navy shall coordinate with the Service to develop a plan for the Service's approval, within one year from the date of this Opinion, to either (1) search for and remove derelict fishing nets in Puget Sound and the Straits of Juan de Fuca, or (2) coordinate with an organization like the *Northwest Straits Coalition* to fund their search and removal efforts of such gear. Such funding or efforts under the plan should yield benefits commensurate with the number of murrelets killed or injured by the proposed action in Conservation Zone 1 over the next 20 years. That is, derelict gear removal should occur at a rate that would minimize the impact of the take anticipated. Removal of derelict fishing nets pursuant to the Navy's implementation of the approved plan is likely to reduce murrelet death or injury due to their entanglement in the drifting nets during foraging activities. This reduction in murrelet death and injury impacts within the action area will indirectly minimize the impacts of death and injury-related take on the murrelet caused by the proposed action.

3. To implement RPM 3, the Navy shall coordinate with the Service to develop a plan for the Service's approval, within one year from the date of this Opinion, to either fund or implement efforts to remove plastic and other debris from the marine environment within the Offshore Area. Such funding or efforts should yield benefits commensurate with the number of short-tailed albatross anticipated to be taken by the proposed action over the next 20 years. Removal of such debris pursuant to the Navy's implementation of the approved plan is likely to reduce albatross death or injury due to their ingestion of debris during foraging activities. This reduction in albatross death and injury impacts within the action area will indirectly minimize the impacts of death and injury-related take on the albatross caused by the proposed action.

19 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.

The Service provides the following recommendations:

1. To assist the Service in analyzing the effects of the Navy's activities on listed species, we request that the following information be provided along with the above annual monitoring report. The Service is available to discuss best information to monitor.

    a. For each activity conducted:

        i. Activity name as described in the proposed action

        ii. Number of events conducted throughout the year

        iii. Location of each event – as specific as possible (i.e. distance offshore)

        iv. Date event occurred – including beginning and end dates

v. Time event occurred, providing as much information as possible on when specific portions of the event occurred

vi. Number of ordnances used per event

vii. Total hours of sonar used per event

b. For projectiles and missiles:

i. Type and number of projectiles and missiles used per event

ii. Firing rate – for a given event (i.e., 5 bursts per shot, number of shots per minute, etc.)

iii. How many projectiles or missiles are fired along the same trajectory (i.e., is both the firing location and target stationary so all projectiles and missiles are fired along the same trajectory, or is the firing location moving and the target stationary, or both are moving, etc.)

iv. Distance projectiles and missiles traveled, distance to target

v. Accuracy of projectiles or missiles hitting the target

c. For sonar:

i. Type of sonar used

ii. Duration sonar was used

iii. Average time sonar was used per hour

2. The information used to determine effects of acoustics (explosives, sonar, projectile shock wave, etc.) is dated. The Service requests that the Navy monitor acoustic levels of different activities to provide updated information for technology used by the Navy. The Service requests that the Navy coordinate with the Service to develop an acoustic monitoring plan to determine SPL, impulse levels, and other acoustic metrics for the following activities:

a. Underwater explosives

b. In-air explosives

c. Sonar SPL outputs

d. Bow shock or projectile shockwaves

3. Improve upon debris retrieval and removal processes. Debris related to detonations, weapons firing and other training activity should be retrieved whenever possible. Disposal should be done at a secure upland location to ensure that it does not re-enter the marine environment.

4. Reduce marine forage base threats to the marbled murrelet by avoiding impacts to marine shoreline, eelgrass, and other habitats where marine forage fish spawn. Offset existing and future impacts to these habitats by completing effective shoreline and marine habitat restoration projects and by conserving marine shoreline habitat areas within the range of the marbled murrelet.

5. Develop and/or fund research programs that improve our understanding of the hearing capabilities of seabirds as well as how seabirds are affected by elevated sound levels and shock waves.

6. Develop and/or fund research programs that improve our understanding of the abundance, distribution, and status of marine forage fish that comprise the prey base of the marbled murrelet.

7. To the maximum extent possible, conduct training and testing activities that produce the following stressors beyond 50 nm from shore in the Offshore Area, to avoid, reduce, or minimize the take of marbled murrelets: E3 and E4 detonations; E1 medium-caliber projectiles; E3/E6 large-caliber projectiles; and small-caliber, medium-caliber, and large-caliber non-explosive projectiles.

8. The Navy should coordinate with the Service to develop a plan, within one year from the date of this Opinion, that relies on adaptive management to refine our understanding of the take impacts on the bull trout, marbled murrelet, and short-tailed albatross caused by the proposed action. Such information may trigger adjustments to the Incidental Take Statement or reinitiation of consultation, as appropriate, and facilitate the identification of additional ways to further minimize the impacts of take on these species caused by the proposed action.

20 REINITIATION NOTICE

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

21 LITERATURE CITED

Abbott, R.R., E. Bing-Sawyer, and R. Blizard. 2002. Assessment of pile driving impacts on the Sacramento blackfish (*Orthodon microlepidotus*). Caltrans, Administrative draft, Oakland, California, October 10, 2002. 16 pp.

Abookire, A.A., and J.F. Piatt. 2005. Oceanographic conditions structure forage fishes into lipid-rich and lipid-poor communities in lower Cook Inlet, Alaska, USA. Marine Ecology Progress Series 287:229-240.

Abraham, C.L., and W.J. Sydeman. 2004. Ocean climate, euphausiids and auklet nesting: inter-annual trends and variation in phenology, diet and growth of a planktivorous seabird, Ptychoramphus aleuticus. Marine Ecology Progress Series 274:235-250.

Adams, J., J.J. Felis, J.W. Mason, and J.Y. Takekawa. 2014. Pacific continental shelf environmental assessment (PaCSEA): Aerial seabird and marine mammal surveys off northern California, Oregon and Washington, 2011-2012. Bureau of Ocean Energy Management, BOEM 2014-003, Santa Cruz and Vallejo, CA, March, 2014. 266 pp.

Ainley, D.G., S.G. Allen, and L.B. Spear. 1995. Offshore occurrence patterns of marbled murrelets in central California. Pages 361-369 In Ecology and conservation of the marbled murrelet General Technical Report: PSW-GTR-152, Pacific Southwest Experimental Station, U.S. Forest Service, Albany, California.

Allsopp, M., A. Walters, D. Sanillo, and P. Johnston. 2006. Plastic debris in the world's oceans, 44. Available at <http://www.unep.org/regionalseas/marinelitter/publications/docs/plastic_ocean_report.pdf> (Date Accessed: December 1, 2015).

Auman, H.J., J.P. Ludwig, J.P. Giesy, and T. Colborn. 1997. Plastic ingestion by Laysan albatross chicks on Sand Island Midway Atoll, in 1994 and 1995. Pages 239-244 In G. Robinson, and R. Gales, eds. Albatross biology and conservation, Surrey Beatty & Sons, Chipping Norton, New South Wales, Australia.

Austin Jr, O.L. 1949. The status of Stellar's albatross. Pacific Science 3:283-295.

Avery-Gomm, S., J.F. Provencher, K.H. Morgan, and D.F. Bertram. 2013. Plastic ingestion in marine-associated bird species from the eastern North Pacific. Marine Pollution Bulletin 72(1):257-259.

Avery-Gomm, S., P.D. O'Hara, L. Kleine, V. Bowes, L.K. Wilson, and K.L. Barry. 2012. Northern fulmars as biological monitors of trends of plastic pollution in the eastern North Pacific. Marine Pollution Bulletin http://dx.doi.org/10.1016/j.marpolbul.2012.04.017:1-6.

Ballance, L.T., D.G. Ainley, and G.L. Hunt Jr. 2001. Seabird foraging ecology. Pages 2636-2644 *In* J.H. Steele, S.A. Thorpe, and K.K. Turekian, eds. Encyclopedia of ocean sciences, 5th. Academic Press, London, UK.

Balmori, A. 2005. Possible effects of electromagnetic fields from phone masts on a population of white stork (*Ciconia ciconia*). Electromagnetic Biology and Medicine 24:109-119.

Barrett, J. 2008. The influence of oceanographic and terrestrial attributes on marbled Murrelet (*Brachyramphus marmoratus*) marine habitat selection during the breeding season. BSc. Agricultural and Environmental Sciences. McGill University, Burnaby, BC, Canada. 81 pp.

Barrett, J., D.B. Lank, D. Esler, and K. Rothley. 2008. Marine habitat selection by breeding and non-breeding marbled murrelets in summer: The influence and interaction of fine scale oceanographic processes and terrestrial habitat.

Battin, J., M.W. Wiley, M.H. Ruckelshaus, R.N. Palmer, E. Korb, K.K. Bartz, and H. Imaki. 2007. Projected impacts of climate change on salmon habitat restoration. Proceedings of the National Academy of Sciences of the United States of America 104(16):6720-6725.

Beamer, E. 2003. Unpublished beach seine data in Crescent Harbor.

Beauchamp, W.D., F. Cooke, C. Lougheed, L.W. Lougheed, C.J. Ralph, and S. Courtney. 1999. Seasonal movements of marbled murrelets: evidence from banded birds. Condor 101(3):671-674.

Becker, B.H. 2001. Effects of oceanographic variation on marbled murrelet diet and habitat selection. Doctorate of Science. University of California at Berkeley, Berkeley, CA.

Becker, B.H., and S.R. Beissinger. 2003a. Scale-dependent habitat selection by a nearshore seabird, the marbled murrelet, in a highly dyanamic upwelling system. Marine Ecology-Progress Series 256:243-255.

Becker, B.H., and S.R. Beissinger. 2003b. Scale-dependent habitat selection by a nearshore seabird, the marbled murrelet, in a highly dynamic upwelling system. Marine Ecology Progress Series 256:243-255.

Becker, B.H., M.Z. Peery, and S.R. Beissinger. 2007. Ocean climate and prey availability affect the trophic level and reproductive success of the marbled murrelet, an endangered seabird. Inter-Research Marine Ecology Progress Series 329:267-279.

Beissinger, S.R. 1995. Population trends of the marbled murrelet projected from demographic analyses. Pages 385-393 In C.J. Ralph, G.L. Hunt, M.G. Raphael, and J.F. Piatt, eds. Ecology and conservation of the marbled murrelet. General Technical Report: PSW-GTW-152, Pacific Southwest Experimental Station, U.S. Forest Service, Albany, California.

Bentivoglio, N., J. Baldwin, P.G.R. Jodice, D. Evans Mack, T. Max, S. Miller, S.K. Nelson, K. Ostrom, C.J. Ralph, M.G. Raphael, C.S. Strong, C.W. Thompson, and R. Wilk. 2002. Northwest Forest Plan marbled murrelet effectiveness monitoring 2000 annual report. U.S. Fish and Wildlife Service, Portland, Oregon, April 2002. 73 pp.

Blight, L.K., and A.E. Burger. 1997. Occurence of plastic particles in seabirds from the Eastern North Pacific. Marine Pollution Bulletin 34(5):323-325.

Bloxton, T.D., and M.G. Raphael. 2005. Breeding ecology of the marbled murrelet in Washington State: 2004 Season Summary, A report to the U.S. Fish and Wildlife Service, Western Washington Fish and Wildlife Office, Lacey, Washington; Pacific Northwest Research Station, U.S. Forest Service, Olympia, Washington. 14 pp.

Bloxton, T.D., and M.G. Raphael. 2006. At-sea movements of radio-tagged marbled murrelets in Washington. Northwestern Naturalist 87(2):162-162.

Bloxton, T.D., and M.G. Raphael. 2009. Breeding ecology of the marbled murrelet in Washington State, five year project summary (2004-2008). USDA Forest Service, A report to the U.S. Fish and Wildlife Service, Western Washington Fish and Wildlife Office, Lacey, Washington; Pacific Northwest Research Station, U.S. Forest Service, Olympia, Washington, May 2009. 41 pp.

Bond, A.L., J.F. Provencher, R.D. Elliot, P.C. Ryan, S. Rowe, I.L. Jones, G.J. Robertson, and S.I. Wilhelm. 2013. Ingestion of plastic marine debris by Common and Thick-billed Murres in the northwestern Atlantic from 1985 to 2012. Marine Pollution Bulletin 77:192-195.

Brenkman, S.J., and S.C. Corbett. 2007. Use of otolith chemistry and radiotelemetry to determine age-specific migratory patterns of anadromous bull trout in the Hoh River, Washington. Transactions of the American Fisheries Society 136:1-11.

Brenkman, S.J., and S.C. Corbett. 2005. Extent of anadromy in bull trout and implications for conservation of a threatened species. North American Journal of Fisheries Management 25:1073-1081.

Brennan, J.S. 2007. Marine riparian vegetation communities of Puget Sound: prepared in support of the Puget Sound nearshore partnership. U.S. Army Corps of Engineers, Seattle District, Puget Sound Nearshore Partnership Technical Report 2007-02, Seattle, Washington. 25 pp.

Brittan-Powell, E.F., and R.J. Dooling. 2002. Auditory brainstem responses in adult budgerigars (*Melopsittacus undulatus*). Journal of the Acoustical Society of America 112(3):999-1008.

Brothers, N.P., J. Cooper, and S. Lokkeborg. 1999. The incidental catch of seabirds by longline fisheries: Worldwide review and technical guidelines for mitigation. FAO Fisheries Circular, 937, Rome, 1999. 107 pp.

Brown, A.L. 1990. Measuring the effect of aircraft noise on sea birds. Environment international 16:587-592.

Bruderer, B., D. Peter, and T. Steuri. 1999. Behaviour of migrating birds exposed to X-band radar and a bright light beam. The Journal of Experimental Biology 202:1015-1022.

Buchanan, K.L. 2000. Stress and the evolution of condition-dependent signals. Trends in Ecology & Evolution 15(4):156-160.

Burger, A.E. 1995. Marine distribution, abundance and habitat of marbled murrelets in British Columbia. Pages 295-312 In C.J. Ralph, G.L. Hunt, M.G. Raphael, and J.F. Piatt, eds. Ecology and conservation of the marbled murrelet. General Technical Report.PSW-GTW-152, Pacific Southwest Experimental Station, U.S. Forest Service, Albany, California.

Burger, A.E. 2000. Bird in hot water: responses by Marbled Murrelets to variable ocean temperatures off Southwestern Vancouver Island. Pages 723-732 In Proceedings of a Conference on the Biology and Management of Species and Habitats at Risk, February 15-19, 1999, B.C. Ministry of Environment, Lands and Parks, Victoria, B.C., and University College of the Cariboo, Kamloops, B.C.

Burger, A.E. 2002. Conservation assessment of marbled murrelets in British Columbia: a review of biology, populations, habitat associations and conservation. Canadian Wildlife Service, Technical Report Series Number 387, Pacific and Yukon Region, July 2002. 194 pp.

Burger, A.E., and T.A. Chatwin. 2002. Multi-scale studies of populations, distribution and habitat associations of marbled murrelets in Clayoquot Sound, British Columbia. Ministry of Water, Land and Air Protection, Victoria, BC, March 2002. 162 pp.

Burkett, E.E. 1995. Marbled murrelet food habits and prey ecology. Pages 223-246 In C.J. Ralph, G.L. Hunt, M.G. Raphael, and J.F. Piatt, eds. Ecology and conservation of the marbled murrelet. General Technical Report: PSW-GTW-152, Pacific Southwest Experimental Station, U.S. Forest Service, Albany, California.

Busch, D.S., and L.S. Hayward. 2009. Stress in a conservation context: A discussion of glucocorticoid actions and how levels change with conservation-relevant variables. Biological Conservation 142(12):2844-2853.

Carter, H.R., and S.G. Sealy. 1990. Daily foraging behavior of marbled murrelets. Studies in Avian Biology 14:93-102.

Champion, H.R. 2009. Injuries from explosions: Physics, biophysics, pathology, and required research focus. The Journal of Trauma Injury, Infection, and Critical Care 66:1468-1477.

Collins, M., R. Knutti, J. Arblaster, J. Dufresne, T. Fichefet, P. Friedlingstein, X. Gao, W.J. Gutowski Jr., T. Johns, G. Krinner, M. Shongwe, C. Tebaldi, A.J. Weaver, and M. Wehner. 2013. Long-term climate change: Projections, commitments and irreversibility. Pages 1029-1136 In T.F. Stocker, D. Qin, G.-. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex, and P.M. Midgley, eds. Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, United Kingdom and New York, NY.

Commander, Pacific Fleet and Naval Sea Systems Command. 2015. Supplemental Analysis for the Northwest Training and Testing Biological Evaluation: Analysis of Potential Effects to Bull Trout Designated Critical Habitat. USN, March 30, 2015. 25 pp.

Commander, Pacific Fleet and Naval Sea Systems Command. 2016. U.S Fish and Wildlife Service, Washington. Enclosure 1: Justification why marbled murrelets will not be affected by high frequency sonars. January 13, 2016.

Cooper, J. 1982. Methods of reducing mortality of seabirds caused by underwater blasting. Cormorant 10:109-113.

Cornell Lab of Ornithology. August 11, 2015. Snowy plover siting checklist S24579592, 2. Available at <https://ebird.org/ebird/view/checklist?subID=S24579592> (Date Accessed: October 1, 2015).

Crowell, S.E., A.M. Wells-Berlin, C.E. Carr, G.H. Olsen, R.E. Therrien, S.E. Yannuzzi, and D.R. Ketten. 2015. A comparison of auditory brainstem responses across diving bird species. Journal of Comparative Physiology A 201(8):803-815.

Cucurachi, S., W.L.M. Tamis, M.G. Vijver, W.J.G.M. Peijnenburg, J.F.B. Bolte, and G.R. deSnoo. 2013. A review of the ecological effects of radiofrequency electromagnetic fields (RF-EMF). Environment International 51:116-140.

Cudahy, E., and W.T. Ellison. 2002. A review of the potential for in vivo tissue damage by exposure to underwater sound. Naval Submarine Research Laboratory, Department of the Navy, Groton, Connecticut, March 12, 2002. 6 pp.

Cury, P.M., I.L. Boyd, S. Bonhommeau, T. Anker-Nilssen, R.J.M. Crawford, R.W. Furness, J.A. Mills, E.J. Murphy, H. Osterblom, M. Paleczny, J.F. Piatt, J. Roux, L. Shannon, and W.J. Sydeman. 2011. Global seabird response to forage fish depletion - One-third for the birds. Science 334:1703-1706.

Damon, E.G., D.R. Richmond, E.R. Fletcher, and R.K. Jones. 1974. The Tolerance of Birds to Airblast. National Technical Information Service, AD-785 259, Springfield, VA, July 23, 1974. 38 pp.

Davis, R.J., K.M. Dugger, S. Mohoric, L. Evers, and W.C. Aney. 2011. Northwest forest plan- the first 15 years (1994-2008): status and trends of northern spotted owl populations and habitats. USDA, USFS, Pacific Northwest Research Station, General Technical Report PNW-GTR-850, Portland, Oregon, October 2011. 147 pp.

Day, R.H., and D.A. Nigro. 2000. Feeding ecology of Kittlitz's and marbled murrelets in Prince William Sound, Alaska. Waterbirds 23(1):1-14.

Delaney, D.K., T.G. Grubb, P. Beier, L.L. Pater, and M.H. Reiser. 1999. Effects of helicopter noise on Mexican spotted owls. Journal of Wildlife Management 63(1):60-76.

Department of Homeland Security. 2009. Bomb threat stand-off chart, 1. Available at <https://www.llis.dhs.gov/sites/default/files/DHS-BombThreatChart-6-5-09.pdf> (Date Accessed: August 13, 2014).

Department of the Navy. 2015. Environmental Monitoring of Explosive Ordnance Disposal Underwater Detonation Training in the Northwest Training Range Complex on September 30, 2014. Navy Region Northwest, Naval Facilities Engineering Command, and Naval Undersea Warfare Center, Keyport., January 26, 2015. 25 pp.

Derose-Wilson, A., J.D. Fraser, S.M. Karpanty, and M.D. Hillman. 2015. Effects of overflights on incubating Wilson's plover behavior and heart rate. The Journal of Wildlife Management 79(8):1246-1254.

Di Lorenzo, E., A.J. Miller, N. Schneider, and J.C. McWilliams. 2005. The warming of the California current system: Dynamics and ecosystem implications. Journal of Physical Oceanography 35:336-362.

Doksaeter, L., N.O. Handegard, O.R. Godo, P.H. Kvadsheim, and N. Nordlund. 2012. Behavior of captive herring exposed to naval sonar transmissions (1.0–1.6 kHz) throughout a yearly cycle. Journal of Acoustical Society of America 131(2):1632-1642.

Dolbeer, R.A. 2006. Height distribution of birds recorded by collisions with civil aircraft. The Journal of Wildlife Management 70(5):1345-1350.

Dooling, R.J. 2002. Avian hearing and the avoidance of wind turbines. University of Maryland, NREL/TP-500-30844, College Park, Maryland, June 2002. 84 pp.

Dooling, R.J., B. Lohr, and M.L. Dent. 2000. Chapter 7: Hearing in birds and reptiles. Pages 309-359 In R.J. Dooling, F.R. Richard, and A.N. Popper, eds. Comparative hearing: birds and reptiles, Springer-Verlag New York, Inc., New York, New York.

Dooling, R.J., and A.N. Popper. 2007. The effects of highway noise on birds. Environmental BioAcoustics LLC, Rockville, Maryland, September 30, 2007. 74 pp.

Dooling, R.J. 1980. Behavior and psychophysics of hearing in birds. Pages 261-288 In A.N. Popper, and R.R. Fay, eds. Comparative studies of hearing in vertebrates, Springer Vertlag, New York.

Dooling, R.J. 1982. Auditory perception in birds. In D.E. Kroodsma, E. Miller, and H. Ouellet, eds. Acoustic communication in birds, Academic Press, New York.

Dooling, R.J., and E.F. Brittan-Powell. 2005. Draft proposal: outline for measuring hearing sensitivity in the Alcidae. Center for the Comparative and Evolutionary Biology of Hearing, University of Maryland, College Park, MD, October 2005.

Dooling, R.J., and M.L. Dent. 2002. General principles involved in the effect of noise on hearing and vocal communications in birds. Journal of the Acoustical Society of America 111(5):2391.

Dooling, R.J., B. Lohr, and M.L. Dent. 2000. Chapter 7 hearing in birds and reptiles. Pages 308-359 In R.J. Dooling, R.R. Fay, and A.N. Popper, eds. Comparative studies of hearing in vertebrates, Springer, New York.

Dooling, R.J., and S.C. Therrien. 2012. Hearing in birds: What changes from air to water. Pages 77-82 In A.N. Popper, and A. Hawkins, eds. Effects of Noise on Aquatic Life, Springer Verlag, New York, NY.

Ebbesmeyer, C.C., W.J. Ingraham Jr., T.C. Royer, and C.E. Grosch. 2007. Tub toys orbit the Pacific subarctic gyre. EOS, Transactions American Geophysical Union 88(1):1-3.

Efroymson, R.A., W.H. Rose, S. Nemeth, and G.W. Suter II. 2000. Ecological risk assessment framework for low-altitude overflights by fixed-wing and rotary-wing military aircraft. Oak Ridge National Laboratory, ORNL/TM-2000/289, Oak Ridge, TN. 115 pp.

Eriksen, M., L.C.M. Lebreton, H.S. Carson, M. Thiel, C.J. Moore, J.C. Borerro, F. Galgani, P.G. Ryan, and J. Reisser. 2014. Plastic pollution in the world's oceans: More than 5 trillion plastic pieces weighing over 250,000 tons afloat at sea. PloS ONE 9(12):e111913. doi:10.1371/ journal.pone.0111913.

Evans Mack, D., W.P. Ritchie, S.K. Nelson, E. Kuo-Harrison, P. Harrison, and T.E. Hamer. 2003. Methods for surveying marbled murrelets in forests: a revised protocol for land management and research. Pacific Seabird Group unpublished document available at http://www.pacificseabirdgroup.org, Seattle, Washington, January 6, 2003. 81 pp.

Evans, D., and Asso. INC. 1999. Environmental baseline assessment for Chinook salmon (*Oncorhynchus ishawytscha*) and native char (*Salvelinus confluentus, Salvelinus malma*) in the Sauk River and Sauk River Forks fifth-field watersheds. Prepared for Mt. Baker Snoqualmie National Forest, April 30, 1999. 13 pp.

Falxa, G.A., D. Baldwin, S.K. Lynch, S.L. Nelson, and S.F. Miller. 2009. Marbled murrelet effectiveness monitoring, Northwest Forest Plan: 2008 summary report, August 2009. 19 pp.

Falxa, G.A., and M.G. Raphael. 2015. Northwest Forest Plan—The First Twenty Years (1994-2013): Status and Trend of Marbled Murrelet Populations and Nesting Habitat. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Gen. Tech. Rep. PNW-GTR-XXXX, Portland, OR, May 26, 2015. 191 pp.

Falxa, G., J. Baldwin, M. Lance, D. Lynch, S.K. Nelson, S.F. Pearson, M.G. Raphael, C. Strong, and R. Young. 2015. Marbled murrelet effectiveness monitoring, Northwest Forest Plan: 2014 summary report. Northwest Forest Plan Interagency Regional Monitoring Program, Portland, OR, August 2015. 18 pp.

Federal Aviation Administration. 2002. Estimated airplane noise levels in A-weighted decibels, 127. Available at <http://www.faa.gov/documentLibrary/media/Advisory_Circular/AC%2036-3H%20Base.pdf> (Date Accessed: October 22, 2015).

Federal Aviation Administration. 2014. Aeronautical information manual. Official guide to basic flight information and ATC procedures. U.S. Department of Transportation, www.faa.gov/atpubs, April 3, 2014. 726 pp.

FEMA. 2003. Risk management series: Reference manual to mitigate potential terrorist attacks against buildings. FEMA.

Fernie, K.J., and D.M. Bird. 2000. Effects of electromagnetic fields on the growth of nestling American kestrels. The Condor 102(2):461-465.

Fernie, K.J., and S.J. Reynolds. 2005. The effects of electromagnetic fields from power lines on avian reproductive biology and physiology: A review. Journal of Toxicology and Environmental Health, Part B 8:127-140.

Finfer, D.C., T.G. Leighton, and P.R. White. 2008. Issues relating to the use of a 61.5 dB conversion factor when comparing airborne and underwater anthroprogenic noise levels. Applied Acoustics 69:464-471.

Finkelstein, M.E., S. Wolf, M. Goldman, D.F. Doak, P.R. Sievert, and G.H. Balough H. 2010. The anatomy of a (potential) disaster: Volcanoes, behavior, and population viability of the short-tailed albatross (*Phoebastria albatrus*). Biological Conservation 143:321-331.

Fitch, J.E., and P.H. Young. 1948. California Fish and Game 34(2):53-70.

Fitzgerald, K. 2015. Email from Katherine Fitzgerald, Endangered Species Biologist, USFWS, to Lindsy Wright, Fish and Wildlife Biologist, USFWS, re: duration of each "count" of sonar for NWTT. November 12, 2015.

Flint, P., J.A. Reed, J.C. Franson, T.E. Hollmen, J.B. Grand, M.D. Howell, R.B. Lanctot, D.L. Lacroix, and C.P. Dau. 2003. Monitoring Beaufort Sea waterfowl and marine birds. U.S. Geological Survey, Alaska Science Center, OCS Study MMS 2003-037, Anchorage, AK. 125 pp.

Food and Agricultural Organization of the United Nations. 1999. International plan of action for reducing incidental catch of seabirds in longline fisheries. FAO Fisheries and Aquaculture Department. 1 pp.

Forsman, E.D., R.G. Anthony, K.M. Dugger, E.M. Glenn, A.B. Franklin, G.C. White, C.J. Schwarz, K.P. Burnman, D.R. Anderson, J.D. Nichols, J.E. Hines, J.B. Lint, R.J. Davis, S.H. Ackers, L.S. Andrews, B.L. Biswell, P.C. Carlson, L.V. Diller, S.A. Gremel, D.R. Herter, J.M. Higley, R.B. Horn, J.A. Reid, J. Rockweit, J.P. Schaberl, T.J. Snetsinger, and S.G. Sovern. 2011. Population demography of northern spotted owls. Studies in avian biology No. 40. A publication of the Cooper Ornithological Society, University of California Press, Berkeley, California. 106 pp.

Forsman, E.D., E.C. Meslow, and H.M. Wight. 1984. Distribution and biology of the spotted owl in Oregon. USDA, 87, Corvallis, Oregon, 1984. 64 pp.

Ganguly, A.R., K. Steinhaeuser, D.J. Erickson, M. Branstetter, E.S. Parish, N. Singh, J.B. Drake, and L. Buja. 2009. Higher trends but larger uncertainty and geographic variability in 21st century temperature and heat waves. Proceedings of the National Academy of Sciences 106(37):15555-15559.

Gaspin, J.B. 1975. Experimental investigations of the effects of underwater explosions on swimbladder fish, I: 1973 Chesapeake Bay tests. White Oak Laboratory, Naval Surface Weapons Center, NSWC/WOL/TR 75-58, Silver Spring, Maryland. 76 pp.

Gaston, A.J., and J.L. Smith. 2001. Changes in oceanographic conditions off northern British Columbia (1983–1999) and the reproduction of a marine bird, the Ancient Murrelet (Synthliboramphus antiquus). Canadian Journal of Zoology 79:1735-1742.

Gilman, E., C.H. Boggs, N. Brothers, J. Ray, B. Woods, K. Ching, J. Cook, S. Martin, and D. Chaffey. 2002. Performance assessment of an underwater setting chute to minimize seabird mortality in the Hawaii pelagic longline tuna fishery. Submitted to U.S. Fish and Wildlife Service in fulfillment of Endangered Species Act and Migratory Bird Treaty Act permit conditions, Final Report, Honolulu, HI, December 2002. 58 pp.

Gilman, E., N.P. Brothers, and D.R. Kobayashi. 2005. Principles and approaches to abate seabird by-catch in longline fisheries. Fish and Fisheries 6:35-49.

Gilman, E., N. Brothers, and D.R. Kobayashi. 2007. Comparison of three seabird bycatch avoidance methods in Hawaii-based pelagic longline fisheries. Fisheries Science 73:208-210.

Gilman, E., D.R. Kobayashi, and M. Chaloupka. 2008. Reducing seabird bycatch in the Hawaii longline tuna fishery. Endangered Species Research 5:309-323.

Gisiner, R.C., E. Cudahy, G.V. Frisk, R. Gentry, R. Hofman, A.N. Popper, and J.W. Richardson. 1998. Effects of anthropogenic noise in the marine environment. Pages 1-141 In Gisiner, R.C. ed. Workshop on the effects of anthropogenic noise in the marine environment, February 10-12, 1998, Marine Mammal Science Program, Office of Naval Research, Arlington, VA. 141 pp.

Glick, P., B.A. Stein, and N.A. Edelson. 2011. Scanning the conservation horizon: a guide to climate change vulnerability assessment. National Wildlife Federation, Washington, D.C., 2011. 168 pp.

Glick, P., J. Clough, and B. Nunley. 2007. Sea-level rise and coastal habitats in the Pacific northwest an analysis for Puget Sound, southwestern Washington, and northwestern Oregon. National Wildlife Federation, Washington, D.C., July 2007. 106 pp.

Goetz, F., E. Connor, E. Jeanes, and M. Hayes. 2012. Migratory patterns and habitat use of bull trout in the Puget Sound. Presentation at the *Salvelinus Confluentus* Curiosity Society Meeting, NatureBridge, Lake Crescent, Olympic National Park, August 15-17, 2012.

Goetz, F., E.D. Jeanes, and E.M. Beamer. 2004. Bull trout in the nearshore. U.S. Army Corps of Engineers, Preliminary draft, Seattle, Washington, June 2004. 396 pp.

Goetz, F., E.D. Jeanes, and C.M. Morello. 2007. Puget Sound bull trout migration and habitat use study: Nookack River and estuary and northeast Puget Sound nearshore, USFWS Interagency Agreement # 13410-6-H001, September 2007. 28 pp.

Gremel, S. 2015. Email from Scott Gremel, NPS, Wildlife Biologist, Spotted Owl Monitoring Program, ONP, to Vince Harke, USFWS, Fish and Wildlife Biologist, Washington Fish and Wildlife Office, re: Question regariding spotted owls and elevation on the Olympic Peninsula. November 1, 2015.

Guillette, L.J., T.S. Gross, G.R. Masson, J.M. Matter, H.F. Percival, and A.R. Woodward. 1994. Developmental abnormalities of the gonad and abnormal sex hormone concentrations in juvenile alligators from contaminated and control lakes in Florida. Environmental Health Perspectives 102(8):680-688.

Gutierrez, R.J., A.B. Franklin, and W.S. LaHaye. 1995. Spotted owl (Strix occidentalis). Pages 1-28 In A. Poole, and F. Gill, eds. The birds of North America no. 179, The Academy of Natural Sciences and The American Ornithologists' Union, Washington, D.C.

Guy, T.J., S.L. Jennings, R.M. Suryan, E.F. Melvin, M.A. Bellman, L.T. Ballance, B.A. Blackie, D.A. Croll, T. Deguchi, T.O. Geernaert, R.W. Henry, M. Hester, K.D. Hyrenbach, J. Jahncke, M.A. Kappes, K. Ozaki, J. Roletto, F. Sato, W.J. Sydeman, and J.E. Zamon. 2013. Overlap of North Pacific albatrosses with the U.S. west coast groundfish and shrimp fisheries. Fisheries Research 147:222-234.

Halvorsen, M.B., B.M. Casper, C.M. Woodley, T.J. Carlson, and A.N. Popper. 2012. Threshold for onset of injury in chinook salmon from exposure to impulsive pile driving sounds. PloS one 7(6):1-11.

Halvorsen, M.B., D.G. Zeddies, D.R. Chicoine, and A.N. Popper. 2013. Effects of low-frequency naval sonar exposure on three species of fish. Journal of Acoustical Society of America 134(2):1-6.

Halvorsen, M.B., D.G. Zeddies, W.T. Ellison, D.R. Chicoine, and A.N. Popper. 2012. Effects of mid-frequency active sonar on hearing in fish. Journal of Acoustical Society of America 131(1):599-607.

Hamer Environmental, L.P. 2009. Use of radar to determine passage rates and height distributions of marbled murrelets at the proposed radar ridge wind resource area, Pacific County, Washington. Hamer Environmental, L.P., Final Report: Breeding Season 2007, Winter & Breeding Seasons 2008, Winter & Breeding Seasons 2009, Mount Vernon, WA, August 31, 2009. 54 pp.

Hamer, T.E., and S.K. Nelson. 1995. Characteristics of marbled murrelet nest trees and nesting stands. Pages 69-82 In C.J. Ralph, G.L. Hunt, M.G. Raphael, and J.F. Piatt, eds. Ecology and conservation of the marbled murrelet, U.S. Department of Agriculture Forest Service, Pacific Southwest Research Station, General Technical Report PSW-152, Albany, California.

Hamer, T., and K. Nelson. 1998. Effects of disturbance on nesting marbled murrelets: Summary of preliminary results. 24 pp.

Hasegawa, H., and A.R. DeGange. 1982. The short-tailed albatross, *Diomedea albatrus*, its status, distribution and natural history. American Birds 36(5):806-814.

Hastings, M.C. 1995. Physical effects of noise on fishes. Inter-noise, Newport Beach, California. 6 pp.

Hastings, M.C., and A.N. Popper. 2005. Effects of sound on fish. California Department of Transportation, Contract No. 43A0139, Task Order, 1, Sacramento, CA, January 28, 2005. 82 pp.

Hastings, M.C., A.N. Popper, J.J. Finneran, and P. Lanford. 1996. Effects of low-frequency underwater sound on hair cells of the inner ear and lateral line of the teleost fish *Astronotus ocellatus*. Journal of the Acoustical Society of America 99(3):1759-1766.

Hawkins, A.D., and A.D.F. Johnstone. 1978. The hearing of the Atlantic Salmon, Salmo salar. Journal of Fish Biology 13(6):655-673.

Hawkins, A.D., and A.N. Popper. 2014. Assessing the impact of underwater sounds on fishes and other forms of marine life. Acoustics Today :30-41.

Haynes, T.B., R.A. Ronconi, and A.E. Burger. 2007. Habitat use and behavior of the Pacific sand lance (*Ammodytes hexapterus*) in the shallow subtidal region of southwestern Vancouver Island. Northwestern Naturalist 88:155-167.

Hayward, L.S., A.E. Bowles, J.C. Ha, and S.K. Wasser. 2011. Impacts of acute and long-term vehicle exposure on physiology and reproductive success of the northern spotted owl. Ecosphere 2(6).

Hazen, E.L., S. Jogensen, R.R. Rykaczewski, S.J. Bograd, D.G. Foley, I.D. Jonsen, S.A. Shaffer, J.P. Dunne, D.P. Costa, L.B. Crowder, and B.A. Block. 2012. Predicted habitat shifts of Pacific top predators in a changing climate. Nature Climate Change doi:10.1038/nclimatel686.

Health Canada. 2015. Limits of human exposure to radiofrequency electromagnetic energy in the frequency range from 3 KHZ to 300 KHZ. Consumer and Clinical Radiation Protection Bureau Environmental and Consumer Safety Branch, Safety Code 6 (2015), Health Canada. 18 pp.

Heatwole, D. 2003. Email from Danelle Heatwole, Wetland Ecosystem Team at the School of Aquatic & Fishery Sciences, University of Washington, to Jim Muck, Fish and Wildlife Biologist at the USFWS, Washington Fish and Wildlife Office, re: Crescent Harbor Data. December 17, 2003.

Hebert, P.N., and R.T. Golightly. 2006. Movements, nesting, and response to anthropogenic disturbance of marbled murrelets (*Brachyramphus marmoratus*) in Redwood National and State Parks, California. California Department of Fish and Game, 2006-02, Sacramento, California, May, 2006. 321 pp.

Henkel, L.A., R.G. Ford, W.B. Tyler, and J.N. Davis. 2007. Comparison of aerial and boat-based survey methods for marbled murrelets *Brachyramphys Marmoratus* and other marine birds. Marine Ornithology 35:145-151.

Henkel, L.A., and J.T. Harvey. 2006. Potential prey resources for marbled murrelets in Central California. California Fish and Game 92(4):191-206.

Henry, B., and B. Tyler. 2014. 2014 at-sea monitoring of marbled murrelets in Central California. UC Santa Cruz, Institute of Marine Science, Santa Cruz, CA, November 13, 2014. 5 pp.

Hildebrand, J.A. 2009. Anthropogenic and natural sources of ambient noise in the ocean. Marine Ecology Progress Series 395:5-20.

Hillman, M.D., S.M. Karpanty, J.D. Fraser, and A. Derose-Wilson. 2015. Effects of Aircraft and Recreation on Colonial Waterbird Nesting Behavior. The Journal of Wildlife Management 79(7):1192-1198.

Hirai, H., H. Takada, Y. Ogata, R. Yamashita, K. Mizukawa, M. Saha, C. Kwan, C. Moore, H. Gray, D. Laursen, E.R. Zettler, J.W. Farrington, C.M. Reddy, E.E. Peacock, and M.W. Ward. 2011. Organic micropollutants in marine plastics debris from the open ocean and remote and urban beaches. Marine Pollution Bulletin 62:1683-1692.

Holberton, R.L., B. Helmuth, and J.C. Wingfield. 1996. The corticosterone stress response in gentoo and king penguins during the non-fasting period. The Condor 98(4):850-854.

Holthuijzen, A.M.A., W.G. Eastland, A.R. Ansell, M.N. Kochert, R.D. Williams, and L.S. Young. 1990. Effects of blasting on behavior and productivity of nesting prairie falcons. Wildlife Society Bulletin 18(3):270-281.

Hood, L.C., P.D. Boersma, and J.C. Wingfield. 1998. The adrenocortical response to stress in incubating magellanic penguins (*Spheniscus magellanicus*). Auk 115(1):76-84.

Huber, M., and R. Knutti. 2011. Anthropogenic and natural warming inferred from changes in Earth’s energy balance. Nature Geoscience 5(1):31-36.

Hull, C.L., G.W. Kaiser, C. Lougheed, L.W. Lougheed, S. Boyd, and F. Cooke. 2001. Intraspecific variation in commuting distance of marbled murrelets (*Brachyramphus marmoratus*): Ecological and energetic consequences of nesting further inland. The Auk 118(4):1036-1046.

Hunt Jr., G.L., C.L. Baduini, Brodeur, R. D. Coyle,K. O., N.B. Kachel, J.M. Napp, S.A. Salo, J.D. Schumacher, P.J. Stabeno, D.A. Stockwell, T.E. Whitledge, and S.I. Zeeman. 1999. The Bering Sea in 1998: The second consecutive year of extreme weather-forced anomalies. EOS, Transactions American Geophysical Union 80(47):561-572.

IPCC (Intergovernmental Panel on Climate Change). 2007a. Climate change 2007: Synthesis report. Contribution of working groups I, II and III to the fourth assessment report of the Intergovernmental Panel on Climate Change. Intergovernmental Panel on Climate Change;, Geneva, Switzerland, 2007. 52 pp.

IPCC. 2007b. Summary for policymakers. pp 1-18 In: Climate Change 2007: The physical science basis. Contribution of working group I to the fourth assessment report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, New York, 2007. 582 pp.

IPCC. 2012. Summary for policy makers. Pages 3-21 In C.B. Field, V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L.:. Ebi M.D., K.J. Mach, G. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley, eds. Managing the risks of extreme events and disasters to advance climate change adaptation. A special report of working groups I and II of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, United Kingdom and New York, New York.

IPCC. 2014a. Climate change 2014: Impacts, adaptation, and vulnerability part A: Global and sectoral aspects, contribution of working group II to the fifth assessment report of the intergovernmental panel on climate change. Cambridge University Press, Cambridge, UK. 1150 pp.

IPCC. 2014b. Climate change 2014: Synthesis report, contribution of working groups I, II, and III to the fifth assessment report of the intergovernmental panel on climate change. Intergovernmental Panel on Climate Change, Geneva, Switzerland. 151 pp.

Jessop, T.S., A.D. Tucker, C.J. Limpus, and J.M. Whittier. 2003. Interactions between ecology, demography, capture stress, and profiles of corticosterone and glucose in a free-living population of Australian freshwater crocodiles. General and comparative endocrinology 132(1):161-170.

Jiang, Z. 2003. Wave dynamic processes induced by a supersonic projectile discharging from a shock tube. Physics of Fluids 15(6):1665-1675.

Johnson, C.L., and R.T. Reynolds. 2002. Responses of Mexican spotted owls to low-flying military jet aircraft. USDA, Forest Service, Rocky Mountain Research Station, RMRS-RN-12, Fort Collins, CO, January 2002. 4 pp.

Johnston, E.L., and D.A. Roberts. 2009. Contaminants reduce the richness and evenness of marine communities: A review and meta-analysis. Environmental Pollution 157:1745-1752.

Jones, I.L., F.M. Hunter, and G.J. Robertson. 2002. Annual adult survival of Least Auklets (Aves, Alcidae) varies with large-scale climatic conditions of the North Pacific Ocean. Oecologia 133:38-44.

Jorgensen, R., K.K. Olsen, I. Falk-Petersen, and P. Kanapthippilai. 2005. Investigations of potential effects of low frequency sonar signals on survival, development and behaviour of fish larvae and juveniles. The Norwegian College of Fishery Science, University of Tromso, Tromso, Norway, April 2005. 51 pp.

Kane, A.S., J. Song, M.B. Halvorsen, D.L. Miller, J.D. Salierno, and L.E. Wysocki. 2010. Exposure of fish to high-intensity sonar does not induce acute pathology. Journal of Fish Biology 76(7):1825-1840.

Ketten, D.R., C. Merigo, E. Chiddick, H. Krum, and E.F. Melvin. 2000. Acoustic fatheads: parallel evolution of underwater sound reception mechanisms in dolphins, turtles, and sea birds. In Ketten, D.R., C. Merigo, E. Chiddick, H. Krum and E.F. Melvin eds. Forum Acusticum, 1999, S. Hirzel Verlag, Berlin.

Kirtman, B., S.B. Power, A.J. Adedoyin, G.J. Boer, R. Bojariu, I. Camilloni, F. Doblas-Reyes, A.M. Fiore, M. Kimoto, G. Meehl, M. Prather, A. Sarr, C. Schär, R. Sutton, G.J. van Oldenborgh, G. Vecchi, and H. Wang. 2013. Near-term climate change: Projections and predictability. Pages 953-1028 In T.F. Stocker, D. Qin, G.-. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex, and P.M. Midgley, eds. Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, United Kingdom and New York, NY.

Kitaysky, A.S., J.C. Wingfield, and J.F. Piatt. 1999. Dynamics of food availability, body condition, and physiological stress response in breeding black-legged kittiwakes. Functional Ecology 13(5):577-584.

Kitaysky, A.S. 1999. Metabolic and developmental responses of alcid chicks to experimental variation in food intake. Physiological and Biochemical Zoology 72(4):462-473.

Knudsen, F.R., C.B. Schreck, S.M. Knapp, P.S. Enger, and O. Sand. 1997. Infrasound produces flight and avoidance responses in Pacific juvenile salmonids. Journal of Fish Biology 51(4):824-829.

Korte, S.M., J.M. Koolhaas, J.C. Wingfield, and B.S. Mcewen. 2005. The Darwinian concept of stress: benefits of allostasis and costs of allostatic load and the trade-offs in health and disease. Neuroscience and biobehavioral reviews 29(1):3-38.

Kraemer, C. 1994. Some observations on the life history and behavior of the native char, dolly varden (*Salvelinus malma*) and bull trout (*Salvelinus confluentus*) of the north Puget Sound region. Washington Department of Fish and Wildlife, Olympia, WA.

Krausman, P.R., L.K. Harris, C.L. Blasch, K.K.G. Koenen, and J. Francine. 2004. Effects of military operations on behavior and hearing of endangered Sonoran pronghorn. Wildlife Monographs (157):1-41.

Kuletz, K.J. 1997. Marbled murrelet. Exxon Valdez Oil Spill Trustee Council.

Kuletz, K.J. 2005. Foraging behavior and productivity of a non-colonial seabird, the marbled murrelet (*Brachyramphus marmoratus*), relative to prey and habit. Doctoral dissertation. University of Victoria. 195 pp.

Kuletz, K.J., M. Renner, E.A. Labunski, and G.L. Hunt Jr. 2014. Changes in the distribution and abundance of albatrosses in the eastern Bering Sea: 1975–2010. Deep Sea Research Part II: Topical Studies in Oceanography 109:282-292.

Kvadsheim, P.H., and K.M. Sevaldsen. 2005. The potential impact of mid frequency active sonar on stocks of juvenile fish during sonar intense operations, FFI/RAPPORT-2005/01027.

Lacroix, D.L., R.B. Lanctot, J.A. Reed, and T.L. McDonald. 2003. Effect of underwater seismic surveys on molting male Long-tailed Ducks in the Beaufort Sea, Alaska. Canadian Journal of Zoology 81:1862-1875.

Laist, D.W. 1987. Overview of the biological effects of lost and discarded plastic debris in the marine environment. Marine Pollution Bulletin 18(6B):319-326.

Lance, M.M., and S.F. Pearson. 2016. 2015 Washington at-sea marbled murrelet population monitoring: Research progress report. Washington Department of Fish and Wildlife, Wildlife Program, Science Division, Olympia, WA, January 2016. 23 pp.

Littel, J.S., M. McGuire Elsner, L.W. Binder, and A.K. Snover. 2009. The Washington climate change impacts assessment: evaluating Washington's future in a changing climate. Climate Impacts Group, University of Washington, Seattle, Washington.

Long, L.L., and J.C. Ralph. 1998. Regulation and observations of human disturbance near nesting marbled murrelets. Pacific Southwest Research Station, Arcata, California, June 1998. 35 pp.

Lynch, D., G. Falxa, J. Baldwin, M.M. Lance, S.K. Nelson, S.F. Pearson, M.G. Raphael, C. Strong, and R. Young. 2016. Marbled murrelet effectiveness monitoring, Northwest Forest Plan: 2015 summary report. 19 pp.

Lynch, D. 2015. Email from Deanna Lynch, Fish and Wildlfe Biologist, USFWS, to Barbara Bodenstein, Wildlife Disease Specialist, USGS National Wildlife Health Center, re: Question-alcid necropsies and plastic ingestion. November 9, 2015.

Malt, J., and D. Lank. 2007. Temporal dynamics of edge effects on nest predation risk for the marbled murrelet. Biological Conservation 140(1):160-173.

McCauley, R.D., J.L. Fewtrell, and A.N. Popper. 2003. High intensity anthropogenic sound damages fish ears. Journal of the Acoustical Society of America 113(1):638-642.

Mcewen, B.S., and J.C. Wingfield. 2003. The concept of allostasis in biology and biomedicine. Hormones and behavior 43(1):2-15.

McKenna, M.F., D. Ross, S.M. Wiggins, and J.A. Hildebrand. 2012. Underwater radiated noise from modern commercial ships. The Journal of Acoustical Society of America 131(1):92-103.

McKinley, A., and E.L. Johnston. 2010. Impacts of contaminant sources on marine fish abundance and species richness: a review and meta-analysis of evidence from the field. Marine Ecology Progress Series 420:175-191.

McLennan, M.W. 1997. A simple model for water impact peak pressure and pulse width: A technical memorandum. July 9, 1997. Personal Observation.

McShane, C., T.E. Hamer, H.R. Carter, R.C. Swartzman, V.L. Friesen, D.G. Ainley, K. Nelson, A.E. Burger, L.B. Spear, T. Mohagen, R. Martin, L.A. Henkel, K. Prindle, C. Strong, and J. Keany. 2004. Evaluation reports for the 5-year status review of the marbled murrelet in Washington, Oregon, and California. EDAW, Inc, Seattle, Washington. 370 pp.

Meehl, G., T. Stocker, W. Collins, P. Friedlingstein, A. Gaye, J. Gregory, A. Kitoh, R. Knutti, J. Murphy, A. Noda, S. Raper, I. Watterson, A. Weaver, and Z. Zhao. 2007. Global Climate Projections. Pages 747-845 In S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor, and H.L. Miller, eds. Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on

Climate Change, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Melvin, E.F., J.K. Parrish, K.S. Dietrich, and O.S. Hamel. 2001. Solutions to seabird bycatch in Alaska's demersal longline fisheries. Washington Sea Grant Program, Project A/FP-7., Seattle, WA, August 31, 2001. 63 pp.

Menza, C., J. Leirness, T. White, A. Winship, B. Kinlan, J.E. Zamon, L. Ballance, E. Becker, K. Forney, J. Adams, D. Pereksta, S. Pearson, J. Pierce, L. Antrim, N. Wright, and E. Bowlby. 2015. Modeling seabird distributions off the Pacific coast of Washington. NOAA: National Centers for Coastal Ocean Science, Silver Springs, MD, June 2015. 63 pp.

Merizon, R.A.J., S.P. Courtney, W. Beattie, D.M. Brosnan, D. Evans, T. Grubba, W. Kerschke, J.M. Luginbuhl, R. Millner, E.A. Neatherlin, D. Nysewander, M. Raphael, and M. Salema. 1997. Seabird surveys in Puget Sound 1996. Sustainable Ecosystems Institute, Inc, Portland, Oregon, March 1997. 36 pp.

Morfey, C.L. 2001. Dictionary of acoustics. Pages 347-347 p. In Dictionary of acoustics, Academic Press, San Diego.

Mosher, J.G. 2015. Email from John Mosher, US Navy, Northwest Environmental Program Manager, US Pacific Fleet, to Lee Corum, Endangered Species Biologist, USFWS, re: More information on Electronic Warfare. September 17, 2015.

Mote, P., A. Petersen, S. Reeder, H. Shipman, and L.W. Binder. 2008. Sea level rise in the coastal waters of Washington state. University of Washington Climate Impacts Group; Washington Department of Ecology, January 2008. 11 pp.

Mote, P.W., A.K. Snover, L.W. Binder, A.F. Hamlet, and N.J. Mantua. 2005. Uncertain future: climate change and its effects on Puget Sound - foundation document. A report prepared for the Puget Sound Action Team by the Climate Impacts Group (Center for Science in the Earth System, Joint Institute for the Study of the Atmosphere, University of Washington), Seattle, Washington, October 2005. 37 pp.

Mueller, R.P., D.A. Neitzel, and W.V. Mavros. 1998. Evaluation of low and high frequency sound for enhancing fish screening facilities to protect outmigrating salmonids. U.S. Department of Energy, Bonneville Power Administration, BPA Report DOE/BP-62611-13, Portland, Oregon, February 1998. 26 pp.

Munsch, S., J. Cordell, J. Toft, F. Stevick, C. Levy, E. Morgan, and M. Caputo. 2014. Elliott Bay seawall project: Fish, algae, and light studies, 2011-2013. Wetland Ecosystem Team, University of Washington, School of Aquatic and Fishery Sciences, Seattle, WA. 71 pp.

Nedwell, J., and B. Edwards. 2002. Measurements of underwater noise in the Arun River during piling at County Wharf, Littlehampton. Subacoustech Ltd, Report No. 513 R 0108, Hampshire, UK, August 01, 2002. 25 pp.

Nedwell, J., A. Turnpenny, J. Langworthy, and B. Edwards. 2003. Measurements of underwater noise during piling at the Red Funnel Terminal, Southampton, and observations of its effect on caged fish. Subacoustech, Ltd, Report Reference: 558 R 0207, October 27, 2003.

Nelson, S.K. 1997. Marbled murrelet: *Brachyramphus marmoratus*. Birds of North America (276).

Nelson, S.K., and T.E. Hamer. 1995. Nesting biology and behavior of the marbled murrelet. Pages 57-67 *In* C.J. Ralph, G.L. Hunt, M.G. Raphael, and J.F. Piatt, eds. Ecology and conservation of the marbled murrelet. General Technical Report. PSW-GTW-152, Pacific Southwest Experimental Station, U.S. Forest Service, Albany, California.

NOAA United States Coast Survey. 1993. Bathymetry Data, United States West Coast Puget Sound - Northern Part, Chart #18441.

Northcutt, G., and C. Gans. 1983. The genesis of neural crest and epidermal placodes: A reinterpretation of vertebrate origins. The Quarterly Review of Biology 58(1):1-28.

Northwest Fisheries Science Center. 2011. Risk Assessment of U.S. West coast groundfisheries to threatened and endangered marine species. Northwest Fisheries Science Center, National Marine Fisheries Service, Seattle, WA, January 13, 2012. 272 pp.

NWFPEMP. 2016. Marbled murrelet population estimates, 2000-2015. Based on at-sea surveys conducted in Conservation Zones 1-5. Data provided by the Marbled Murrelet Effectiveness Monitoring Program, NWFP. Northwest Forest Plan Marbled Murrelet Effectiveness Monitoring Program, January 25, 2016. 5 pp.

OBIS SEAMAP. 2015. Marbled murrelet search results screenshot, 1. Available at <seamap.env.duke.edu/species/176996> (Date Accessed: November 12, 2015).

O'Connor, A.J. 2013. Distributions and fishery associations of immature short-tailed albatrosses, *Pheobastria albatrus*, in the North Pacific. Master of Science in Marine Resource Management. Oregon State University, Corvallis, OR. 87 pp.

O'Donnell, B.P., N.L. Naslund, and C.J. Ralph. 1995. Patterns of seasonal variation of activity of marbled murrelets in forest stands. Pages 117-128 In C.J. Ralph, G.L. Hunt, M.G. Raphael, and J.F. Piatt, eds. Ecology and conservation of the marbled murrelet.General Technical Report. PSW-GTW-152, Pacific Southwest Experimental Station, U.S. Forest Service, Albany, California.

O'Keeffe, D.J., and G.A. Young. 1984. Handbook on the environmental effects of underwater explosions. Naval Surface Weapons Center, NSWC TR 83-240, Silver Spring, Maryland, September 13, 1984. 203 pp.

Ostrand, W.D., K.O. Coyle, G.S. Drew, J.M. Maniscalco, and D.B. Irons. 1998. Selection of forage-fish schools by murrelets and tufted puffins in Prince William Sound, Alaska. Condor 100(2):286-297.

Pacific Fisheries Management Council. 2015. Current HMS SAFE Report: Commercial Fisheries Descriptions, 6. Available at <http://pcouncil.org/highly-migratory-species/stock-assessment-and-fishery-evaluation-safe-documents/current-safe-document/commercial-fisherie...> (Date Accessed: October 8, 2015).

Pall, M.L. 2013. Electromagnetic fields act via activation of voltage-gated calcium channels to produce beneficial or adverse effects. Journal of Cellular and Molecular Medicine 17(8):958-965.

Pater, L. 1981. Gun blast far field peak overpressure contours. Naval Surface Weapons Center, NSWC TR 79-442, Dahlgren VA, March 1981. 142 pp.

Pater, L.L., T.G. Grubb, and D.K. Delaney. 2009. Recommendations for improved assessment of noise impacts on wildlife. Journal of Wildlife Management 73(5):788-795.

Paton, P.W.C. 1995. Marbled murrelet inland patterns of activity: Defining detections and behavior. Pages 113-116 *In* C.J. Ralph, G.L. Hunt, Raphael M. G., and J.F. Piatt, eds. Ecology and conservation of the marbled murrelet. General Technical Report. PSW-GTW-152, Pacific Southwest Experimental Station, United States Department of Agriculture, Forest Service, Albany, CA.

Pearson, S.F., M.M. Lance, and M.G. Raphael. 2014. 2013 Washington at-sea marbled murrelet population monitoring: research progress report. Washington Department of Fish and Wildlife, Wildlife Science Division;USDA Forest Service Pacific Northwest Research Station, Olympia, Washington, April 2014. 18 pp.

Pearson, S.F., C. Sundstrom, and W. Ritchie. 2015. Washington State snowy plover population monitoring, research, and management: 2014 nesting season research progress report. Washington Department of Fish and Wildlife, Wildlife Science Division, Olympia, WA, April 2015. 27 pp.

Peery, A.Z., S.R. Beissinger, S.H. Newman, B.H. Becker, E.E. Burkett, and T.D. Williams. 2004. Individual and temporal variation in inland flight behavior of Marbled Murrelets: Implications for population monitoring. Condor 106(2):344-353.

Peery, Z., S.R. Beissinger, and S. Newman. 2003. Post-breeding season movements and distribution of marbled murrelets in central California: preliminary report. 34 pp.

Penttila, D. 2007. Marine forage fishes in Puget Sound. U.S. Army Corps of Engineers, Puget Sound Nearshore Partnership Report 2007-03, Seattle, Washington. 30 pp.

Peterson, W.T., C.A. Morgan, J.O. Peterson, J.L. Fisher, B.J. Burke, and K. Fresh. 2014. Ocean Ecosystem Indicators of Salmon Marine Survival in the Northern California Current. NMFS, Fish Ecology Division, Northwest Fisheries Science Center, Newport, OR and Seattle, WA, December 2014. 83 pp.

Pettit, T.N., G.S. Grant, and G.C. Whittow. 1981. Ingestion of plastics by laysan albatross. The Auk 98(4):839-841.

Phillips, J.R. 2007. Email from John R. Phillips, Natural Resource Manager, Environmental Affairs Dept., NAS Whitbey Island, to Deanna Lynch, Fish and Wildlife Biologist, WFWO, re: Bangor Detonation Site. November 5, 2007.

Piatt, J.F., and F.R. Glenn. 1993. Distribution and abundance of marbled murrelets in Alaska. The Condor 95:662-669.

Piatt, J.F., K.J. Kuletz, A.E. Burger, S.A. Hatch, V.L. Friesen, T.P. Birt, M.L. Arimitsu, G.S. Drew, A.M.A. Harding, and K.S. Bixler. 2007a. Status review of the marbled murrelet (*Brachyramphus marmoratus*) in Alaska and British Columbia, U.S. Geological Survey Open-File Report 2006-1387, 2006. 258 pp.

Piatt, J.F., W.J. Sydeman, and H.I. Browman. 2007b. Seabirds as indicators of marine ecosystems. Marine Ecology-Progress Series 352:199-309.

Piatt, J.F., and N.L. Naslund. 1995. Chapter 28: Abundance, distribution, and population status of marbled murrelets in Alaska. USDA Forest Service, Gen. Tech. Rep. PSW-152. 10 pp.

Piatt, J.F., W.J. Sydeman, and H.I. Browman. 2007. Seabirds as indicators of marine ecosystems. Marine Ecology Progress Series 352:199-309.

Popper, A.N., M.E. Smith, P.A. Cott, B.W. Hanna, A. MacGillivray, M.E. Austin, and D.A. Mann. 2005. Effects of exposure to seismic airgun use on hearing of three fish species. Journal of the Acoustical Society of America 117(6):3958-3971.

Popper, A.N., M.B. Halvorsen, A. Kane, D.L. Miller, M.E. Smith, J. Song, P. Stein, and L.E. Wysocki. 2007. The effects of high-intensity, low-frequency active sonar on rainbow trout. The Journal of Acoustical Society of America 122(1):623-635.

Popper, A.N., A.D. Hawkins, R.R. Fay, D.A. Mann, S. Bartol, T.J. Carlson, S. Coombs, W.T. Ellison, R. Gentry, M.B. Halvorsen, S. Lokkeborg, P.H. Rogers, B.L. Southall, D.G. Zeddies, and W.N. Tavolga. 2014. Sound exposure guidelines for fishes and sea turtles: A technical report prepared by ANSI-accredited standards committee SS/SC1 and registered with ANSI. Springer Briefs in Oceanography, ASA S3/SC1.4 TR-2014, April 20, 2014. 87 pp.

Prinn, R., S. Paltsev, A. Sokolov, M. Sarofim, J. Reilly, and H. Jacoby. 2011. Scenarios with MIT integrated global systems model: significant global warming regardless of different approaches. Climatic Change 104:515-537.

Provencher, J.F., A.J. Gaston, M.L. Mallory, P.D. O'Hara, and H.G. Gilchrist. 2010. Ingested plastic in a diving seabird, the thick-billed murre (Uria lomvia), in the eastern Canadian Arctic. Marine Pollution Bulletin 60:1406-1411.

PSAT (Puget Sound Action Team). 2007. 2007 Puget Sound update: ninth report of the Puget Sound assessment and monitoring program. Puget Sound Action Team, PSAT 07-02, Olympia, Washington, February, 2007. 276 pp.

Puget Sound Partnership. 2008. Discussion paper: habitat and land use. Puget Sound Partnership, July 11, 2008. 103 pp.

Puget Sound Water Quality Action Team. 2002. Puget Sound update 2002: Eighth report of the Puget Sound ambient monitoring program. Puget Sound Water Quality Action Team, Olympia, WA, September 2002. 144 pp.

Ralph, C.J., G.L. Hunt, M.G. Raphael, and J.F. Piatt. 1995. Ecology and conservation of the marbled murrelet in North America: An overview. Pages 3-22 *In* C.J. Ralph, G.L. Hunt, M.G. Raphael, and J.F. Piatt, eds. Ecology and conservation of the marbled murrelet. General Technical Report. PSW-GTW-152, Pacific Southwest Experimental Station, United States Department of Agriculture, Forest Service, Albany, California.

Rao, V.S., I.A. Titushkin, E.G. Moros, W.F. Pickard, H.S. Thatte, and M.R. Cho. 2008. Nonthermal effects of radiofrequency-field exposure on calcium dynamics in stem cell-derived neuronal cells: Elucidation of calcium pathways. Radiation Research 169(3):319-329.

Raphael, M.G., G.A. Falxa, K.M. Dugger, B.M. Galleher, D. Lynch, S.L. Miller, S.K. Nelson, and R.D. Young. 2011. Status and trend of nesting habitat for the marbled murrelet. US Department of Agriculture, Forest Service, Pacific Northwest Research Station, General Technical Report PNW-GTR-848, Portland, Oregon, 2011. 52 pp.

Raphael, M.G., J. Baldwin, G.A. Falxa, M.H. Huff, M.M. Lance, S. Miller, S.F. Pearson, C.J. Ralph, C. Strong, and C. Thompson. 2007. Regional population monitoring of the marbled murrelet: field and analytical methods. U.S. Department of Agriculture Forest Service, PNW-GTR-716, Portland, Oregon, May 2007. 70 pp.

Raphael, M.G., A.J. Shirk, G.A. Falxa, and S.F. Pearson. 2015. Habitat associations of marbled murrelets during the nesting season in nearshore waters along the Washington to California coast. Journal of Marine Systems 146:17-25.

Raya Rey, A., P. Trathan, K. Putz, and A. Schiavini. 2007. Effect of oceanographic conditions on the winter movements of rockhopper penguins udyptes chrysocome chrysocome from Staten Island, Argentina. Marine Ecology Progress Series (330):285-295.

Redlarski, G., B. Lewczuk, A. Zak, A. Koncicki, M. Krawczuk, J. Piechocki, K. Jakubiuk, P. Tojza, J. Jaworski, D. Ambroziak, L. Skarbek, and D. Gradolewski. 2015. The influence of electromagnetic pollution on living organisms: Historical trends and forecasting changes. BioMed Research International 2015:1-19.

Reilly, P.N., and T.O. Moore. 1986. Pacific herring, Clupea harengus pallasi, studies in San Francisco Bay, central and northern California, and Washington March 1985 to May 1986. State of California Department of Fish and Game, Administrative Report Number 86-6. 102 pp.

Rejt, L., T. Mazgajski, R. Kubacki, J. Kieliszek, E. Sobiczewska, and S. Szmigielski. 2007. Influence of radar radiation on breeding biology of tits (*Parus sp.*). Electromagnetic Biology and Medicine 26:235-238.

Rice, C., E.M. Beamer, D. Lomax, R. Henderson, and G. Pess. 2002. Project summary: Skagit Bay tow netting study.

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

Richmond, D.R., J.T. Yelverton, and R.E. Fletcher. 1973. Far-field underwater-blast injuries produced by small charges. Lovelace Foundation for Medical Education and Research, Contract Number DASA-01-71-C-0013, Washington, D.C.

Rieman, B.E., and J.D. McIntyre. 1993. Demographic and habitat requirements for conservation of Bull Trout. USDA, Forest Service, Intermountain Research Station, General Technical Report INT-302, Ogden, Utah, September 1993. 38 pp.

Robards, M.D., P.J. Gould, and J.F. Piatt. 1997. The highest global concentrations and increased abundance of oceanic plastic debris in the North Pacific: Evidence from seabirds. Pages 71-80 In J.M. Coe, and D.B. Rogers, eds. Marine Debris, Springer Verlag, New York.

Robards, M.D., M.F. Willson, R.H. Armstrong, and J.F. Piatt. 1999. Sand lance: a review of biology and predator relations and annotated bibliography. USDA Forest Service Pacific Northwest Research Station, Research Paper PNW-RP-521, Portland, Oregon, September 1999. 189 pp.

Robertson, G., S.G. Candy, and B. Wienecke. 2010. Effect of line shooter and mainline tension on the sink rates of pelagic longlines and implications for seabird interactions. Western and Central Pacific Fisheries Commission, Scientific Committee Sixth Regular Session, Nuku'alofa, Tonga, August 19, 2010. 21 pp.

Rochman, C.M., E. Hoh, T. Kurobe, and S.J. Teh. 2013. Ingested plastic transfers hazardous chemicals to fish and induces hepatic stress. Scientific Reports 3(3263):1-7.

Rojek, N.A., M.W. Parker, H.R. Carter, and G.J. McChesney. 2007. Aircraft and vessel disturbances to Common Murres *Uria aalge* at breeding colonies in central California, 1997-1999. Marine Ornithology 35(1):61-69.

Romano, T.A., M.J. Keogh, C. Kelly, P. Feng, L. Berk, C.E. Schlundt, D.A. Carder, and J.J. Finneran. 2004. Anthropogenic sound and marine mammal health: Measures of the nervous and immune systems before and after intense sound exposure. Canadian Journal of Fisheries and Aquatic Sciences 61(7):1124-1134.

Ronconi, R.A., and A.E. Burger. 2008. Limited foraging flexibility: Increased foraging effort by a marine predator does not buffer against scarce prey. Marine Ecology-Progress Series 366:245-258.

Ryals, B.M., and R.J. Dooling. 2001. Changes in innervation and auditory sensitivity following acoustic trauma and hair cell regeneration in birds. Pages 84-99 In R.J. Salvi, and D. Henderson, eds. Auditory system plasticity and regeneration, Thieme Medical Publishers, Inc, New York, NY.

Ryals, B.M., R.J. Dooling, E. Westbrook, M.L. Dent, A. MacKenzie, and O.N. Larsen. 1999. Avian species differences in susceptibility to noise exposure. Hearing research 131:71-88.

Ryan, P.G., and S. Jackson. 1987. The lifespan of ingested plastic particles in seabirds and their effect on digestive efficiency. Marine Pollution Bulletin 18(5):217-219.

Salathe Jr, E.P., L.R. Leung, Y. Qian, and Y. Zhang. 2010. Regional climate model projections for the State of Washington. Climatic Change 102(1-2):51-75.

Sanborn, S., K. Nelson, J. Bower, and S.W. Singer. 2005. Categorization of the marbled murrelet vocal repertoire.

Sanzenbacher, P.M., B.A. Cooper, J.H. Plissner, and J. Bond. 2014. Intra-annual patterns in passage rates and flight altitudes of marbled murrelets, *Brachyramphus marmoratus*, at inland sites in Northern California. Marine Ornithology 42:169-174.

Saunders, J., and R.J. Dooling. 1974. Noise-induced threshold shift in the parakeet (*Melopsittacus undulatus*). Proceedings of the National Academy of Sciences of the United States of America 71(5):1962-1965.

Saunders, J.C., and W.J. Henry. 1989. System in birds: structural and functional contributions to auditory perception. Pages 35-64 In R.J. Dooling, and S.H. Hulse, eds. The comparative psychology of audition: perceiving complex sounds, Lawrence Erlbaum Associates, Inc, Hillsdale, New Jersey.

Science Applications International Corporation. 2011. Environmental sound panel for marbled murrelet underwater noise injury threshold. Science Applications International Corporation, Bothwell, Washington, August 31, 2011. 38 pp.

Science Applications International Corporation. 2012. Marbled murrelet hydroacoustic science panel II. Final summary report. Panel conducted March 28-30, 2012 in Lacey, Washington. Science Applications International Corporation, Bothell, Washington, September 4, 2012. 33 pp.

Sealy, S.G. 1975. Feeding ecology of the ancient and marbled murrelets near Langara Island, British Columbia. Canadian Journal of Zoology 53(4):418-433.

Sebeok, T.A. 1977. Communication in crustaceans and arachnids. Pages 305-307 In How Animals Communicate, Indiana University Press, Bloomington, Indiana.

Sievert, P.R., and L. Sileo. 1993. The effects of ingested plastic on growth and survival of albatross chicks. Pages 212-217 In The status, ecology, and conservation of marine birds of the North Pacific, Canadian Wildlife Service Special Publication, Ottawa, Canada.

Singer, S.W., N.L. Naslund, S.A. Singer, and C.J. Ralph. 1991. Discovery and observations of two tree nests of the marbled murrelet. The Condor 93:330-339.

Smith, M.E., A.S. Kane, and A.N. Popper. 2004. Acoustical stress and hearing sensitivity in fishes: Does the linear threshold shift hypothesis hold water? Journal of Experimental Biology 207(20):3591-3602.

Smith, M.E., A. Coffin B., Miller Diane L., and A.N. Popper. 2006. Anatomical and functional recovery of the goldfish (*Carassius auratus*) ear following noise exposure. The Journal of Experimental Biology 209:4193-4202.

Smith, M.E., A.S. Kane, and A.N. Popper. 2004. Noise-induced stress response and hearing loss in goldfish (*Carassius auratus*). Journal of Experimental Biology 207(3):427-435.

Smith-Root. 2015. Knowledge Base: How do I select the right electrofisher? 2. Available at <http://www.smith-root.com/support/kb/how-do-i-select-the-right-electrofisher/> (Date Accessed: March, 30 2016).

Solomon, S., D. Qin, M. Manning, R. Alley, T. Berntsen, N. Bindoff, Z. Chen, A. Chidthaisong, J. Gregory, G. Hegerl, M. Heimann, B. Hewitson, B. Hoskins, F. Joos, J. Jouzel, V. Kattsov, U. Lohmann, T. Matsuno, M. Molina, N. Nicholls, J. Overpeck, G. Raga, V. Ramaswamy, J. Ren, M. Rusticucci, R. Somerville, T. Stocker, R. Stouffer, P. Whetton, R. Wood, and D. Wratt. 2007. Technical Summary. Pages 19-91 In S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor, and H.L. Miller, eds. Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Song, J.K., D.A. Mann, P.A. Cott, B.W. Hanna, and A.N. Popper. 2008. The inner ears of northern Canadian freshwater fishes following exposure to seismic air gun sounds. Journal of the Acoustical Society of America 124(2):1360-1366.

Sparling Jr., D.W. 1977. Sounds of laysan and black-footed albatrosses. The Auk 94:256-269.

Speckman, S.G., J.F. Piatt, and A.M. Springer. 2003. Deciphering the social structure of marbled murrelets from behavioral observations at sea. Waterbirds 26(3):266-274.

Speich, S.M., and T.R. Wahl. 1995. Marbled murrelet populations of Washington -- marine habitat preferences and variability of occurrence. Pages 313-326 In C.J. Ralph, G.L. Hunt, M.G. Raphael, and J.F. Piatt, eds. USDA Forest Service Gen. Tech Rep. PSW-152. USDA.

Stein, J., and D. Nysewander. 1999. An estimate of marbled murrelet productivity from observations of juveniles on the inland marine waters of Washington State during the 1993 through 1995 post-breeding seasons. Washington Department of Fish and Wildlife, Olympia, WA, July 1999.

Steiner, I., and B. Bruderer. 1999. Initial orientation and homing behavior of pigeons under the influence of short wave transmissions. Journal for Ornithology 140:165-177.

Stemp, R. 1985. Observations on the effects of seismic exploration on seabirds. Pages 217-233 In Canada Oil and Gas Lands Administration.

Stick, K.C. 2005. 2004 Washington state herring stock status report. Washington Dept. of Fish and Wildlife, Fish Program Fish Management Division, SS 05-01, May 2005. 82 pp.

Stick, K.C., A. Lindquist, and D. Lowry. 2014. 2012 Washington State herring stock status report. Washington Department of Fish and Wildlife, Fish Program, Fish Management Division, FPA 14-09, Olympia, WA, July 2014. 106 pp.

Stinson, D.W. 2005. Status report for the Mazama pocket gopher, streaked horned lark, and Taylor’s checkerspot. WDFW, Olympia, Washington, November 2005. 129 pp.

Stout, H.A., R.G. Gustafson, W.H. Lenarz, B.B. McCain, D.M. VanDoornik, T.L. Builder, and R.D. Methot. 2001. Status review of Pacific herring (*Clupea pallasi*) in Puget Sound, Washington. U.S. Department of Commerce NOAA, NOAA Technical Memorandum NMFS-NWFSC-45, Seattle, Washington. 40 pp.

Strachan, G., M. McAllister, and C.J. Ralph. 1995. Marbled murrelet at-sea and foraging behavior. Pages 247-253 In C.J. Ralph, G.L. Hunt, M.G. Raphael, and J.F. Piatt, eds. Ecology and conservation of the marbled murrelet. PSW-GTR-152, U.S. Department of Agriculture, Albany, CA.

Strong, C.S., B.K. Keitt, W.R. McIver, C.J. Palmer, and I. Gaffney. 1995. Distribution and population estimates of marbled murrelets at sea in Oregon during the summers of 1992 and 1993. Pages 339-352 In C.J. Ralph, G.L. Hunt, M.G. Raphael, and J.F. Piatt, eds. Ecology and conservation of the marbled murrelet. General Technical Report: PSW-GTW-152, Pacific Southwest Experimental Station, U.S. Forest Service, Albany, California.

Stumpf, J.P., N. Denis, T.E. Hamer, G. Johnson, and J. Verschuyl. 2011. Flight height distribution and collision risk of the marbled murrelet Brachyramphus marmoratus: Methodology and preliminary results. Marine Ornithology 39:123-128.

Suryan, R. 2015. Email from Robert Suryan, Oregon State University, to Lee Corum, Endangered Species Biologist, USFWS, re: Short-tailed albatross telemetry. September 16, 2015.

Suryan, R.M., G.R. Balogh, and K.N. Fischer. 2008. Marine habitat use of North Pacific albatrosses during the non-breeding season and their spatial and temporal interactions with commercial fisheries in Alaska, North Pacific Research Board Project 532 Final Report, March 2008. 83 pp.

Suryan, R.M., T. Deguchi, and G.R. Balogh. 2013. Short-tailed albatross new colony establishment phase 2: post-fledging survival and marine habitat use of hand-reared vs. naturally-reared chicks, North Pacific Research Board Project 723 and 1014 Final Report, November 2013. 147 pp.

Suryan, R.M., K.S. Dietrich, E.F. Melvin, G.R. Balogh, F. Sato, and K. Ozaki. 2007. Migratory routes of short-tailed albatrosses: Use of exclusive economic zones of North Pacific Rim countries and spatial overlap with commercial fisheries in Alaska. Biological Conservation 137:450-460.

Suryan, R.M., J.A. Santora, and W.J. Sydeman. 2012. New approach for using remotely sensed chlorophyll a to identify seabird hotspots. Marine Ecology Progress Series 451:231-225.

Suryan, R.M., F. Sato, G.R. Balogh, K.D. Hyrenbach, P.R. Sievert, and K. Ozaki. 2006. Foraging destinations and marine habitat use of short-tailed albatrosses: A multi-scale approach using first-passage time analysis. Deep-Sea Research Part II 53:370-386.

Swarthout, E.C.H., and R.J. Steidl. 2001. Flush responses of Mexican spotted owls to recreationists. The Journal of Wildlife Management 65(2):312-317.

Swisdak, M.M. 1975. Explosion effects and properties: Part 1- Explosion effects in air. Naval Surface Weapons Center, NSWC/WOL/TR 75-116, Silver Spring, MD, October 6, 1975. 156 pp.

Swisdak, M.M. 1978. Explosion effects and properties: Part 2- Explosion effects in water. Naval Surface Weapons Center, NSWC/WOL/TR 76-116, Silver Spring, MD, February 22, 1978. 112 pp.

Tanaka, K., H. Takada, R. Yamashita, K. Mizukawa, M. Fukuwaka, and Y. Watanuki. 2013. Accumulation of plastic-derived chemicals in tissues of seabirds ingesting marine plastics. Marine Pollution Bulletin 69(1-2):219-222.

Teleki, G.C., and A.J. Chamberlain. 1978. Acute effects of underwater construction blasting on fishes in Long Point Bay, Lake Erie. Journal of the Fisheries Research Board of Canada 35:1191-1198.

Tempel, D.J., and R.J. Gutiérrez. 2003. Fecal corticosterone levels in California spotted owls exposed to low-intensity chainsaw sound. Wildlife Society Bulletin 31(3):1-5.

Teuten, E.L., J.M. Saquing, D.R.U. Knappe, M.A. Barlaz, S. Jonsson, A. Bjorn, S.J. Rowland, R.C. Thompson, T.S. Galloway, R. Yamashita, D. Ochi, Y. Watanuki, C. Moore, P.H. Viet, T.S. Tana, M. Prudente, R. Boonyatumanond, M.P. Zakaria, K. Akkhavong, Y. Ogata, H. Hirai, S. Iwasa, K. Mizukawa, Y. Hagino, A. Imamura, M. Saha, and H. Takada. 2009. Transport and release of chemicals from plastics to the environment and to wildlife. Philosophical Transactions of the Royal Society B: Biological Sciences 364:2027-2045.

The National Counterterrorism Center. 2014a. Bomb threat stand-off distances - 2014 counterterrorism calendar, 2. Available at <http://www.nctc.gov/site/technical/bomb_threat.html> (Date Accessed: December 30,2015).

The National Counterterrorism Center. 2014b. Bomb threat stand-off distances - 2014 counterterrorism calendar. Methods and tactics, 2. Bomb threat stand-off distances. Available at <http://www.nctc.gov/site/technical/bomb_threat.html> (Date Accessed: August 13, 2014).

Thomas, G.L., and P.M. Washington. 1988. Obervations of the fish assemblage in Camas Slough, Washington. A report on the effects of underwater blasting. James River Corporation, August 24, 1988. 12 pp.

Thompson, C.W. 1997. Distribution and abundance of marbled murrelets on the outer coast of Washington - Winter 1996-1997. Washington Department of Fish and Wildlife, Olympia, WA, September 1997. 16 pp.

Titmus, A.J., and K.D. Hyrenbach. 2011. Habitat associations of floating debris and marine birds in the North East Pacific Ocean at coarse and meso spatial scales. Marine Pollution Bulletin 62:2496-2506.

Trimper, P.G., N.M. Standen, L.M. Lye, D. Lemon, T.E. Chubbs, and G.W. Humphries. 1998. Effects of low-level jet aircraft noise on the behaviour of nesting osprey. Journal of Applied Ecology 35(1):122-130.

U.S. Air Force. 2012. Biological assessment in support of reinitiation of consultation for the German Air Force Beddown (USFWS Consultation # 2-22-96-F-334, May 8, 1998) and the realistic bombing training initiative (USFWS Consultation # 2-22-98-I-124, April 12, 2000) in the Southwest (NM, TX, AZ). 878 pp.

U.S. Department of the Navy. 2009. U.S. Navy explosive ordnance disposal (EOD) training activities for 2009 in Crescent Harbor Final Monitoring Report. U.S. Department of the Navy, Silverdale, WA, December 15, 2009. 16 pp.

U.S. Department of the Navy. 2014. Pacific Northwest Electronic Warfare Range Final Environmental Assessment. Naval Facilities Engineering Command, Silverdale, WA, September 2014. 228 pp.

U.S. Department of the Navy. 2015a. Northwest training and testing activities: Final environmental impact statement/ overseas environmental impact statement. Naval Facilities Engineering Command, Northwest, Volume 1, Silverdale, WA, October 2015. 1004 pp.

U.S. Department of the Navy. 2015b. Northwest training and testing activities: Final environmental impact statement/ overseas environmental impact statement. Naval Facilities Engineering Command, Northwest, Volume 2, Silverdale, WA, October 2015. 970 pp.

U.S. Department of the Navy. 2015c. Northwest training and testing activities: Final environmental impact statement/ overseas environmental impact statement. Naval Facilities Engineering Command, Northwest, Volume 4, Silverdale, WA, October 2015. 662 pp.

USDA Forest Service. 2016. U.S. Department of Agriculture, Forest Service, Draft Special Use Permit for Navy Electronic Warfare Training on the Olympic Peninsula, WA., Olympia, WA, February 8, 2016. 29 pp.

USFWS. 1993. Endangered and threatened wildlife and plants; determination of threatened status for the Pacific Coast population of the western snowy plover. Federal Register 58(42):12864-12874.

USFWS. 1997a. Intra-FWS concurrence memorandum and biological opinion on the proposed issuance of an incidental take permit (PRT- 812521) for northern spotted owls, marbled murrelets, gray wolves, grizzly bears, bald eagles, peregrine falcons, Aleutian Canada geese, Columbian white-tailed deer, and Oregon silverspot butterflies, and the approval of the implementation agreement for the Washington State Department of Natural Resources Habitat Conservation Plan (FWS Reference: 1-3-96-FW-594).

USFWS. 1997b. Recovery Plan for the threatened marbled murrelet (*Brachyramphus marmoratus*) in Washington, Oregon, and California. U.S. Department of the Interior, Portland, Oregon, 1997. 203 pp.

USFWS. 2002. Bull trout (Salvelinus confluentus) draft recovery plan - Chapter 1: Introduction. U.S. Fish and Wildlife Service, Portland, Oregon, October 2002. 137 pp.

USFWS. 2003. Biological opinion and letter of concurrence for effects to bald eagles, marbled murrelets, northern spotted owls, bull trout, and designated critical habitat for marbled murrelets and northern spotted owls from Olympic National Forest program of activities for August 5, 2003, to December 31, 2008. Western Washington Fish and Wildlife Office, 1-3-03-F-0833, Lacey, Washington, August 05, 2003.

USFWS. 2004. Draft Recovery Plan for the Coastal-Puget Sound distinct population segment of bull trout (Salvelinus confluentus). Volume I: Puget Sound Management Unit, 389+xvii pp and Volume II: Olympic Peninsula Management Unit, 277+xvi pp, Portland, Oregon.

USFWS. 2006. Biological opinion for the issuance of an incidental take permit to the state of Washington for the forest practices habitat conservation plan, 1-3-06-FWI-0301, May 16, 2006. 1152 pp.

USFWS. 2007. Western snowy plover (Charadrius alexandrinus nivosus) Pacific coast population recovery plan - Volume 1 and Volume 2 (Appendices. U.S. Fish and Wildlife Service, California/Nevada Operations Office, Sacramento, CA, August 13, 2007.

USFWS. 2008a. Bull trout (Salvelinus confluentus) 5 year review: summary and evaluation. U.S. Department of Fish and Wildlife Service, Portland, Oregon, April 25, 2008. 55 pp.

USFWS. 2008b. Short-tailed albatross recovery plan. USFWS: Short-tailed Albatross Recovery Team, Region 7, Anchorage, AK, September 17, 2008. 105 pp.

USFWS. 2009a. Marbled Murrelet (*Brachyramphus marmoratus*) 5-Year Review. U.S. Fish and Wildlife Service, Lacey, Washington, June 12, 2009.

USFWS. 2009b. Short-tailed albatross (*Phoebastria albatrus*), 5-Year review: Summary and evaluation. USFWS, Anchorage Fish and Wildlife Field Office, Anchorage, AK, September 24, 2009. 78 pp.

USFWS. 2010. US Pacific Fleet Northwest Training Range Complex in the Northern Pacific Coastal waters of the states of Washington, Oregon, and California and activities in Puget Sound and airspace over the state of Washington, FWS Ref. 13410-2009-F-0104, Lacey, Washington. 159+appendices pp.

USFWS. 2012a. Biological Opinion Regarding the Effects of the Continued Operation of the Pacific Coast Groundfish Fishery as Governed by the Pacific Coast Groundfish Fishery Management Plan and Implementing Regulations at 50 CFR Part 660 by the National Marine Fisheries Service on California least tern (*Sterna antil/arum browni*), southern sea otter (*Enhydra lutris nereis*), bull trout (*Salvelinus conjluentus*), marbled murrelet (*Brachyramphus marmoratus*) and the short-tailed albatross (*Phoebastria albatrus*). Oregon Fish and Wildlife Office, Portland, OR, November 21, 2012. 50 pp.

USFWS. 2012b. Report on Marbled Murrelet recovery implementation team meeting and stakeholder workshop. USFWS, Lacey, Washington, April 17, 2012. 66 pp.

USFWS. 2013. Biological Opinion for Effects to Northern Spotted Owls, Critical Habitat for Northern Spotted Owls, Marbled Murrelets, Critical Habitat for Marbled Murrelets, Bull Trout, and Critical Habitat for Bull Trout from Selected Programmatic Forest Management Activities March 25,2013 to December 31,2023 on the Olympic National Forest Washington. March 25, 2013. Personal Observation.

USFWS. 2014. Five-year review: Summary and evaluation short-tailed albatross (Phoebastria albatrus). USFWS, Anchorage Fish and Wildlife Field Office, Anchorage, AK, September 22, 2014. 43 pp.

USFWS. 2015a. Biological opinion for the Alaska Federal/State preparedness plan for response to oil & hazardous substance discharges/releases: Consultation with U.S. Coast Guard and Environmental Protection Agency. USFWS, Anchorage Fish and Wildlife Field Office, 2011-0036, Anchorage, AK, February 27, 2015. 250 pp.

USFWS. 2015b. Draft coastal recovery unit implementation plan for bull trout recovery plan. USFWS, Washington Fish and Wildlife Office and Oregon Fish and Wildlife Office, Lacey, WA & Portland, OR, June 2015. 145 pp.

USFWS. 2015c. Recovery plan for the coterminus United States population of bull trout (Salvelinus confluentus). U.S. Fish and Wildlife Service, Portland, OR, September 28, 2015. xii + 179 pp.

USFWS, and NMFS. 1998. Final endangered species consultation handbook: Procedures for conducting consultation and conference activities under section 7 of the Endangered Species Act. U. S. Fish and Wildlife Service and National Marine Fisheries Service, U.S. GPO: 2004-690-278, Washington, D.C., March 1998. 189 pp.

USGS. 2008. Migration timing and habitat characteristics of anadromous bull trout in Skagit Bay, Washington.

USGS. 2009. Letter from Richard Wagner, water quality specialist, U.S. Geological Survey, to Shawn Yannity, Stillaguamish Tribe Natural Resources Department, regarding summaries of field data and chemical analyses of water samples collected by the U.S. Geological Survey and Stillaguamish Tribe of Indians from surface waters within the Stillaguamish watershed in September 2008, June 2, 2009.

USGS. 2015. ScienceBase search results :Seabirds, 7. Available at <https://www.sciencebase.gov/catalog/items?q=&filter=tags%3Dseabirds> (Date Accessed: November 12, 2015).

Van Fossen, L. 2007. Annual Report on seabird interactions and mitigation efforts in the Hawaii longline fishery for 2006. NMFS, Administrative Report, Honolulu, HI, April 2007. 40 pp.

Washington Department of Ecology. 2015. Problems with Puget Sound, 1. Available at <http://www.ecy.wa.gov/puget_sound/threats.html> (Date Accessed: March 30, 2016).

Washington Department of Wildlife (WDFW). 2015. Species and Ecosystem; Marine Beach Spawning Fish Ecology website, Available at <http://wdfw.wa.gov/conservation/research/projects/marine_beach_spawning/> (Date Accessed: November 1, 2015).

Washington State Department of Natural Resources. 2015. Letter from Peter Goldmark, WA State Director of Public Lands, to Rear Admiral Jeffrey Ruth, Commander, Navy Region Northwest, re: Navy Electromagnetic Warfare Training on the Olympic Peninsula. February 27, 2015.

Wasser, S.K., K.R. Bevis, G. King, and E. Hanson. 1997. Noninvasive physiological measures of disturbance in the northern spotted owl. Conservation Biology 11(4):1019-1022.

WDFW. 2008. Surf smelt - biology. 7 pp.

WDFW. 2013. Threatened and endangered wildlife. Annual report 2012. Listing and Recovery Section, Wildlife Program, WDFW, Olympia, Washington, 2013. 251 pp.

Westerling, A.L., H.G. Hidalgo, D.R. Cayan, and T.W. Swetnam. 2006. Warming and earlier spring increase western U.S. forest wildfire activity. Science 313:940-943.

Wever, E.G. 1974. Chapter 13: The evolution of vertebrate hearing. Pages 424-454 In H.W.e.a. Ades, ed. Auditory System, Springer Verlag, Berlin.

Williams, R., E. Ashe, and P.D. O'Hara. 2011. Marine mammals and debris in coastal waters of British Columbia, Canada. Marine Pollution Bulletin 62:1303-1316.

Woehler, E.J. 2002. Hearing abilities in Antarctic Penguins. Polarforschung 72(2):95-98.

World Wildlife Federation. 2015. Threats to oceans and coasts, 8. Available at <http://wwf.panda.org/about_our_earth/blue_planet/problems/> (Date Accessed: November 1, 2015).

Yamashita, R., H. Takada, M. Fukuwaka, and Y. Watanuki. 2011-12. Physical and chemical effects of ingested plastic debris on short-tailed shearwaters, Puffinus tenuirostris, in the North Pacific Ocean. Marine Pollution Bulletin 62(12):2845-2849.

Yelverton, J.T., and D.R. Richmond. 1981. Underwater explosion damage risk criteria for fish, birds, and mammals. Pages 1-17 In 102nd Meeting of the Acoustical Society of America, November 30 - December 04, 1981, Department of Biodynamics, Lovelace Biomedical and Environmental Research Institute, Albuquerque, New Mexico.

Yelverton, J.T., D.R. Richmond, R.E. Fletcher, and R.K. Jones. 1973. Safe distances from underwater explosions for mammals and birds. Lovelace Foundation for Medical Education and Research, DNA 3114 T, Albuquerque, NM, July 13, 1973. 64 pp.

Yelverton, J.T., D.R. Richmond, W. Hicks, K. Saunders, and R.E. Fletcher. 1975. The relationship between fish size and their response to underwater blast. Report prepared for the Defense Nuclear Agency, AD-A015-970, Albuquerque, New Mexico. 39 pp.

Young, G.A. 1991. Concise methods for predicting the effects of underwater explosions on marine life. Naval Surface Warfare Center, White Oak Lab, NAVSWC MP 91-220, Silver Spring, Maryland. 19 pp.

APPENDIX F
STATUS OF THE SPECIES: BULL TROUT CORE AREAS
LOWER SKAGIT
STILLIGUAMISH
SNOHOMISH

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Appendix F
Bull Trout Core Areas: Lower Skagit, Stillaguamish-Skykomish, and Snohomish

LOWER SKAGIT CORE AREA

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

Bull trout occur throughout the Lower Skagit core and express fluvial, adfluvial, resident, and anadromous life history forms. Adfluvial bull trout occur in Baker Lake and Lake Shannon. 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 (Kraemer 2001, p. 2). Populations expressing the resident life history form are found throughout the basin and often co-occur with migratory life history forms. Life history expression of bull trout is highly plastic. Individual fish may change life histories during their lifetime (USFWS 2008a, p. 2). Also, life history of progeny may vary from that of the parents (Brenkman et al. 2007, pp. 8-9; Rieman and McIntyre 1993, pp. 2-3).

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

The Lower Skagit core area population is considered at "low risk" for extirpation (USFWS 2008b, p. 35). This core area is one of four population strongholds in the Coastal Recovery Unit (USFWS 2015a, p. 79). The status of the bull trout core area population can be summarized by four key elements necessary for long-term viability: 1) number and distribution of local populations, 2) adult abundance, 3) productivity (i.e., trend in adult abundance), and 4) connectivity (USFWS 2004, p. 215).

Number and Distribution of Local Populations

Twenty local populations are recognized within the Lower Skagit core area (USFWS 2004, p. 76; USFWS 2015b, p. A-148): 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) Sulphur Creek (Lake Shannon), 17) Tenas Creek, 18) Upper South Fork Sauk River, 19) Upper Suiattle River, and 20) Upper White Chuck River. Core areas with more than 10 interconnected local populations are at a diminished risk of local extirpation and adverse effects from random naturally-occurring events (USFWS 2004, pp.

216-218). Eighteen local populations within the Lower Skagit core area are interconnected. Connectivity of two local populations with the rest of the core area is partially obstructed (see Connectivity section below).

Adult Abundance

The Lower Skagit core area is believed to contain the largest spawning population of bull trout in Washington. Adult abundance is estimated to be between 5,000 and 10,000 individuals based on partial spawner survey data from less than half of the core area (USFWS 2008a, p. 3). This core area is not considered at risk from genetic drift because it supports more than 1,000 adults (USFWS 2004, pp. 218-224). However, some local populations may be at risk from inbreeding depression because they appear to contain fewer than 100 adults (USFWS 2004, pp. 218-224). At least half of the local populations are believed to have 100 or more adults, and thus are not at risk from inbreeding depression. Abundance data for most local populations are limited and/or outdated. These data are described below. More recent and/or higher quality survey data for most local populations are needed to reach more confident conclusions.

The WDFW conducted surveys in index reaches of six local populations from 2001 to 2011 (Downen 2009; Fowler 2012), although not every local population was surveyed in every year. It is uncertain what proportion of available habitat was represented by the surveyed index reaches. Therefore, survey results represent minimum abundances. Unless otherwise noted, the following adult abundances are based on redd survey results. Survey years are noted in parentheses.

Bacon Creek: 42 to 134 adults (2009 to 2011); 118 to 300 adults (2001 to 2008).

Cascade River: 182 to 414 adults (2009 to 2011); 666 to 868 adults (2006 to 2008).

Downey Creek: 190 to 282 adults (2009 to 2011); 316 to 394 adults (2005 to 2008).

Forks of Sauk River: 154 to 416 adults (2005 to 2011); 350 to 740 adults (2001 to 2004); 10 to 104 adults (1988 to 1996).

Goodell Creek: 25 to 63 adults (2004 to 2008); 150 to 175 adults (2002 to 2003). Abundances are peak live counts of individual fish.

Illabot Creek: 100 to 260 adults (2005 to 2008); 600 to 660 adults (2002 to 2004).

Puget Sound Energy has performed limited bull trout surveys annually in the Baker Lake and Sulphur Creek (Lake Shannon) local populations since 2009. Similar surveys were performed by the National Park Service and/or R2 Consulting from 2000 to 2006. Surveys have been intended to provide indicators of relative, not absolute, abundance. Nonetheless, surveys suggest the following:

Baker Lake: May contain at least 100 adults, but likely fewer than 500.

Sulphur Creek (Lake Shannon): Less than 100 adults.

For all other local populations, there are no recent adult abundance data. In 2001, the WDFW provided abundance estimates for many core areas (Kraemer 2001). However, the methods and assumptions used to derive these estimates were not described; therefore, the quality and accuracy of these estimates is uncertain.

Buck Creek: Less than 500 migratory adults. "Abundant" residents believed to be near historical numbers.

Lime Creek: Less than 100 migratory adults. "Abundant" residents.

Lower White Chuck River: Less than 500 migratory adults. "Abundant" residents believed to be near historical numbers.

Newhalem Creek: Unknown abundance.

Milk Creek: Limited migratory use presumably due to natural factors. "Abundant" residents believed to be near historical numbers.

South Fork Cascade River: Less than 500 migratory adults. "Abundant" residents believed to be near historical numbers.

Straight Creek: Less than 100 migratory adults. "Unknown" resident component.

Sulphur Creek: Less than 500 migratory adults. "Abundant" residents believed to be near historical numbers.

Tenas Creek: Less than 100 migratory adults. "Limited" resident component.

Upper South Fork Sauk River: Less than 500 migratory adults. "Abundant" residents believed to be near historical numbers.

Upper Suiattle River: "Unknown" abundance of migratory and resident forms.

Upper White Chuck River: "Unknown" abundance of migratory and resident forms, but believed to be one of the larger local populations, presumably due to the quantity and quality of habitat.

<u>Productivity</u>

Most local populations are not consistently monitored; therefore, trends in abundance are unknown. Data from the six local populations monitored by the WDFW (Downen 2009; Fowler 2012) suggest that a basin-wide decline in productivity occurred in the mid-2000's (see Adult Abundance section above). Unusually low summer flows and record flood events in the mid-2000's may have been primary contributors to this decline. It is unknown if productivity is continuing to decline or has stabilized. This uncertainty is due to the following: 1) the relatively recent timing of the decline; 2) lack of any abundance data more recent than 2011; and, 3) inherent inter-annual variability in bull trout abundance surveys. Any persistent and widespread decline in productivity across the core area would increase the risk of extirpation (USFWS 2004, pp. 224-225). More recent and/or higher quality survey data for most local populations are needed to reach more confident conclusions.

Long-term monitoring data from the Forks of Sauk River local population suggests that this local population remains at abundances greater than pre-listing levels despite the apparent recent decline in productivity. The extent to which this is true for other local populations is unknown.

Monitoring data from 2009 to 2014 for the Baker Lake and Sulphur Creek (Lake Shannon) local populations suggest stable or increasing trends in productivity, likely due to recent intensive sockeye salmon hatchery production and fry releases into the lakes.

Connectivity

There are no connectivity barriers between 18 of the 20 local populations, and most, if not all, of these local populations contain migratory life history forms. Thus, there are no extirpation risks associated with connectivity among these local populations. Connectivity within the Baker River system, and between the Baker River system and other local populations, is partially obstructed by two hydropower dams owned and operated by Puget Sound Energy. Bull trout passage across the dams has improved with the construction of new passage infrastructure (floating surface collectors for downstream migrants; adult trap-and-haul facility for upstream migrants) and implementation of improved passage protocols. These were negotiated as part of the 2004 Settlement Agreement and 2008 Federal Energy Regulatory Commission license renewal. The overarching bull trout passage strategy is the most effective one that can be achieved with the dams in place. However, there are limitations that prevent the passage measures from being fully effective, which places the two local populations above the dams - Baker Lake and Sulphur Creek (Lake Shannon) - at increased risk of extirpation. The Service works closely with Puget Sound Energy to monitor passage effectiveness and make improvements where possible.

Currently, bull trout in the Lower Skagit core area can migrate upstream only as far as Gorge Dam. Historically, bull trout may have been able to migrate as far as the current site of Diablo Dam (USFWS 2004, p. 77), approximately 4 miles upstream from Gorge Dam.

Changes in Environmental Conditions

Since the bull trout listing, federal actions occurring in the Lower Skagit core area have had short- and long-term effects to bull trout and bull trout habitat, and have both positively and negatively affected bull trout. These actions have included: statewide federal restoration programs with riparian restoration, replacement of fish passage barriers, and fish habitat improvement projects; federally funded transportation projects involving repair and protection of roads and bridges; federally authorized repair and maintenance of levees and emergency bank protection actions; 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.

Carpenter, Turner, Otter Pond, Red, Fisher, Hansen, Lake, Nookachamps, and East Fork Nookachamps Creeks are all temperature-impaired tributaries to the Skagit River within the Lower Skagit core area. These creeks are addressed in a TMDL study of the lower Skagit basin (WDOE 2008, p. 18).

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. State fishing regulations allow a daily limit of two fish within the Lower Skagit core area. Emergency regulations were implemented in 2007 within sections of the Skagit River to prohibit the retention of bull trout to address the decline in bull trout spawners that had been observed. These declines may have been the result of drought and flood events. Changes in fishing regulations were implemented in 2008 by WDFW within portions of the Skagit, Sauk, and Cascade Rivers, including new selective gear rules and catch and release requirements (USFWS 2008a, p. 12)

A number of major restoration and conservation land protection projects have been completed in the Skagit River watershed that improve and protect bull trout habitat. Many of these projects were implemented as the result of project prioritization processes and state and federal funding coordinated by the Skagit Watershed Council (E. Connor, Seattle City Light, pers. comm. 2008 in USFWS 2008a, p. 12). Major restoration projects that have been implemented or completed since 2004 include the Milltown Island and Wiley Slough Estuary Restoration Project sponsored by the Skagit River System Cooperative (SRSC) and WDFW, and the sediment reduction projects in the middle Skagit and Suiattle River watersheds sponsored by the U.S. Forest Service. Over 1,100 acres of habitat in the Cascade River was put into permanent conservation protection through the partnership of Seattle City Light, Washington Department of Natural Resources, and USFWS (USFWS 2008a, p. 12). Several miles of foraging, migration, and overwintering habitat along the middle Skagit River have been protected since 2004 by the Skagit Land Trust and The Nature Conservancy, and major areas along the middle Skagit are being restored by the Skagit Fisheries Enhancement Group and SRSC. The SRSC has been reducing the impacts of bank armoring on foraging, migration, and overwintering habitats in the Sauk River by acquiring lands and subsequently removing riprap (USFWS 2008a, p. 12). Additionally, the severity of downstream fish passage impacts at Upper Baker Dam have been reduced (USFWS 2008a, p. 9) and work to upgrade the upstream adult trap and haul facility at the Lower Baker Dam has been completed.

Climate change is expected to negatively affect the Lower Skagit core area (USFWS 2008a, p. 19). Climate change is expected to result in higher water temperatures, lower spawning flows, and increased magnitude of winter peak flows (Battin et al. 2007 in USFWS 2008a, p. 19; Lee and Hamlet 2011). Glacial retreat, snowpack reduction, bluff erosion, landslides, and increased peak flows, are expected to result in increased rates of aggradation downstream (Lee and Hamlet 2011, p. 128-131). Higher peak flows and increased aggradation may increase redd scour and smothering, resulting in mortality to eggs, incubating embryos, and pre-emergent juveniles. The unusually low summer flows and record flood events in the mid-2000’s, which are believed to be a primary contributor to basin-wide declines in bull trout abundance, may be an indicator of how climate change may affect bull trout in the Lower Skagit core area (USFWS 2008a, p. 19).

Threats

There are five primary threats to bull trout in the Lower Skagit core area (USFWS 2015b, pp. A-11 to A-12):

Upland/Riparian Land Management: Legacy Forest Management. Associated sediment impacts, particularly from forest roads, have led to habitat degradation within key spawning and rearing basins (i.e., Sauk and Suiattle Rivers) in the core area.

Instream Impacts: Flood Control. Flood and erosion control associated with agricultural practices, transportation corridors, residential development and urbanization continues to result in poor structural complexity within lower river FMO habitats (e.g., Skagit and lower Sauk Rivers) key to the persistence of the anadromous life history form.

*Water Quality: Agriculture Practices and Residential Development and Urbaniza*tion. Related activities have resulted in sediment and temperature impairment in major tributaries to the lower Skagit River and possibly upper Sauk River

Water Quality: Climate Change. Increasing variability in flows (higher peak and lower base flows) are anticipated to significantly impact both spatial and life history diversity of bull trout within the core area.

Connectivity Impairment: Fish Passage Issues. Upstream and downstream connectivity at hydropower facilities (i.e., Baker River hydropower project) is directly tied to active fish passage measures under the 2004 Settlement Agreement and 2008 Federal Energy Regulatory Commission license renewal.

Additional threats to the Lower Skagit core area bull trout population include the following:

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

- Estuarine nearshore foraging habitats have been, and continue to be, negatively affected by agricultural practices and development activities. In addition, declines in forage fish species, particularly surf smelt and Pacific herring, in the marine nearshore areas of the Salish Sea (Therriault et al. 2009; Greene et al. 2015) have resulted in part from degradation of habitats including natural beaches and eel-grass beds, and from water pollution impacts. Anadromous bull trout feed heavily on these species in nearshore areas (Goetz et al. 2004, pp. 109-112). Declines in marine nearshore habitat quality and prey resources may limit the abundance of the anadromous life history form.

- Declines in abundance of anadromous salmonids have reduced the bull trout forage base and may limit the abundance and productivity of the core area’s bull trout populations (USFWS 2008a, p. 15). Anadromous salmonids are vital to Lower Skagit core area bull trout because they provide an abundant forage resource. However, the abundance of many species of anadromous salmonids in the Lower Skagit core area has been in decline for a decade (chum salmon, *Oncorhynchus keta*) or more (Chinook salmon, *O. tshawytscha*, and steelhead trout, *O. mykiss*) (WDFW 2015). Bull trout abundance and growth rates are positively correlated with abundance of spawning anadromous salmonids in the Lower Skagit core area (Kraemer 2003, pp. 5, 9-10; Zimmerman and Kinsel 2010, pp. 26, 30) and elsewhere (Copeland and Meyer 2011, pp. 937-938). Such correlations have been observed for other species as well (Bentley et al. 2012; Nelson and Reynolds 2014). Anadromous salmonids provide a direct forage resource via eggs and juveniles, which make up a substantial proportion of the bull trout diet (Lowery and Beauchamp 2015). Spawning fish and carcasses also stimulate ecosystem productivity, thereby increasing abundance of aquatic invertebrates and resident fishes (e.g., Cederholm et al. 1999; Moore et al. 2008; Copeland and Meyer 2011; Rinella et al. 2012). Aquatic invertebrates and resident fishes are also important components of the Lower Skagit core area bull trout diet (Lowery and Beauchamp 2015).

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. Bull trout did not occur above Sunset Falls on the South Fork Skykomish River prior to 1958, when the Washington Department of Fisheries (now Washington Department of Fish and Wildlife) implemented a trap-and-haul program for anadromous salmonids. This program is still operating.

Fluvial, resident, and anadromous life history forms of bull trout occur in the Snohomish-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 typical adfluvial populations; however, anadromous and fluvial forma occasionally forage in a number of lowland lakes having connectivity to the mainstem rivers (USFWS 2004, p. 99).

The Snohomish, Snoqualmie, Skykomish, North Fork Skykomish, and South Fork Skykomish Rivers provide important foraging, migrating, and overwintering habitat for subadult and adult bull trout. The topography of the basin limits the amount of key spawning and early rearing habitat in comparison with many other core areas. 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.

In 2008, the Snohomish-Skykomish core area population was considered at “potential risk” for extirpation (USFWS 2008b, p. 35). Since 2008, some of the key status indicators have declined. The status of the bull trout core area population can be summarized by 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, p. 215).

Number and Distribution of Local Populations

Four local populations are recognized within the Snohomish-Skykomish core area (USFWS 2004, pp. 99-105; USFWS 2015, p. A-14): 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. Core areas with fewer than 5 interconnected local populations are at increased risk of local extirpation and adverse effects from random naturally-occurring events (USFWS 2004, pp. 216-218). Three of the four Snohomish-Skykomish core area local populations are interconnected (see Connectivity section below).

Adult Abundance

The Snohomish-Skykomish core area probably supports between 500 and 1,000 adults. In 2008, it was believed that this core area supported just over 1,000 adults (USFWS 2008a, p. 2; USFWS 2008b, p. 35). However, abundance indices in the two primary local populations (North Fork Skykomish River and South Fork Skykomish River) have substantially declined since then (WDFW 2015). From 2002 to 2007, North Fork redd counts averaged 305 redds, peaking at 538 redds in 2002. In contrast, from 2009 to 2014, counts averaged 90 redds, with a minimum of 17 redds observed in 2013, the lowest single-year count since surveys began in 1988. During the same time, spawner counts at the South Fork Skykomish River trap declined from a mean of 94 fish from 2002 to 2007, to a mean of 63 fish from 2009 to 2014. The Troublesome Creek local population is mainly a resident population upstream of a natural migration barrier . Adult abundance is unknown for this local population. The Salmon Creek local population likely has fewer than 100 adults.

The Snohomish-Skykomish core area is at risk from genetic drift because it likely contains fewer than 1,000 spawning adults per year (USFWS 2004, pp. 218-224). Two local populations (South Fork Skokomish River, Salmon Creek) are at risk from inbreeding depression because they are believed to contain fewer than 100 spawning adults per year (USFWS 2004, pp. 218-224). The North Fork Skykomish River local population is not at risk from inbreeding depression. Risk from inbreeding depression to the Troublesome Creek local population is unknown.

Productivity

Population trends for the two primary local populations (North Fork Skykomish River and South Fork Skykomish River) have been in decline since peaking in the early- to mid-2000's. Long-term redd counts for the North Fork Skykomish River local population increased from the time of listing, peaked between 2001 and 2004, and have generally been in decline since. The five-year running average from 2012 to 2014 varied between 83 and 118 redds, which is equivalent to pre-listing levels (75 to 118 redds) despite peaking at 348 to 366 redds between 2004 and 2006. A similar trend is evident in adult counts at the South Fork Skykomish River trap, although recent five-year running averages (62 to 66 adults) are still above pre-listing levels (38 to 44 adults). The five-year running average peaked between 2005 and 2007 at 95 to 102 adults. It is believed that the South Fork Skykomish River local population is continuing to colonize new spawning and rearing habitat, which may partially explain the less dramatic declining trend. 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. The Snohomish-Skykomish core area is at increased risk of extirpation due to declining productivity (USFWS 2004, pp. 224-225).

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 reduces the risk of extirpation from habitat isolation and fragmentation. However, connectivity with the South Fork Skykomish local population is dependent upon the trap-and-haul facility at Sunset Falls.

Changes in Environmental Conditions

Since the bull trout listing, federal actions occurring in the Snohomish-Skykomish core area have had short- and long-term effects to bull trout and bull trout habitat, and have both positively and negatively affected bull trout. These actions have included: statewide federal restoration programs with 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.

Climate change is expected to negatively affect the Snohomish-Skykomish core area (USFWS 2008a, p. 14). Climate change is expected to result in higher water temperatures, lower spawning flows, and increased magnitude of winter peak flows (Battin et al. 2007 in USFWS 2008a, p. 14). Higher peak flows may increase redd scour and mortality to eggs, incubating embryos, and pre-emergent juveniles. Bull trout spawning and rearing areas are particularly vulnerable to future climate change impacts, especially due to the narrow distribution of spawning sites within this system (USFWS 2008a, p. 14).

Threats

There are four primary threats to bull trout in the Snohomish-Skykomish core area (USFWS 2015, p. A-14):

Instream Impacts: Flood Control. Flood and erosion control associated with agricultural practices, residential development, and urbanization continues to result in poor structural complexity within lower river FMO habitats key to the persistence of the anadromous life history form.

Instream Impacts: Recreational Mining. Recreational mining activities impact spawning and rearing tributary habitats.

Water Quality: Residential Development and Urbanization. Associated impacts increase seasonal high water temperature in lower mainstem rivers, migration corridors that are key to the persistence of the anadromous life history form.

Connectivity Impairment: Fish Passage Issues. Persistence of the South Fork Skykomish River local population is reliant upon continued funding and ongoing operation of the trap-and-haul facility at Sunset Falls.

Additional threats to the Snohomish-Skykomish core area bull trout population include the following:

- Degraded habitat conditions from effects associated with timber harvests, logging roads, and timber land fertilization, especially in the upper watershed, where spawning occurs.
- Blocked fish passage, altered stream morphology, and degraded water quality in the lower watershed resulting from agricultural and livestock management practices.
- Injury and/or mortality from illegal harvest or incidental hooking/netting, which may occur where recreational fishing is allowed by the Washington Department of Fish and Wildlife.
- Degraded water quality from municipal and industrial effluent discharges and development.
- Degradation of riparian areas due to residential development and urbanization, and associated loss of foraging habitat and prey.

STILLAGUAMISH CORE AREA

The Stillaguamish core area is comprised of 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 in the Stillaguamish core area primarily consist of the anadromous and fluvial life-history forms (USFWS 2004, p. 96). Resident bull trout occur in the upper South Fork Stillaguamish River (USFWS 2004, p. 98; USFWS 2008a, p. 1) and possibly also upstream of the anadromous barrier on Higgins Creek (USFWS 2008a, p. 3). There are no known populations in the North Fork Stillaguamish River above a natural anadromous barrier at river mile 37.5 (Kraemer, in litt. 1999).

The South Fork Stillaguamish River upstream of Granite Falls has supported anadromous bull trout since the construction of a fishway in the 1950s (USFWS 2004, pp. 97-98). Previously, the falls were impassable to anadromous fish. Anecdotal information from fish surveys in the 1920s and 1930ssuggest that native char likely were present above Granite Falls prior to construction of the fishway (USFWS 2004, pp. 97-98).

Spawning habitat is generally limited in the Stillaguamish core area due to two primary factors: 1) there is a relatively small amount of high elevation areas, which often provide the best thermal regimes for spawning, egg incubation, and early juvenile rearing; and, 2) historical land management practices, particularly related to timber harvesting, have degraded much of the available spawning and rearing habitat. In the North Fork Stillaguamish River basin, migratory bull trout spawn in the upper reaches of the Deer Creek subbasin, including Upper Deer, Little Deer, and Higgins Creeks. There is also a spawning population of resident char (bull trout or Dolly Varden) above the anadromous barrier on Higgins Creek (USFWS 2008a, p. 3). In the Boulder River subbasin, bull trout spawn below the impassible falls at river mile 3. Adult bull trout have been observed in the North Fork Stillaguamish River above the Boulder River confluence, including in the Squire Creek subbasin (USFWS 2004, p. 97). However, these fish are suspected to be strays, colonizers (USFWS 2015, p. A-149), and/or fish foraging from other core areas (USFWS 2004, pp. 3-4), although there has been no extensive juvenile sampling or evaluation of spawning success.

In the South Fork Stillaguamish River basin, bull trout are known to spawn and rear in Canyon, Palmer, Perry, and Buck Creeks and the upper South Fork mainstem above Palmer Creek (USFWS 2004, pp. 94-99). Primary spawning grounds have been identified in the South Fork Stillaguamish River above the Palmer Creek confluence. 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 (*Oncorhynchus kisutch*) salmon. Migratory and resident fish coexist on the spawning grounds.

In Canyon Creek, bull trout use the upper south fork of the creek for spawning and rearing (USFWS 2004, p. 98). Although there have been isolated and incidental observations of spawning by migratory-size bull trout, electrofishing surveys in the early 2000s were unable to locate any juvenile or resident fish. Spawning and early rearing habitat is believed to be in poor condition due to the relatively low elevation and persistent effects of historical land management activities, including logging.

The Stillaguamish core area population was considered “at risk” for extirpation in 2008 (USFWS 2008b, p. 35). Extirpation risk may be greater now due to lower abundance and declining productivity. The status of the bull trout core area population can be summarized by 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, p. 215).

Number and Distribution of Local Populations

Three local populations are recognized within the Stillaguamish core area: 1) Upper Deer Creek, 2) South Fork Stillaguamish River, and 3) Canyon Creek. These local populations are relatively well-distributed throughout the core area. The Upper Deer Creek local population may be extirpated (USFWS 2015, p. A-13), based on the paucity of historical observations of bull trout and more recent failures to detect bull trout. Core areas with fewer than 5 interconnected local populations are at increased risk of local extirpation and adverse effects from random naturally-occurring events (USFWS 2004, pp. 216-218).

A fourth local population - North Fork Stillaguamish River - was recognized from the early 2000s (USFWS 2004, p. 94-99) until 2015, when it was no longer considered a local population (USFWS 2015, p. A-149). Numerous adult bull trout have been observed in this part of the Stillaguamish River system during staging and spawning periods. However, these are now thought to have been anadromous individuals from outside the basin (USFWS 2015, p. A-149). Bull trout redds, possibly from colonizing individuals from outside the basin, were observed in the 1980s (USFWS 2015, p. A-149). No bull trout redds have been detected since then, though redd surveys have been limited. Because of the past adult detections in this area, the North Fork Stillaguamish River is considered a potential local population only.

Adult Abundance

The Stillaguamish core area likely contains fewer than 250 adults, however survey data is limited and origin of fish observed in the former North Fork Stillaguamish River local population is uncertain. This core area is at risk from genetic drift because it contains fewer than 1,000 spawning adults per year (USFWS 2004, pp. 218-224).

The South Fork Stillaguamish River local population may be the only functional population in the core area (USFWS 2008a, p. 2). Average adult abundance in this local population, estimated from redd counts, was approximately 40 fish from 2009 to 2011, a decline from approximately 125 fish from 2005 to 2008 (Fowler 2012).

The Upper Deer Creek and Canyon Creek local populations are believed to be very low, although systematic surveys are not performed here. Past observations of redds and adults suggest that each of these populations number well below 100 adults (USFWS 2004, p. 96). Surveys in 2002 and 2003 did not detect any native char in either area (USFWS 2008a, p. 3). The Upper Deer Creek local population may be extirpated (USFWS 2015, p. A-13).

The North Fork Stillaguamish River is not currently believed to support a spawning local population, although there is insufficient information to rule out the possibility of one in existence (USFWS 2015, p. A-149). It is believed that upwards of 100 adult bull trout utilize this area (USFWS 2004, pp. 96-97), presumably as strays, colonizers (USFWS 2015, p. A-149), and/or fish foraging from other core areas (USFWS 2004, pp. 3-4).

All Stillaguamish core area local populations are at risk from inbreeding depression because they appear to contain fewer than 100 spawning adults per year (USFWS 2004, pp. 218-224).

Productivity

Productivity of the Stillaguamish River core area may be in decline based on trends in redd counts observed in the South Fork Stillaguamish River, the primary local population. Average adult abundance estimated from redd counts was approximately 40 fish from 2009 to 2011, a decline from approximately 125 fish from 2005 to 2008 (Fowler 2012). In addition, the three-year running average of redd counts declined every year from 2007 (53 redds per year) to 2011 (18 redds per year). More recent survey data is needed to confirm whether this apparent trend is continuing. Declining productivity places the core area at increased risk of extirpation (USFWS 2004, p. 224-225).

Connectivity

The presence of migratory bull trout in the primary local population (South Fork Stillaguamish River) and likely other local populations diminishes the risk of local extirpation from connectivity issues. However, persistence of migratory life history forms in the South Fork Stillaguamish River depends upon continued operation of the Granite Fall fishway, which may not be fully functional (USFWS 2008a, p. 5). In addition, a weir on Cook Slough impedes upstream fish passage and/or traps migratory spawners (USFWS 2015, p. A-13).

Bull trout habitat within the Stillaguamish core area 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 Snohomish-Skykomish core area have had short- and long-term effects to bull trout and bull trout habitat, and have both positively and negatively affected bull trout. These actions have included: statewide federal restoration programs with 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. For example, in 2000, State forest practice regulations were significantly revised following the Forest and Fish agreement. These regulations increased riparian protection, unstable slope protection, recruitment of large wood, and improved road standards significantly. Because there is biological uncertainty associated with some of the prescriptions, the Forest and Fish agreement relies on an adaptive management program for assurance that the new rules will meet the conservation needs of bull trout. The updated regulations are expected to significantly reduce the level of future timber harvest impacts to bull trout streams on private lands, however, most legacy threats from past forest practices will likely continue to be a threat for decades.

The number of non-federal actions occurring in the Stillaguamish core area since the bull trout listing is unknown. Beneficial actions include Snohomish County revised Critical Area Regulations, effective October 1, 2007. The revised regulations included consideration for anadromous fish intended to preserve the critical area functions beneficial to these species. In addition, recent salmon recovery efforts are improving conditions for bull trout. Although directed toward salmonids other than bull trout, the regional salmon recovery plan under the Shared Strategy for Puget Sound and watershed-scale implementation under the Puget Sound Partnership have resulted in general aquatic habitat improvements that benefit many target and non-target species, including bull trout. Other non-federal 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.

Climate change is expected to negatively affect the Stillaguamish core area (USFWS 2008a, pp. 14-15). Climate change projections for the Puget Sound region suggest the following impacts to occur in river systems across the region, including the Stillaguamish (Battin et al. 2007; Beechie et al. 2013; Hall et al. 2014; Tohver et al. 2014): greater proportion of rain during the winter and less snowpack in the late spring and early summer; higher water temperatures, especially during the summer; lower flows during the summer and early fall; and, increased magnitude of winter peak flows Snowpack reduction, increased peak flows, and associated bluff erosion and landslides may result in increased rates of sediment aggradation downstream (Lee and Hamlet 2011, p. 128-131). Higher peak flows and increased aggradation may increase redd scour and smothering, resulting in mortality to eggs, incubating embryos, and pre-emergent juveniles. In addition, the Stillaguamish River basin already suffers from temperature exceedances within its mainstem and two forks (WDOE 2007), making it particularly vulnerable to climate change impacts. There are no glaciers or protected areas in the Stillaguamish River basin that could help to buffer the impacts of climate change (USFWS 2008a, p. 14-15).

Threats

There are six primary threats to bull trout in the Stillaguamish core area (USFWS 2015, p. A-13):

Upland/Riparian Land Management: Forest Management. Legacy and ongoing impacts have exacerbated landslide activity in the watershed degrading salmonid habitat and water quality.

Instream Impacts: Recreational Mining. Activities impact spawning and rearing tributary habitats.

Water Quality: Forest Management, Residential Development and Urbanization. Legacy impacts result in seasonal high water temperatures in mainstem river, North and South Forks, and some local population tributaries; anticipated to be further exacerbated by climate change.

Connectivity Impairment: Fish Passage Issues. Stillaguamish weir on Cook Slough impedes upstream fish passage and/or traps migratory spawners.

Connectivity Impairment: Fish Passage Issues. Persistence of the migratory life history in the South Fork Stillaguamish River local population is reliant upon continued functionality of the fishway at Granite Falls.

Small Population Size: Genetic and Demographic Stochasticity. Available spawner abundance data indicates the low number of adults results in increased genetic and demographic stochasticity in the South Fork Stillaguamish and Upper Deer Creek local populations, in fact, the Upper Deer Creek local population may be extirpated.

Additional threats to the Stillaguamish core area bull trout population include the following:

- Estuarine nearshore foraging habitats have been severely diminished in quantity and quality (USFWS 2008a, pp. 8, 13). In addition, declines in forage fish species, particularly surf smelt and Pacific herring, in the marine nearshore areas of the Salish Sea (Therriault et al. 2009; Greene et al. 2015) have resulted in part from degradation of habitats including natural beaches and eel-grass beds, and from water pollution impacts. Anadromous bull trout feed heavily on these species in nearshore areas (Goetz et al. 2004, pp. 109-112). Declines in marine nearshore habitat quality and prey resources may limit the abundance of the anadromous life history form.

- The abundance of many species of anadromous salmonids in the Stillaguamish core area has been in decline for many years (WDFW 2015). Bull trout abundance and growth rates are positively correlated with abundance of live-spawning anadromous salmonids in the nearby Lower Skagit core area (Kraemer 2003, pp. 5, 9-10; Zimmerman and Kinsel 2010, pp. 26, 30) and elsewhere (Copeland and Meyer 2011, pp. 937-938). Such correlations have been observed for other species as well (Bentley et al. 2012; Nelson and Reynolds 2014). Anadromous salmonids provide a direct forage resource via eggs and juveniles, which can make up a substantial proportion of the bull trout diet (e.g., Lowery and Beauchamp 2015). Live spawners and carcasses also stimulate ecosystem productivity, thereby increasing abundance of aquatic invertebrates and resident fishes (e.g., Cederholm et al. 1999; Moore et al. 2008; Copeland and Meyer 2011; Rinella et al. 2012), which bull trout forage on (Lowery and Beauchamp 2015). The long-term decline in abundance of live-spawning anadromous salmonids and the related decline in the forage base may limit the long-term abundance and productivity of the core area's bull trout populations.

- Climate change is expected to negatively affect spawning and rearing bull trout via elevated water tempertures during migration, spawning, and rearing periods; redd scour due to increased peak flows; decreased habitat quantity as a result of lower summer flows.

- Historical planting of Westslope cutthroat trout in the North and South Forks of the Stillaguamish River in areas overlapping bull trout spawning and rearing is a concern (USFWS 2004; USFWS 2008a, p. 7).

LITERATURE CITED - Lower Skagit Core Area

Bentley, K.T., D.E. Schindler, J.B. Armstrong, R. Zhang, C.P. Ruff, and P.J. Lisi. 2012. Foraging and growth responses of stream-dwelling fishes to inter-annual variation in a pulsed resource subsidy. Ecosphere 3(12):1-17. http://dx.doi.org/10.1890/ES12-00231.1

Brenkman, S.J., S.C. Corbett, and E.C. Volk. 2007. Use of otolith chemistry and radiotelemetry to determine age-specific migratory patterns of anadromous bull trout in the Hoh River, Washington. Transactions of the American Fisheries Society 136:1-11.

Cederholm, C.J., M.D. Kunze, T. Murota, and A. Sibatani. 1999. Pacific salmon carcasses: Essential contributions of nutrients and energy for aquatic and terrestrial ecosystems. Fisheries 24:6-15.

Copeland, T., and K.A. Meyer. 2011. Interspecies synchrony in salmonid densities associated with large-scale bioclimatic conditions in central Idaho. Transactions of the American Fisheries Society 140:928-942.

Downen, M.R. 2009. 2008 Skagit bull trout monitoring program annual report. Washington Department of Fish and Wildlife, 2009. 4 pp.

Fowler, A. 2012. 2011 Skagit, Stillaguamish, and North Fork Skykomish Rivers bull trout monitoring report. Washington Department of Fish and Wildlife, La Connor, Washington. 13 pp.

Goetz, F.A., E. Jeanes, and E. Beamer. 2004. Bull Trout in the Nearshore. Preliminary Draft Report. U.S. Army Corps of Engineers, Seattle, WA.

Greene, C., L. Kuehne, C. Rice, K. Fresh, and D. Penttila. 2015. Forty years of change in forage fish and jellyfish abundance across greater Puget Sound, Washington (USA): anthropogenic and climate associations. Marine Ecology Progress Series 525:153-170.

Kraemer, C. 2001. Draft: Puget Sound bull trout core areas - lower Skagit core area. Washington Department of Fish and Wildlife, Olympia, WA, July 31, 2001. 8 pp.

Kraemer, C. 2003. Lower skagit bull trout age and growth information developed from scales collected from anadromous and fluvial char. Management Brief. Washington Department of Fish and Wildlife, Olympia, WA.

Lee, S., and A.F. Hamlet. 2011. Skagit River Basin Climate Science Report. Summary report prepared for Skagit County and the Envision Skagit Project by the Department of Civil and Environmental Engineering and The Climate Impacts Group, University of Washington.

Lowery, E.D., and D.A. Beauchamp. 2015. Trophic Ontogeny of Fluvial Bull Trout and Seasonal Predation on Pacific Salmon in a Riverine Food Web. Transactions of the American Fisheries Society 144:724-741, DOI:10.1080/00028487.2015.1035452.

Moore, J.W., D.E. Schindler, C.P. Ruff. 2008. Habitat saturation drives thresholds in stream subsidies. Ebcology 89:306-312.

Nelson, M.C., and J.D. Reynolds. 2014. Time-Delayed Subsidies: Interspecies Population Effects in Salmon. PLoS ONE 9(6): e98951. doi:10.1371/journal.pone.0098951.

Rieman, B.E., and J.D. McIntyre. 1993. Demographic and habitat requirements for conservation of bull trout. U.S. Department of Agriculture, Forest Service, Intermountain Research Station, General Technical Report INT-302, Ogden, Utah, September 1993. 38 pp.

Rinella, D.J., M.S. Wipfli, C.A. Stricker, R.A. Heintz, and M.J. Rinella. 2012. Pacific salmon (Oncorhynchus spp.) runs and consumer fitmess: growth and energy storage in stream-dwelling salmonids increase with salmon spawner density. Canadian Journal of Fsiheries and Aquatic Sciences 69:73-84.

Therriault, T.W., D.E. Hay, and J.F. Schweigert. 2009. Biologic overview and trends in pelagic forage fish abundance in the Salish Sea (Strait of Georgia, British Columbia). Marine Ornithology 37: 3-8.

USFWS. 2004. Draft Recovery Plan for the Coastal-Puget Sound distinct population segment of bull trout (*Salvelinus confluentus*). Volume I: Puget Sound Management Unit, 389+xvii pp and Volume II: Olympic Peninsula Management Unit, 277+xvi pp, Portland, Oregon.

USFWS. 2008a. Bull trout core area templates - an unpublished compilation of updated bull trout core area analysis to support the five-year review. Lower Skagit River Core Area Chapter. U.S. Fish and Wildlife Service, Portland, OR, August 24, 2008..

USFWS. 2008b. Bull Trout (Salvelinus confluentus) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Portland, OR. 53 pp.

USFWS. 2015a. Recovery Plan for the Coterminous United States Population of Bull Trout (*Salvelinus confluentus*). Portland, OR. xii + 179 pp.

USFWS. 2015b. Coastal Recovery Unit Implementation Plan for Bull Trout (*Salvelinus confluentus*). Lacey, WA and Portland, OR.

WDFW (Washington Department of Fish and Wildlife). 2015. Salmon Conservation Reporting Engine, Skykomish Bull Trout. Olympia, WA. https://fortress.wa.gov/dfw/score/score/species/species.jsp. Accessed October 1, 2015.

WDOE. 2008. Lower Skagit River tributaries temperature total maximum daily load. Water quality improvement report. Water Quality Program, WDOE, Publication No. 08-10-020, Bellevue, Washington, July 2008. 252 pp.

Zimmerman, M., and C. Kinsel. 2010, Migration of Anadromous Juvenile Bull Trout in the Skagit River, 1990-2009. Report FPT 11-01. Washington Department of Fish and Wildlife, Olympia, WA.

LITERATURE CITED - Snohomish-Skykomish Core Area

USFWS. 2004. Draft Recovery Plan for the Coastal-Puget Sound distinct population segment of bull trout (*Salvelinus confluentus*). Volume I: Puget Sound Management Unit, 389+xvii pp. Portland, Oregon.

USFWS. 2008a. Bull trout core area templates - an unpublished compilation of updated bull trout core area analysis to support the five-year review. Snohomish-Skykomish River Core Area Chapter. U.S. Fish and Wildlife Service, Portland, OR, August 24, 2008.

USFWS. 2008b. Bull Trout (*Salvelinus confluentus*) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Portland, OR. 53 pp.

USFWS. 2015. Coastal Recovery Unit Implementation Plan for Bull Trout. Lacey, WA and Portland, OR.

WDFW (Washington Department of Fish and Wildlife). 2015. Salmon Conservation Reporting Engine, Skykomish Bull Trout. Olympia, WA. https://fortress.wa.gov/dfw/score/score/species/population_details.jsp?stockId=8108. Accessed September 21, 2015.

LITERATURE CITED - Stillaguamish Core Area

Battin, J., M.W. Wiley, M.H. Ruckelshaus, R.N. Palmer, E. Korb, K.K. Bartz, and H. Imaki. 2007. Projected impacts of climate change on salmon habitat restoration. Proceedings of the National Academy of Sciences of the United States of America 104(16):6720-6725.

Bentley, K.T., D.E. Schindler, J.B. Armstrong, R. Zhang, C.P. Ruff, and P.J. Lisi. 2012. Foraging and growth responses of stream-dwelling fishes to inter-annual variation in a pulsed resource subsidy. Ecosphere 3(12):1-17. http://dx.doi.org/10.1890/ES12-00231.1

Beechie, T., H. Imaki, J. Greene, A. Wade, H. Wu, G. Pess, P. Roni, J. Kimball, J. Stanford, P. Kiffney, and N. Mantua. 2013. Restoring salmon habitat for a changing climate. River Research and Applications, 29(8), 939-960.

Cederholm, C.J., M.D. Kunze, T. Murota, and A. Sibatani. 1999. Pacific salmon carcasses: Essential contributions of nutrients and energy for aquatic and terrestrial ecosystems. Fisheries 24:6-15.

Copeland, T., and K.A. Meyer. 2011. Interspecies synchrony in salmonid densities associated with large-scale bioclimatic conditions in central Idaho. Transactions of the American Fisheries Society 140:928-942.

Fowler, A. 2012. 2011 Skagit, Stillaguamish, and North Fork Skykomish Rivers bull trout monitoring report. Washington Department of Fish and Wildlife, La Connor, Washington. 13 pp.

Goetz, F.A., E. Jeanes, and E. Beamer. 2004. Bull trout in the nearshore. Preliminary draft. U.S. Army Corps of Engineers, Seattle, WA.

Greene, C., L. Kuehne, C. Rice, K. Fresh, and D. Penttila. 2015. Forty years of change in forage fish and jellyfish abundance across greater Puget Sound, Washington (USA): anthropogenic and climate associations. Marine Ecology Progress Series 525:153-170.

Hall, J.E., T.J. Beechie, and G.R. Pess. 2014. Influence of climate and land cover on river discharge in the North Fork Stillagaumish River. Final Contract Report to the Stillaguamish Tribe of Indians. NOAA Fisheries, Seattle, WA.

Kraemer, C. 1999. Document from Curtis Kraemer, WDFW, re Bull trout in the Stillaguamish River system. July 1999.

Kraemer, C. 2003. Lower skagit bull trout age and growth information developed from scales collected from anadromous and fluvial char. Management Brief. Washington Department of Fish and Wildlife, Olympia, WA.

Lee, S., and A.F. Hamlet. 2011. Skagit River Basin Climate Science Report. Summary report prepared for Skagit County and the Envision Skagit Project by the Department of Civil and Environmental Engineering and The Climate Impacts Group, University of Washington.

Lowery, E.D., and D.A. Beauchamp. 2015. Trophic Ontogeny of Fluvial Bull Trout and Seasonal Predation on Pacific Salmon in a Riverine Food Web. Transactions of the American Fisheries Society 144:724-741, DOI:10.1080/00028487.2015.1035452.

Moore, J.W., D.E. Schindler, C.P. Ruff. 2008. Habitat saturation drives thresholds in stream subsidies. Ebcology 89:306-312.

Nelson, M.C., and J.D. Reynolds. 2014. Time-Delayed Subsidies: Interspecies Population Effects in Salmon. PLoS ONE 9(6): e98951. doi:10.1371/journal.pone.0098951.

Rinella, D.J., M.S. Wipfli, C.A. Stricker, R.A. Heintz, and M.J. Rinella. 2012. Pacific salmon (Oncorhynchus spp.) runs and consumer fitmess: growth and energy storage in stream-dwelling salmonids increase with salmon spawner density. Canadian Journal of Fsiheries and Aquatic Sciences 69:73-84.

Therriault, T.W., D.E. Hay, and J.F. Schweigert. 2009. Biologic overview and trends in pelagic forage fish abundance in the Salish Sea (Strait of Georgia, British Columbia). Marine Ornithology 37: 3-8.

Tohver, I.M., A.F. Hamlet, and S. Lee. 2014. Impacts of 21st-Century Climate Change on Hydrologic Extremes in the Pacific Northwest Region of North America. Journal of the American Water Resources Association 50(6): 1461-1476. DOI: 10.1111/jawr.12199.

USFWS. 2004. Draft Recovery Plan for the Coastal-Puget Sound distinct population segment of bull trout (*Salvelinus confluentus*). Volume I: Puget Sound Management Unit, 389+xvii pp. Portland, Oregon.

USFWS. 2008a. Bull trout core area templates - an unpublished compilation of updated bull trout core area analysis to support the five-year review. Stillaguamish River Core Area Chapter. U.S. Fish and Wildlife Service, Portland, OR, August 24, 2008.

USFWS. 2008b. Bull Trout (Salvelinus confluentus) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Portland, OR. 53 pp.

USFWS. 2015. Coastal Recovery Unit Implementation Plan for Bull Trout (*Salvelinus confluentus*). Lacey, WA and Portland, OR.

WDOE (Washington Department of Ecology). 2007. Stillaguamish River Fecal Coliform, Dissolved Oxygen, pH, Mercury, and Temperature Total maximum Daily Load: Water Quality Implementation Plan. Publication No. 07-10-033. Olympia, WA.

WDFW (Washington Department of Fish and Wildlife). 2015. Salmon Conservation Reporting Engine, Skykomish Bull Trout. Olympia, WA. https://fortress.wa.gov/dfw/score/score/species/species.jsp. Accessed October 1, 2015.

Zimmerman, M., and C. Kinsel. 2010, Migration of Anadromous Juvenile Bull Trout in the Skagit River, 1990-2009. Report FPT 11-01. Washington Department of Fish and Wildlife, Olympia, WA.

APPENDIX G
ESTIMATING THE PROBABILITY OF MARBLED MURRELETS EXPOSURE TO STRESSORS FROM EXPLOSIONS AND SONAR IN CONSERVATION ZONE 1 (INLAND WATERS)

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Appendix G
Estimating the Probability of Marbled Murrelets Exposure to Stressors from Explosions and Sonar in Conservation Zone 1 (Inland Waters)

This document describes the methodology for determining whether the marbled murrelet (murrelet) (*Brachyramphus marmoratus*) is likely to be exposed to stressors from sonar and explosions in Inland Waters. Since, compared to Offshore Areas, there is more comprehensive survey data available for Inland Waters; we calculated murrelet density and distribution specific to Inland Waters. We used a reasonable worst-case scenario to determine whether exposure was extremely unlikely to occur (discountable). If the probability of exposure according to this "worst-case" analysis was greater than 10 percent, we went on to assess exposure in a "reasonably certain" scenario to determine the probability of exposure, and the number of groups that were likely to be exposed to the stressors (see Appendix A[1]).

In Inland Waters, the first step towards determining the likelihood of murrelets encountering stressors associated with sonar and detonating explosives is to describe the structure of the murrelet population in Conservation Zone 1. The Northwest Forest Plan Effectiveness Monitoring Program reports the abundance and density of murrelets in Conservation Zones 1 to 5 (Falxa and Raphael 2015) during the summer. The most recent population estimates from Falxa et al. (2015), show that Conservation Zone 1 has an annual rate of change of -5.4 percent between 2001 and 2014.

Methods

Murrelets commonly occur in the marine environment in flocks that vary in size and distribution by season (Falxa, 2008; Nysewander et al. 2005, p. 65, 68; Speich et al. 1992). Murrelet summer density varies considerably temporally (within and between years) and spatially in Puget Sound. To best address this temporal variation we estimated population abundance by averaging the murrelet density within each survey area (stratum) between 2011 and 2015 in Conservation Zone 1 (Table 1).

Table 1. Average marbled murrelet density and population size during summer (April through September) in Conservation Zone 1 between 2011 and 2015 (Falxa et al. 2015; Falxa and Raphael 2015)**.**

Conservation Zone 1 (Strata)	Mean Density (birds/km^2)	Mean Population Size Estimate with 95% CI[1]			Survey Area (km^2)
		Mean	Lower	Upper	
1	3.7	3,144	1,661	4,688	845
2	1.3	1,582	786	2,404	1,194
3	0.5	701	252	1,624	1,458
All	**1.6**	**5,427**	**2,699**	**8,716**	**3,497**

[1] CI = confidence interval

[1] Appendices referenced in this appendix are appendices associated with the NWTT Biological Opinion (Service Reference: 01EWFW00-2015-F-0251)

To approximate murrelet winter density, we used winter surveys reported by Nysewander et al. (2005) for the Puget Sound Ambient Monitoring Program (1992-1999). Although Nysewander et al. (2005) did not report summer murrelet density we developed an index based on a close examination of the changes in seasonal abundance of murrelets in Puget Sound reported from summer and winter surveys.

In summer surveys conducted by Nysewander et al. (2005), alcids comprised 5.9 percent to 14.6 percent (mean of 10.3 percent) of the summer marine bird populations over the eight summers in the core survey area covered every year. Murrelets were one of the least abundant alcids observed during the surveys, comprising just 1.5 percent of all alcids in the summer observations.

We calculated an 8-year average density of 87.05 marine birds/km^2 from the information reported by Nysewander et al. (2005, p. 10) for the area encompassing the Explosive Ordnance Disposal (EOD) sites. We then multiplied the 8-year average by the maximum murrelet occurrence rate of 0.00219 murrelets/km^2 [the product of the maximum alcid occurrence rate (0.146 alcids/marine bird) and the proportion of the alcids that were murrelets (0.015 murrelets/alcid)]. The result was an average maximum murrelet summer density of 0.190 murrelets/km^2 (87.05 birds/km^2 x 0.00219) for the 1992-1998 survey period. We calculated the average *maximum* murrelet density in summer to make an appropriate comparison with the winter maximum murrelet density provided in Nysewander et al. (2005). When we compared the maximum summer density (0.190 murrelets/km^2) (Falxa et al. 2009) to the maximum winter density (0.35 murrelets/ km^2), (Nysewander et al. 2005, p. 65) we calculated a 1.84-fold increase (0.35/0.19) in winter density over the summer density estimates We multiply summer abundance by a winter abundance correction factor of 1.84 to predict winter density in Conservation Zone 1.

The significant density increase in the winter is likely due to murrelets from coastal areas of British Columbia (outside the listed range of the species) and Washington (Conservation Zone 2) gathering in Puget Sound.

Group Size and Number of Groups

Murrelet summer foraging groups are most often two birds, with other group sizes (singles and groups of three or more birds) less common (Merizon et al. 1997). To assess murrelet risk we estimated of the size and number (density) of murrelet groups in the affected Conservation Zone 1. The mean group size of murrelets is computed each year for Conservation Zone 1 for the NWFPEM (Falxa 2011). To estimate the number of groups at either the conservation zone or stratum scales, we computed the overall mean group size (**f**) from the 2001 through 2009 annual group size mean (corrected for observer detection bias due to group size) reported by Falxa (Falxa 2011). This resulted in an overall, 2001-2009, mean group size of 1.73 (n = 9) in Conservation Zone 1, with the upper 95 percent level of 1.79 and lower 95 percent level at 1.67. The observed range of average group size was 1.59 (2001) to 1.82 (2003).

Due to the low variation in mean group size between years, we estimated the number of murrelet groups in the conservation zone (from the population size reported in Table 1) or within a given survey stratum (from the reported strata densities in Falxa 2010 in litt.) based upon a 1.73 mean group size. We relied on data provided at the stratum level; therefore, we assume that the density of birds at Crescent Harbor is reasonably similar to Floral Point because they are both in the same stratum (Stratum 2).

Although murrelet group sizes probably increase during the winter, we decided to use the summer mean group size (1.73 birds per group) for the winter because we could not find adequate information to generate a group size estimate. We also were unable to compute winter group density estimates at the scale of the survey strata in Conservation Zone 1 because murrelet winter distribution differs significantly from summer distribution. Thus, using a winter abundance of 9,986 murrelets (5,427 murrelets x 1.84), we estimate that 5,772 groups (9,986 murrelets/1.73 murrelets/group) occur in Conservation Zone 1 during the winter. We established a six-month summer season to generally correspond to the breeding season that begins in April and ends in September and therefore defined the winter season as October to March. Using this information, we then computed the summer and winter group density (groups/km^2) from Equation 1.

Equation 1: $\mathbf{d_{flock} = [(n_{t,s})/(f)] / (a_s)}$

Where $\mathbf{d_{flock}}$ is the group density (groups/km^2); $\mathbf{n_{t,s}}$ is the annual population size (# murrelets) during year **t** in stratum **s**; **f** is mean group size (1.73 birds per group; and **a** is the area of stratum **s** (km^2).

Likelihood of Occurrence

We used a Poisson probability model based upon murrelet group density in Stratum 2 to evaluate the likelihood of one or more murrelet groups occurring within a given area of potential exposure in which injury may occur (critical field). The Poisson probability model depends upon a (Poisson) process that operates continually over some time or space where determining the likelihood of a "success", referred to as an encounter, is the output of interest (for a more thorough discussion, see Ewart and Ford 1974, p. 175-193). The model is ideal for rare events that occur randomly over time or space when all that is known is the average number of occurrences of some event of interest during some specified time period.

We used a Poisson probability model based on murrelet density to estimate the group size (1.73) and number of birds exposed to stressors and to evaluate the likelihood of one or more marbled murrelets being within the range of a critical threshold (i.e., onset of injury, mortality, or disturbance). We considered the foreseeable future when determining the cumulative probability, which is 20 years in this case. Additionally, we considered whether pre-detonation surveys would occur and whether they would reduce the cumulative probability of exposure to less than 10 percent. When pre-detonations surveys were proposed we assumed fifty percent effectiveness, meaning that detonations would be halted only fifty percent of the time that murrelets are present.

In this analysis, murrelet foraging groups were viewed as a Poisson process with an average group density (groups/km^2, represented by $\mathbf{d_{flocks}}$) of birds foraging in Puget Sound. The sizes of critical fields associated with the periodic EOD training (explosives) were treated as independent events, each having a probability of an "encounter" (containing 0, 1, or more murrelet individuals or murrelet groups foraging within some predefined area at the time of the explosion). In this case, we defined any murrelet encounter with an underwater detonation as a "murrelet encounter."

Equation 2 was used to estimate the seasonal probabilities of 0, 1, 2,…x groups occurring within an area of interest in murrelet survey strata 2 or 3.

Equation 2: $fp\,(x|G, t) = [(Gt)^{x} * e^{-Gt}] / x!$

where ***f*p** is the probability of **x** = 0, 1, or 2 group encounters; **e** is the natural logarithm base approximately equal to 2.7183; **G** = the mean number of group encounters within a critical field; and **t** = the number of time units under consideration (Ewart and Ford 1974, p. 189, 190).

Defined in this manner, **Gt** is the mean number of group encounters within a given critical field for **t** units of time representing the duration exposure to the high SPL. For example, when **t** = 1 second, the mean number of group encounters is equal to **G**. The group encounters for each season are derived from the seasonal (winter or summer) group density (group/km^2) multiplied by the area ensonified (km^2). The duration of an acoustic event from an explosion is less than one second; therefore, the time element is not a factor to consider when considering whether repeated exposures may occur over time.

To assess the likelihood of murrelet exposure as described above, the following assumptions were made about murrelet foraging bouts:

- murrelets were assumed to occur at random points in space (but remain spatially constrained to the spatial unit under evaluations during the time it takes for the sound energy field to reach ambient levels;
- any occurrence of a murrelet group is independent of all other murrelet groups;
- there was a zero chance of two or more groups occurring in the same spatial unit (i.e., two groups will not be foraging at the same location at the same time) during one acoustic event; and
- **G** remains constant throughout the given season of interest (i.e., there is a constant mean number of group encounters for the winter and a separate mean for the summer).

Although underwater sound pressure waves can continue for distances exceeding several kilometers (depending on the wave characteristics, frequency, source levels, etc.), it is of foremost interest to predict the probability (**p**), which always has a value between 0 and 1.0. We treated results where $p \geq 0.1$ as an "encounter" and values of $p < 0.1$ were treated as a "miss".

We used a probability of 10 percent as the point at or above which we consider murrelets "encountered." The basis for the use 10 percent is described the U.S. Fish and Wildlife Service (Service) 2008 Biological Opinion (USFWS 13410-2009-0020) on the U.S. Navy's (Navy) proposed Explosive Ordnance Disposal Training at Crescent Harbor (USFWS 2008, p. 99).

The shape, size, orientation, and location of the underwater sound fields are determined by the energy magnitude at the source (dB) and the depth of the sound sources. Determining the probability of a murrelet foraging group encountering an underwater sound wave requires explicit knowledge of ensonified volumes within the foraging depth of murrelets. To reduce this three-dimensional complexity, we used the following simplifying assumptions:

- The directivity of the energy field from the charge is omnidirectional.
- The charge detonations occur at depths of 27 m (at Crescent Harbor EOD) or 16.5 m (at Floral Point EOD). The maximum foraging depth of murrelets is approximately 47 m suggesting that murrelets could forage within the entire water column at Crescent Harbor. Assuming omnidirectional wave propagation, the energy field propagating through the forage zone resembles a cylinder-shaped sound field with a horizontally-growing diameter. The cylinder "top" is defined by the water's surface and the bottom of the cylinder corresponds to the sea floor.
- Due to the short-duration of the acoustic events under consideration in this consultation for detonations (less than 1 second), the mean subsurface density of murrelets within a given critical field (i.e., the mean number of murrelets below the water during the underwater detonation) is less than the surface density because not all murrelets are expected to be foraging during the short duration of the blast.
- For sonar, we determined the maximum duration of an acoustic event based on the number of hours of sonar emitted annually. We used the distance to onset of injury to define the exposure area and modeled the probability of exposure over 20 years.

Applying these assumptions we constructed a conceptual spatial frame to simulate a murrelet encounter and quantify the number of birds that might be exposed during EOD and sonar exercises. To complete the simulation of the exposure scenario, we had to compute the probability of a murrelet encounter while foraging based upon the species foraging behavior and the Navy's proposed pre-detonation surveys for murrelets. No surveys are proposed by the Navy for sonar.

Foraging Behavior

Marbled murrelets spend a considerable amount of time on top of the water (not foraging) in any given day. During summer, murrelets spent 30 to 45 minutes on the surface without feeding, remaining within a few meters of each other. When diving, they were sometimes seen separated by 100 meters or more, after which they immediately called and paddled toward each other. Once reunited, they billed, circled each other, stretched wings, and rested on surface or started diving again (Thorensen 1989, p. 36).

Marbled murrelets are also aggressive feeders during a typical, 30-minute foraging bout, spending up to 22 minutes of the bout (75 percent) submerged/foraging. Thorensen found that during a foraging bout, marbled murrelets mean dive time was 45 seconds and mean time spent on the surface was 15 seconds (1989, p. 36). If a 30-minute foraging bout is comprised of

intervals where the birds dive 45 seconds and surfaces for 15 seconds, this would represent 75 percent of the 30-minute foraging bout spent underwater; total of 22.5 minutes out of 30 minutes (assuming the averages mentioned above, not the upper and lower range values).

Although we expect they would be underwater for approximately 75 percent of a foraging bout, they also spend a significant amount of each day loafing, preening, and other activities on the surface of the water. We expect they are just as likely to be on the surface as underwater at any given point in a day. We therefore assumed murrelets are underwater fifty percent of the day and above the water fifty percent of the day. For sonar, we assumed that murrelets would not be within the range of the sonar for longer than 5-minutes because the birds are rarely stationary.

Pre-detonation Surveys

The Navy will only use command generated detonations, which have no delay. In prior consultations within Conservation Zone 1, the Navy conducted pre-detonation surveys for murrelets and delayed or suspended the EOD exercise when murrelets are observed within 500 m of the charge location. However, wildlife surveys are rarely 100 percent effective at detecting the target organism. The Service formerly evaluated the effectiveness of the Navy's pre-detonation survey protocol (USFWS 2008, p. 100):

> "*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 command generated detonation, in which the detonations can be halted and would eliminate the opportunity for murrelets to 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.*"

Based on this prior evaluation, and because the Navy will not use 2 observers, and follow the Service Protocol for monitoring murrelets, we assume the Navy's pre-detonation surveys have a detection rate of 50 percent.

The sizes of the various injurious energy fields were determined by Equation 3, using radii associated with a given attenuation distance to three threshold values: 212 dB SEL, 36 Pa-sec, and 138 Pa-sec.

Equation 3: $\mathbf{A = \pi r^2}$

where **A** is the area of a circle (km^2); $\boldsymbol{\pi}$ is approximately equal to 3.1428**;** and **r** is the radius (km) of attenuation distances to a received level below the threshold values of interest.

Equation 3 was substituted for **t** in Equation 2, resulting in Equation 4. Equation 4 then could be used to calculate the likelihood of a murrelet encounter (individual or group) given the murrelet density.

Equation 4: $f_p (x|G, A) = [(G\pi r^2)^x * e^{-(G \pi r\hat{}2)}] / x!$

(note: the symbology **r^2** in the exponent of **e** is used to denote r^2).
The general form of Equation 4 was then simplified (Equations 5 - 8) to calculate the probabilities of 0, 1, 2, 3, etc. murrelet groups encountering a sound wave within the area of a critical field derived from Equation 3 using the attenuation distances from Table 12 for the radius **r**.

Equation 5:	$P(X=0) = e^{-\mu}$	(Probability of 0 groups)
Equation 6:	$P(X=1) = (\mu)\, e^{-\mu}$	(Probability of 1 group)
Equation 7:	$P(X=2) = (\mu^2)\, (e^{-\mu})/2!$	(Probability of 2 groups)
Equation 8:	$P(X=3) = (\mu^3)\, (e^{-\mu})/3!$	(Probability of 3 groups)

where **x** = the number of expected murrelet encounters given $\mu = G\pi r^2$ (the expected seasonal murrelet encounter rate within the circular area of interest with radius **r** corresponding to a given attenuation distance to the threshold values in each stratum). Note that **μ** will be adjusted (reduced) by 50 percent for survey effectiveness and 50 percent for murrelets on the surface (not foraging).

Rather than reporting the probability for each group size, we elected to report the sum of all the probabilities, referred to as the cumulative probability, for all values of X = 1 through 5 (at X = 5, the values for **P** were effectively zero at 10^{-4}).

LITERATURE CITED

Ewart, P.J., and J.S. Ford. 1974. Probability for statistical decision making. Pages 177-194 *In* Probability for statistical decision making, Prentice-Hall Inc, Englewood Cliffs, New Jersey.

Falxa, G.A. 2011. Marbled murrelet population monitoring results, 2000-2010. Arcata Fish and Wildlife Office, Arcata, California, March 30, 2011. 6 pp.

Falxa, G., J. Baldwin, M. Lance, D. Lynch, S.K. Nelson, S.F. Pearson, M.G. Raphael, C. Strong, and R. Young. 2015. Marbled murrelet effectiveness monitoring, Northwest Forest Plan: 2014 summary report. Northwest Forest Plan, Marbled Murrelet Effectiveness Monitoring Team, Interagency Regional Monitoring Program - http://www.reo.gov/monitoring., August 2015. 18 pp.

Falxa, G.A. 2008. Raphael, M., M.M. Lance, S.F. Pearson, D. Lynch, G.A. Falxa, K. Nelson, M.H. Huff, R. Young, T.D. Bloxton, J. Bush, B. Tuerler, R.F. Brown, D. Pereksta, K. Schmidt, K. Flotlin, E.E. Burkett, B. McIver, J. Bond, J.H. Watkins, K.R. Hoffman, L.M. Roberts, R.P. Bosch, R. Hamlin, R. Olah, T. Rabot, D. Thomas, M. Roy, P. Hensen, K. Young, and M. Corbett. Re: 2007 results of marbled murrelet at-sea populations surveys. 2008/02.

Falxa, G.A., D. Baldwin, S.K. Lynch, S.L. Nelson, and S.F. Miller. 2009. Marbled murrelet effectiveness monitoring, Northwest Forest Plan: 2008 summary report, August 2009. 19 pp.

Falxa, G.A., and M.G. Raphael. 2015. Northwest Forest Plan—The First Twenty 2013): Status and Trend of Marbled Murrelet Populations and Nesting Habitat. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Gen. Tech. Rep. PNW-GTR-XXXX, Portland, OR, May 26, 2015. 191 pp.

Falxa, G., J. Baldwin, M. Lance, D. Lynch, S.K. Nelson, S.F. Pearson, M.G. Raphael, C. Strong, and R. Young. 2015. Marbled murrelet effectiveness monitoring, Northwest Forest Plan: 2014 summary report. Northwest Forest Plan Interagency Regional Monitoring Program, Portland, OR, August 2015. 18 pp.

McShane, C., T.E. Hamer, H.R. Carter, R.C. Swartzman, V.L. Friesen, D.G. Ainley, K. Nelson, A.E. Burger, L.B. Spear, T. Mohagen, R. Martin, L.A. Henkel, K. Prindle, C. Strong, and J. Keany. 2004. Evaluation reports for the 5-year status review of the marbled murrelet in Washington, Oregon, and California. EDAW, Inc, Seattle, Washington. 370 pp.

Merizon, R.A.J., S.P. Courtney, W. Beattie, D.M. Brosnan, D. Evans, T. Grubba, W. Kerschke, J.M. Luginbuhl, R. Millner, E.A. Neatherlin, D. Nysewander, M. Raphael, and M. Salema. 1997. Seabird surveys in Puget Sound 1996. Sustainable Ecosystems Institute, Inc, Portland, Oregon, March 1997. 36 pp.

Nysewander, D.R., J.R. Evenson, B.L. Murphie, and T.A. Cyra. 2005. Report of marine bird and marine mammal component, Puget Sound ambient monitoring program, for July 1992 to December 1999 period. Washington State Department of Fish and Wildlife, Wildlife Management Program, Olympia, Washington, January 31. 2005. 194 pp.

Speich, S.M., T.R. Wahl, and D.A. Manuwal. 1992. The numbers of Marbled Murrelets in Washington marine waters. Status and Conservation of the Marbled Murrelet in North America :48-60.

Thorensen, A.C. 1989. Diving times and behavior of pigeon guillemots and marbled murrelets off Rosario Head, Washington. Western Birds 20:33-37.

USFWS (U.S. Fish and Wildlife Service). 2008. Biological opinion on the proposed U.S. Navy's explosive ordnance disposal (EOD) training located near Whidbey Island. Washington Fish and Wildlife Office, 13410-2009-F-0020, Lacey, WA, November 7, 2008. 213 pp.

APPENDIX H
PROBABILITY OR LIKELIHOOD OF EXPOSURE

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Probability or Likelihood of Exposure

Probability Distributions

There are many different kinds of distributions. All, however, are either continuous or discrete. Probability distributions can be discrete or continuous. If they are discrete, the variable can have only certain discrete values. A discrete variable can be any number of occurrences between zero and infinity, but it must be a whole number. A die, for example, can have a 1 or a 2, but you cannot roll a 2.5. A variable described by a continuous probability distribution, by contrast, can have any value along a continuum. The number of birds exposed to a deleterious event is a discrete variable. There can be 2 birds impacted, but not 2.2 birds impacted, so we must use a discrete probability distribution.

Use of the Poisson Distribution to Estimate Murrelet Exposure

The Poisson distribution is often an appropriate model for the probability distribution of the number of occurrences of a *rare* event (*n* is large, *p* is small, and *np* is <10). This distribution can be used estimate the probability of one or more murrelets (or groups of murrelets) being exposed by one or more detrimental activities (bomb detonations, pile driving, etc.). 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.

To estimate the probability of exposure (x=1, 2, 3, etc. birds), we can use:

$$P(X; \mu) = (e^{-\mu})\,(\mu^{x}) / x!$$

$$P(X=0) = e^{-\mu};$$
$$P(X=1) = e^{-\mu}(\mu);$$
$$P(X=2) = (e^{-\mu})(\mu^{2})/(2!)$$
$$P(X=3) = (e^{-\mu})(\mu^{3})/(3!); \text{ etc}$$

Where:
- e is the base of the natural logarithm
- μ is the mean # of events per interval of space (birds or groups of birds)
- x is the # of events in a given interval (# of birds or groups of birds likely to be encountered)

Assumptions:
- μ remains constant throughout the season
- Murrelets are randomly distributed throughout the area
- Groups of birds are independent of one another
- The mean of the distribution is μ
- The variance is equal to μ

To estimate the probability of exposure of 1 or more birds (or bird groups) we want the cumulative Poisson probability where you sum up the probabilities of P(x=1) to P(x=∞), or

$P(x \geq 1)$. An easier way to solve this problem is to calculate 1 minus the probability of zero birds being exposed $P(x=0)$.

Murrelet Density (μ)

To calculate the μ (mean # of events per interval of space (birds or groups of birds)), the current excel spreadsheet considers the following:

# of bird groups:

- # of birds in surveyed area / mean # of birds in group (rounded up to a whole number)
- Further reduced if a survey is used at the site (assumes an effectiveness of 0-1) by multiplying the # of bird groups by the proportion underwater

Area of disturbance:

- Calculates the area of disturbance of a circle (πr^2) in m^2 and subtracts any land mass and converts m^2 to km^2
- 3494 (bird survey area) / by the area of disturbance to convert area of disturbance to proportion of total area in area of influence

Expected mean # of bird groups in area of disturbance:

- # of bird groups * proportion of total area in area of influence

Probability of 1 or More Bird Groups Encountered in 1 Disturbance Event

Probability of 1 or more bird groups exposed is equal to 1 minus the probability of zero birds being exposed:

1-(EXP(-(expected mean # of bird groups in area of disturbance)))

Probability of 1 or More Bird Groups Encountered in Multiple Disturbance Events

Within the Multiple Pulse Calc Sheet the Probability of a Murrelet encounter is further extended by multiplying the outcome with the total # of 30 minute periods of the deleterious event. V6 of the spreadsheet currently contains the following logic to calculate the probability of multiple events: P(X=1 or more; over Y deleterious events) = P(A) + P(B) + P(C), etc., where A, B, and C are trials. I believe this to be incorrect. Instead, the following calculation should be used:

$$P(x \geq 1; y) = 1-(1-p)^y$$

Where: y is the # of disturbance events
p is the probability of 1 or more bird groups being impacted if the disturbance occurs once
y is the number of times the disturbance is likely to occur during the project.