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United States Department of the Interior

FISH AND WILDLIFE SERVICE

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

MAR 24 2010

In Reply Refer To:
13410-2009-F-0082

Kim X. Bennis
Head, Operations Services Department
Naval Undersea Warfare Center Division
610 Dowell St.
Keyport, Washington 98345-7610

Dear Ms. Bennis:

Subject: United States Navy (USN) Naval Sea Systems Command (NAVSEA) Naval Undersea Warfare Center (NUWC) Keyport Range Complex Extension (KRCE) in Washington State

This letter corrects and replaces the previous transmittal letter of March 11, 2010, that transmitted the U.S. Fish and Wildlife Service's (FWS) Letter of Concurrence and Biological Opinion (Opinion) (FWS ref. #: 13410-2009-F-0082) issued for the above referenced project. This Letter of Concurrence and Opinion are in response to your December 5, 2008, request for informal consultation and your July 22, 2009, request for formal consultation. Your letter requesting initiation of formal consultation, dated July 22, 2009, was received in this office on July 29, 2009. The FWS responded by letter on August 28, 2009, acknowledging receipt of the request and initiation of formal consultation pursuant to section 7(a)(2) of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*).

In the previous transmittal letter, the FWS stated that "The USN determined that the activities proposed within the Keyport Range Complex Extension (KRCE) would have "no effect" on the snowy plover, "may affect, and are not likely to adversely affect" the threatened Coastal-Puget Sound bull trout (*Salvelinus confluentus*) (bull trout), "would not destroy or adversely modify" designated Coastal-Puget Sound bull trout critical habitat, and "may affect, and are likely to adversely affect" the threatened marbled murrelet (*Brachyramphus marmoratus*) (murrelet)." This statement was incorrect in that the USN did not determine that the activities would "may affect, are likely to adversely affect" the threatened marbled murrelet." The USN originally determined (in the Biological Evaluation) that activities under the proposed action "may affect, are not likely to adversely affect" the marbled murrelet. In follow-up communication on June 11, 2009, the FWS

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stated that we did not concur with the USN determination and indicated that, "our review (of the proposed action) indicates marbled murrelets are likely to be adversely affected by the proposed action." A subsequent letter from the USN in response to the FWS non-concurrence requested initiation of formal consultation, but stated that the USN had numerous questions regarding the justification for the FWS determination.

Our Opinion and Letter of Concurrence are based on our review of the October 2008, Biological Evaluation and the September 2008, Environmental Impact Statement for the proposed action. In addition, the USN and FWS staff met in person and via conference call on numerous occasions to more clearly define the project description and share technical information to assist in clarifying the effects of KRCE underwater activities to federally listed resources.

In summary, the enclosed Letter of Concurrence and Opinion concludes that the proposed action "may affect, but is not likely to adversely affect" bull trout, "is not likely to destroy or adversely modify" bull trout critical habitat, and "is not likely to jeopardize the continued existence of the murrelet." There is no regulatory requirement for U.S. Fish and Wildlife Service concurrence on "no effect" determinations. The determination(s) that actions will have no effect on other federally listed species or federally designated critical habitat rests with the action agency.

Should you have any questions regarding this consultation, or your responsibilities under the Endangered Species Act, please contact Kevin Shelley at (360) 753-4325 (kevin_shelley@fws.gov) or Marc Whisler (360) 753-4410 (marc_whisler@ fws.gov) of this Office.

Sincerely,

Ken S. Berg, Manager
Washington Fish and Wildlife Office

cc:
National Marine Fisheries Service, Lacey, WA (S. Landino)

United States Department of the Interior

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Washington Fish and Wildlife Office
510 Desmond Dr. SE, Suite 102
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13410-2009-F-0082

Kim X. Bennis
Head, Operations Services Department
Naval Undersea Warfare Center Division
610 Dowell St.
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Dear Ms. Bennis:

Subject: United States Navy (USN) Naval Sea Systems Command (NAVSEA) Naval Undersea Warfare Center (NUWC) Keyport Range Complex Extension (KRCE) in Washington State.

This letter transmits the U.S. Fish and Wildlife Service's (FWS) Letter of Concurrence and Biological Opinion (Opinion) (FWS ref. #: 13410-2009-F-0082) issued for the above referenced project. This Letter of Concurrence and Opinion are in response to your December 5, 2008, request for informal consultation and your July 22, 2009, request for formal consultation. Your letter requesting initiation of formal consultation, dated July 22, 2009, was received in this office on July 29, 2009. The FWS responded by letter on August 28, 2009, acknowledging receipt of the request and initiation of formal consultation pursuant to section 7(a)(2) of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*).

The USN determined that the activities proposed within the Keyport Range Complex Extension (KRCE) would have "no effect" on the snowy plover, "may affect, and are not likely to adversely affect" the threatened Coastal-Puget Sound bull trout (*Salvelinus confluentus*) (bull trout), "would not destroy or adversely modify" designated Coastal-Puget Sound bull trout critical habitat, and "may affect, and are likely to adversely affect" the threatened marbled murrelet (*Brachyramphus marmoratus*) (murrelet).

Our Opinion and Letter of Concurrence are based on our review of the October 2008, Biological Evaluation and the September 2008, Environmental Impact Statement for the proposed action. In addition, the USN and FWS staff met in person and via conference call on numerous occasions to more clearly define the project description and share technical information to assist in clarifying the effects of KRCE underwater activities to federally listed resources.

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In summary, the enclosed Letter of Concurrence and Opinion concludes that the proposed action "may affect, but is not likely to adversely affect" bull trout, "is not likely to destroy or adversely modify" bull trout critical habitat, and "is not likely to jeopardize the continued existence of the murrelet." There is no regulatory requirement for U.S. Fish and Wildlife Service concurrence on "no effect" determination for snowy plover. The determination that actions will have no effect on other federally listed species or federally designated critical habitat rests with the action agency.

Should you have any questions regarding this consultation, or your responsibilities under the Endangered Species Act, please contact Kevin Shelley at (360) 753-4325 (kevin_shelley@fws.gov) or Marc Whisler (360) 753-4410 (marc_whisler@ fws.gov) of this Office.

Sincerely,

John Gudtrup for

Ken S. Berg, Manager
Washington Fish and Wildlife Office

Endangered Species Act – Section 7 Consultation

Biological Opinion

USFWS Reference # 13410-2009-F-0082

United States Navy Naval Sea Systems Command (NAVSEA) Naval Undersea Warfare Center (NUWC) Keyport Range Complex Extension (KRCE) in Washington State

Agency:

U.S. Navy, Naval Sea Systems Command, Naval Undersea Warfare Center Division, Keyport, Washington

Consultation Conducted by:

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

Ken S. Berg, Manager
Washington Fish and Wildlife Office

3-11-10
Date

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ACRONYMS and ABBREVIATIONS

Biological Evaluation	BE
Biological Opinion	Opinion
Code of Federal Regulations	CFR
Dabob Bay Range Complex	DBRC
Decibel	dB
Decibels reference 1 micro-Pascal	dB re 1 µPa@1m
Decibels reference 1 micro-Pascal squared second	dB re 1 µPa2.s
Dissolved Oxygen	DO
Draft / Environmental Impact Statement	D/EIS
Endangered Species Act	ESA
Environmental Impact Statement	EIS
Foraging, migration, and overwintering	FMO
Hertz	Hz
Interim Recovery Unit	IRU
Keyport Range Complex Extension	KRCE
Keyport Testing Range	KTR
kiloHertz	kHz
kilometer	km
Marbled Murrelet	Murrelet
Mean higher high water	MHHW
Mean lower low water	MLLW
Meters	m
Micro-Pascal	µPa
Military Operating Areas	MOA
Naval Sea Systems Command	NAVSEA
Naval Undersea Warfare Center	NUWC
Northwest Training Range Complex	NWTRC
Overseas Environmental Impact Statement	OEIS
Olympic Coast National Marine Sanctuary	Sanctuary
Pacific Herring	Herring
Pacific Sand Lance	Sand Lance
Peak Pressure	Peak
Permanent Threshold Shift	PTS
Polybrominated Diphenyl	PBDE
Polychlorinated biphenyls	PCB
Polycyclic aromatic hydrocarbons	PAH
Primary Constituent Element	PCE
Primary Sampling Units	PSU
Puget Sound Assessment and Monitoring Program	PSAMP
Puget Sound Partnership	PSP
Quinault Underwater Tracking Range	QUTR
Reasonable and Prudent Measure	RPM
Research, Development, Test and Evaluation	RDT&E
Root Mean Square	RMS
Sound Exposure Level	SEL
Sound Pressure Level	SPL
Temporary Threshold Shift	TTS
U.S. Fish and Wildlife Service	FWS
U.S. Forest Service	USFS
United States Navy	Navy
Un-manned Aerial System	UAS
Un-manned undersea vehicle	UUV
Washington Department of Ecology	WDOE
Washington Department of Fish and Wildlife	WDFW
Washington Department of Natural Resources	WDNR

CONSULTATION HISTORY

On December 5, 2008, the United States (U.S.) Navy (Navy) sent the U.S. Fish and Wildlife Service (FWS) a letter and supporting documents (Environmental Impact Statement and Biological Evaluation) requesting informal consultation for the Navy's NAVSEA NUWC Keyport Range Complex Extension (KRCE) on Coastal-Puget Sound bull trout (bull trout) and marbled murrelets (murrelet). By letter on February 19, 2009, the FWS concurred with the "may effect" determination for bull trout and murrelet, and "would not destroy or adversely modify" determination for bull trout critical habitat. On March 17, 2009, the Navy verbally provided "not likely to adversely effect" determinations for murrelet, and bull trout. The Navy provided supplemental information about underwater sound related to the activities of KRCE on March 31 and April 14, 2009. The additional information was requested by the FWS to better assess the Navy's Endangered Species Act (ESA) determinations and enhance our understanding of the acoustical effects propagated from the proposed underwater testing of countermeasures and sonar use. In a letter dated June 11, 2009, the FWS did not concur with the Navy's "may effect, but is not likely to adversely affect" determination for marbled murrelet. This letter also identified possible options to eliminate or reduce negative impacts of the KRCE activities to listed species. Through numerous communications and meetings, the FWS requested additional information needed to initiate consultation. By letter dated July 29, 2009, the FWS initiated formal consultation. The Navy committed to several conservation measures to the FWS via e-mail correspondence on January 4, 2010.

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

- December 5, 2008 - The Navy requested informal consultation with the FWS for a "may effect" determination for murrelets and bull trout and a "would not destroy or adversely modify" determination for bull trout critical habitat.
- January 21, 2009 - The Navy and FWS met to discuss the Biological Evaluation (BE) and Environmental Impact Statement (EIS) for the KRCE.
- March 31, 2009 - The Navy met with the FWS to offer more detailed rationale to support the Navy's NLAA determination for murrelets in relation to 1) the general test conditions performed at KRCE and 2) a description of the acoustical characteristics of sound sources associated with KRCE activities.
- April 14, 2009 - The Navy provided the FWS with a written report on the source level, general frequencies, duration, and attenuation levels for the sound sources associated with KRCE activities.
- June 11, 2009 - The FWS sent a letter to the Navy stating we did not concur with effects determination for marbled murrelet. This letter also requested the Navy consider developing, in collaboration with the FWS, conservation measures to eliminate or reduce negative impacts of the KRCE activities to listed species.
- July 22, 2009 - The Navy sent a letter to the FWS requesting formal consultation.

- August 28, 2009 - The FWS sent a letter to the Navy accepting initiation of formal consultation.
- August - December 2009 - The Navy and the FWS jointly defined a more accurate project description through meetings and numerous correspondences.
- November - December 2009 - The Navy and the FWS met in person and via conference call to discuss potential impacts to murrelets and measures to minimize impacts.
- December 2009 - January 2010 - The Navy sent information to the FWS transmitting information to assist use in clarifying the effects of KRCE underwater activities on murrelet.
- January 2010 - The Navy provided performance measures for sound and conservation measures as part of the project description.

BIOLOGICAL OPINION

DESCRIPTION OF THE PROPOSED ACTION

For the purposes of this consultation, the proposed action is to extend the operating areas of the Naval Sea Systems Command (NAVSEA) Naval Undersea Warfare Center Keyport Range Complex in Washington State, and increase the use of selected range sites for Research, Development, Test and Evaluation (RDT & E) activities conducted by NUWC Keyport. Included in the consultation is an evaluation of ongoing activities. The proposed action is ongoing, and will be covered under this Biological Opinion for a period of five years following the signature date of the Record of Decision for the Final Environmental Impact Statement.

The Navy proposes to expand the areas in which they currently conduct RDT&E, increase the use of range sites, and increase the frequency of activities. Currently three areas are utilized for naval RDT&E; two of these locations are within Puget Sound and one in the off the Pacific Coast of Washington State. These include the Keyport Test Range (KTR) in Port Orchard Reach and Dabob Bay Range Complex (DBRC) near the Kitsap-Bangor Naval Base in Hood Canal, and the Quinault Underwater Tracking Range (QUTR) off the Pacific Coast of Washington State with underwater passive acoustic monitoring cables extending from Kalaloch. A portion of the QUTR lies within the boundaries of the Olympic Coast National Marine Sanctuary (Sanctuary) and Quinault Indian Nation's Usual and Accustomed fishing grounds and stations extending about forty miles into the ocean (Daley 1999). A detailed description of the Keyport Range Complex Extension (KRCE) subunits will be included in the Action Area section of this Biological Opinion (Opinion).

The purpose of the RDT&E is to support the Navy's evolving manned and unmanned vehicle program activities, submarine readiness, diver training, and undersea warfare. The KRCE, consisting of the three above-mentioned subunits, is for the testing, training, and evaluation of system capabilities such as guidance, control, and sensor accuracy in multiple marine

environments of differing depths, salinity levels and sea states, and in surrogate and simulated war-fighting environments.

In general, activities conducted by NUWC Keyport on the three range sites support the undersea warfare RDT&E program requirements for equipment testing and military personnel training needs. Underwater testing and training exercises involve proofing of underwater systems for undersea warfare, utilizing Fleet support including aircraft, submarines, and surface ships for deployment of the equipment to be tested. The exercises are expected to occur singularly or in various combinations of activity types. The analyses of the activities of the Action include:

1) generated underwater sound from active sonar and countermeasure systems that would be employed during RDT&E;
2) surface vessel traffic associated with RDT&E;
3) subsurface vessel traffic associated with RDT&E;
4) aircraft operations associated with RDT&E; and
5) non-explosive exercise weapons and expended materials used or produced during RDT&E.

Typical activities conducted by NUWC Keyport on the three range sites primarily support undersea warfare RDT&E program requirements, but general equipment test and military personnel training needs, including Fleet activities, are also supported. Fleet activities in the NAVSEA NUWC Keyport Range Complex do not include the use of surface ship and submarine hull mounted sonars. Test and training activities typically involve a wide variety of platforms, non-explosive exercise weapons, and test-related devices. Submarines, surface ships, and aircraft can be involved in undersea warfare exercises to deploy (launch) and retrieve (recover) non-explosive exercise weapons and target substitutes. The following narratives summarize the information the Navy provided on the various activities it plans to conduct each year over the five-year duration of the proposed action. Each narrative only describes those elements of each activity that might be relevant to our assessment of the potential direct or indirect effects of the Navy's proposal on endangered or threatened species or designated critical habitat. More detailed descriptions of each activity are available in the Navy's Draft Environmental Impact Statement/Overseas Environmental Impact Statement, NAVSEA NUWC Keyport Range Complex Extension, Keyport, Washington. Further deconstruction of the stressors examined for the Action will be included in the *Effects* section of this Opinion.

Sonar Operations

Sonar operations that the Navy proposes to continue conducting in the KRCE would involve utilizing and testing various sonar systems in Puget Sound and State of Washington coastal waters. The various sonar systems the Navy proposes to utilize in the KRCE have source frequencies ranging from 0.1 kilohertz (kHz) to 2500 (kHz) with source levels ranging up to 238 decibels (dB) re 1μPa (micro-Pascal) at 1 meter (m). While some low frequency sound sources do exist as part of the action, the Navy does not propose to research, develop, test, or evaluate low-frequency sonar as part of the KRCE (see Table 1).

Surface Operations

The U.S. Navy proposes to continue to conduct the following Research, Development, Test and Evaluation activities from surface platforms at the KRCE (see Table 1):

1) Support Operations would include surface vessels that carry test equipment and personnel to and from test sites and to secure and monitor designated test areas;
2) Tow test events would involve surface vessels used as tow platforms for systems tests that can be deployed from ships;
3) Launch and recovery operations include surface craft that would be used to deploy and recover unmanned underwater vehicles, sonobuoys, inert mines, torpedoes, target simulators and other test systems.
4) Developmental and operational testing that would involve tests of navigation and communication systems associated with various surface vessels, including some unmanned surface vessels.

Subsurface Operations

The Navy proposes to continue conducting subsurface operations at the KRCE, including diving operations, retrieval of non-explosive exercise weapons and target substitutes, robotic vehicles, unmanned underwater vehicles, and target simulators. The Navy would conduct diving operations as part of research related to underwater equipment systems, testing manned undersea mobility systems, underwater guidance, and navigation systems. The proposed operations would include retrieval and recovery of targets and locating RDT&E equipment that had been jettisoned into the area (or placed there). Tests that would employ robotic vehicles, such as crawlers and unmanned underwater vehicles, would be used to locate and classify underwater objects while rejecting miscellaneous clutter that would not pose a potential threat. Table 1 provides a summary of relevant information for the analyses, based on the project description in BE and EIS. Similar tables are provided elsewhere in the Opinion.

Table 1. Specific activities the U.S. Navy plans to conduct at the Keyport Extension - Keyport Washington each year for the next five years (after Table 2-1, 2-2, 2-3, 2-4, 2-5, 2-7, 2-8 U.S. Navy 2008b).

Range Activity	*Platform/System Used*	*Activities in Action Area*			*Frequencies (kHz)*			*Maximum Source Level (dB re 1 µPa @ 1 m)*
		KTR	***DBRC***	***QUTR***	***KTR***	***DBRC***	***QUTR***	
Active Sonar								
	low frequency	-	-	-	.10-1	.10-1	.10-1	170
	mid frequency	45*	120*	20*	1-25	1-25	1-25	235
	high frequency				25-250	25-250	25-250	235
Countermeasures		5	50	5				
	sonar				.1-.70	.1-.70	.1-.70	235
	continuous sound				.05-10	.05-10	.05-10	170
Other Testing	static in-water	10	10	5	.8-2500†	.8-2500†	.8-2500†	238†
	targets	45**	120**	20**	5-100	5-100	5-100	195-238
	target simulator				.1-10	.1-10	.1-10	170
Vessel Activity	aircraft	0	10	10	-	2-20	2-20	225
	surface – fleet, surface launch craft, barges	76	285	70	.05-10	.05-10	.05-10	170
	underwater diver	45	5	15	-	-	-	-
	submarine	0	30	30	5-100‡	5-100‡	5-100‡	195-238‡
	torpedoes: non-explosive exercise weapons	45	120	20	10-100	10-100	10-100	233
	UUV tracking				10-100	10-100	10-100	195
	UUV/ special UUV				10-2500	10-2500	10-2500	235

*Assuming that all of the activities will occur in a 365-day year and that all of the activities will utilize either or both sonar types.
** Assuming that all UUV tests have a target involved
† Frequencies and dB level assumed as the information on countermeasures is classified
‡ Submarines, torpedoes, and surface vessels produce both continuous sound (vessel) and sonar signatures

Federally Listed Biological Resources

Three federally listed resources under the jurisdiction of the FWS occur within the boundaries of Keyport Extension. Two species and one designated critical habitat (Table 2) (bull trout and marbled murrelet and bull trout critical habitat) are predominantly or entirely aquatic and the snowy plover depends on terrestrial habitat for their breeding, feeding, and sheltering needs.

Table 2. Summary of the federally listed resources that may be affected by the Navy 2010-2014 proposed underwater testing plan for Keyport Underwater Testing Range Extension (Preferred Alternative 2).

Federally-listed Resources within the Keyport Range Extension [1]		**Listing Status**	**Effect Determination made by Navy**[2]
Marbled Murrelet	*Brachyramphus marmoratus*	Threatened	"may effect…"
Coastal-Puget Sound Interim Recovery Unit – Bull Trout	*Salvelinus confluentus*	Threatened	"may effect…"
Snowy Plover	*Charadrius alexandrinus nivosus*	Threatened	"no effect"
Bull Trout Critical Habitat	-	Designated	"Would not destroy or adversely modify"

[1]Under the jurisdiction of the U.S. Fish and Wildlife Service
[2]The effect determination as presented in the Navy Biological Evaluation.

Conservation Measures

The Navy agreed to the following performance measures. These were provided to us via email on January 4, 2010:

PERFORMANCE MEASURE 1: During the period of 1 April through 15 September, the Navy, to the extent practicable, will not commence countermeasure RDT&E activities earlier than two hours after sunrise for RDT&E events conducted at the Keyport and Dabob range sites (KRCE) to reduce exposure to marbled murrelets from continuous underwater sound.

PERFORMANCE MEASURE 2: The Navy will meet the following thresholds for sound sources at the distances described to reduce exposure of marbled murrelets to underwater sound. We recognize these are based on models and are an estimation of sound propagation from sources S1-S8 and will not exceed the maximum level described by the Navy. These are presented below as described by the Navy for RDT&E events conducted at the Keyport and Dabob range sites (KRCE).

Information from the BE and Draft EIS (tables C-2 and C-3) was used to describe the relevant acoustic parameters of representative acoustic sources. These representative acoustic sources were used for modeling the impacts on marine mammals pursuant to the marine Mammal Protection Act. The modeling and the exact use of these sources is described in Appendix C of the BE (and the DEIS/OEIS).

Table 3: Radius to threshold for Sonar sources modeled in BE (and DEIS/OEIS). * - S1, S3, and S5 are the only sources within the hearing range of Marbled Murrelets (<12.5 kHz as provided by USFWS).

Source	Frequency (kHz)	Radius (m) to			
		206 dB $_{SPL}$ re 1 μPa	187 dB $_{SEL}$ re 1 μPa^{2}s	183 dB $_{SEL}$ re 1 μPa^{2}s	150 dB $_{RMS}$ re 1 μPa
S1*	4.5	1	4	6	253
S2	15	< 1	< 1	< 2	46
S3*	10	< 1	2	< 3	24
S4	150	5	5	7	133
S5*	5	23	78	123	691
S6	20	23	76	119	2060
S7	25	16	54	84	571
S8	30	22	75	115	684

The information in this table was calculated using a simplified model of underwater transmission to estimate an approximate radius for the ensonification volume of each acoustic source to a particular threshold. The information conveyed in Table 3 of this report is to be used to provide a rough idea of the effects of sound in the underwater environment, and more specifically the range from each acoustic source to specific thresholds as agreed upon with the FWS. However, as discussed in Appendix C of the BE, modeling underwater acoustic propagation is quite complex. The numbers in Table 3 do not account for different environmental provinces, land shadowing or a whole host of other effects encountered in underwater propagation. These considerations become much more important for the larger ranges. The assumptions used to calculate the radius are most valid for ranges smaller than 50 m.

The thresholds used in this table are:

- 206 dB re 1 μPa, peak sound pressure level (SPL), computed as the peak sound intensity for a single sonar pings.
- 183 dB re 1 μPa^2 s, which is the Sound Exposure Level (SEL), computed as the energy of the sonar ping (or pings if the repetition rate is less than one second) over a one second duration.
- 150 dB re 1 μPa, root mean square (rms) computed as the square root value of the mean of the waveform energy.

PERFORMANCE MEASURE 3: Ninety-five percent of the countermeasures tested will have a duration less than 30 minutes for RDT&E events conducted at the Keyport and Dabob range sites (KRCE), minimizing exposure of marbled murrelet to underwater sound.

PERFORMANCE MEASURE 4: For 97 percent of the countermeasures tested, the distance to the 183 dB SEL threshold is less than 221 m. All countermeasures tested (100 percent) will attenuate to 183 dB SEL (or less) at a distance less than 345 m. Moreover, for 90 percent of the countermeasures tested, the distance is significantly less than 221 m for RDT&E events conducted at the Keyport and Dabob range sites (KRCE) minimizing exposure of marbled murrelet to underwater sound.

ANALYTICAL FRAMEWORK FOR THE JEOPARDY AND ADVERSE MODIFICATION DETERMINATIONS

Jeopardy Determination

In accordance with policy and regulation, the jeopardy analysis in this Opinion relies on four components: (1) the *Status of the Species*, which evaluates the bull trout and murrelet range-wide condition, the factors responsible for that condition, and its survival and recovery needs; (2) the *Environmental Baseline*, which evaluates the condition of the bull trout and murrelet in the Action Area, the factors responsible for that condition, and the relationship of the Action Area to the survival and recovery of the bull trout and murrelet; (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 bull trout and marbled murrelet; and (4) *Cumulative Effects*, which evaluates the effects of future, non-Federal activities in the Action Area on the bull trout and murrelet.

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 bull trout and murrelet, 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 the bull trout and murrelet in the wild.

The jeopardy analysis in this Opinion emphasizes consideration of the range-wide survival and recovery needs of the bull trout and murrelet, and the role of the Action Area in the survival and recovery of the bull trout and murrelet. It is within this context that we evaluate the significance of the effects of the proposed Federal action, taken together with cumulative effects, for purposes of making the jeopardy determination.

Adverse Modification Determination

This Opinion does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 CFR 402.02. Instead, we have relied upon the statutory provisions of the ESA to complete the following analysis with respect to critical habitat.

In accordance with policy and regulation, the adverse modification analysis in this Opinion relies on four components: 1) the *Status of Critical Habitat*, which evaluates the range-wide condition of designated critical habitat for the bull trout in terms of primary constituent elements Primary Constituent Elements (PCEs), the factors responsible for that condition, and the intended recovery function of the critical habitat overall; 2) the *Environmental Baseline*, which evaluates the condition of the critical habitat in the Action Area, the factors responsible for that condition, and the recovery role of the critical habitat in the Action Area; 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 PCEs and how that will influence the recovery role of affected critical habitat units; and 4) *Cumulative Effects*, which evaluates the effects of future, non-Federal activities in the Action Area on the PCEs and how that will influence the recovery role of affected critical habitat units.

For purposes of the adverse modification determination, the effects of the proposed Federal action on bull trout critical habitat are evaluated in the context of the range-wide condition of the critical habitat, taking into account any cumulative effects, to determine if the critical habitat range-wide would remain functional (or would retain the current ability for the PCEs to be functionally established in areas of currently unsuitable but capable habitat) to serve its intended recovery role for the bull trout.

The analysis in this Opinion places an emphasis on using the intended range-wide recovery function of bull trout critical habitat and the role of the Action Area relative to that intended function as the context for evaluating the significance of the effects of the proposed Federal action, taken together with cumulative effects, for purposes of making the adverse modification determination.

STATUS OF THE SPECIES

Status of Marbled Murrelet

The Status of the Species for Marbled Murrelet is described in Appendix A.

Status of Bull Trout Critical Habitat

The Status of Bull Trout Critical Habitat is described in Appendix B.

ACTION AREA AND ENVIRONMENTAL BASELINE

The Action Area is defined as all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR § 402.02). In delineating the Action Area, we evaluated the farthest-reaching physical, chemical, and biotic effects of the action on the environment (Figure 1).

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.

The basis for defining the aquatic Action Area included 1) the distance that underwater sound generated by the action intersects with a land mass or where it attenuates to background levels, and 2) the areas that the Navy vessels operate during the underwater testing/evaluation exercises, as well as transverse to and from exercise areas.

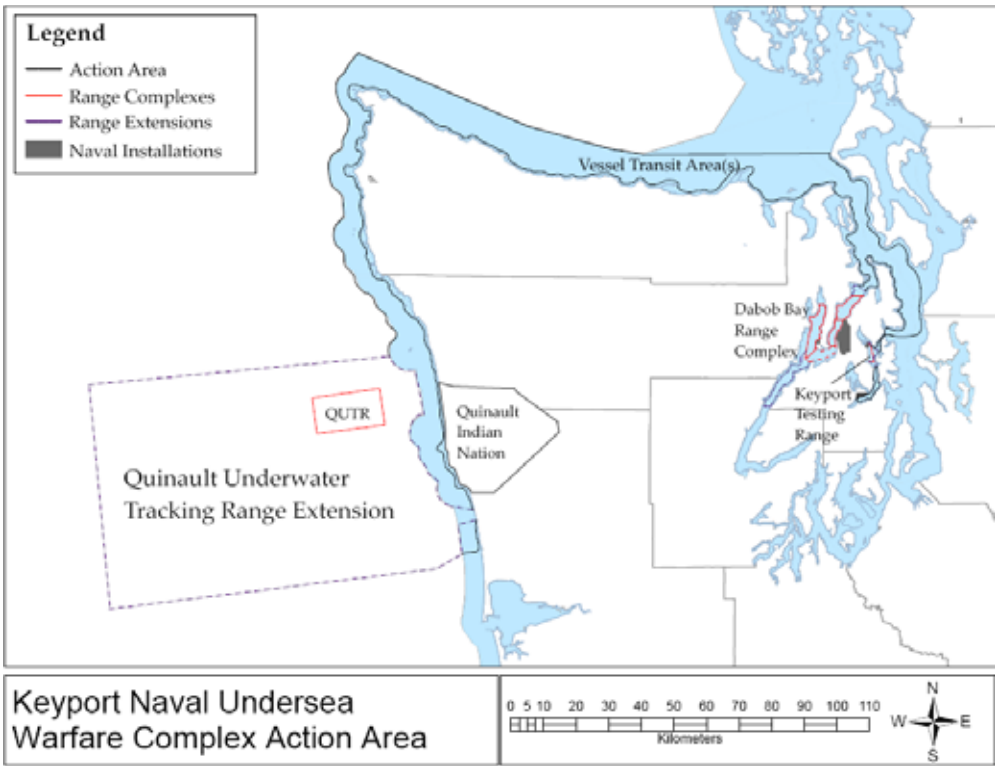

Figure 1. Keyport Naval Undersea Warfare Complex Action Area
Map by USFWS 2009

Puget Sound

The proposed action may directly and indirectly affect listed species and their critical habitat in a portion of the Puget Sound basin, including Dabob Bay of Hood Canal and Port Orchard Reach. To describe adequately the current baseline, we broadly discuss the past and current conditions as well as the on-going activities on a Puget Sound basin-wide basis. The Puget Sound Action Team recently completed the "2007 Puget Sound Update" (PSAT 2007), a comprehensive report of the conditions of Puget Sound based on the Puget Sound Assessment and Monitoring Program (PSAMP). Additionally, the Puget Sound Partnership developed the "Puget Sound Action Agenda – Protecting and Restoring the Puget Sound Ecosystem by 2020" (PSAA 2008). These reports include research findings from a variety of additional monitoring and research efforts conducted by local governments, research institutions, Tribes, State and Federal agencies, and citizen monitoring groups. More site-specific information is provided in descriptions of the subunits of the Action Area.

Physical Environment and Habitat

Puget Sound was carved out by the great glaciers that came down from the north when so much of the earth's water was frozen that the sea level was much lower than at present. Oceanographers have located ancient shorelines 100 ft lower than present beaches (Kvelstad 2004). Puget Sound is a large inland fjord carved by glaciers, fed by a large dendritic system of rivers and streams that flow into it from the Cascade and Olympic mountain ranges. The average

depth of Puget Sound is 137 m, and maximum depth of 283 m occurring immediately north of Seattle. Unique geology and large dynamic river systems continue to shape the shoreline, which consists of 4,023 km of beaches, bluffs, bays, estuaries, mudflats, salt marshes, and wetlands.

Most of the lowland areas of Puget Sound were surveyed in the late 1800's. Tidal estuarine areas were the first occupied and modified by Euro American settlers. Anthropogenic transformation of the Puget Sound nearshore environment since Euro-American settlement in the mid-19th century included the diking and draining for conversion of estuarine ecosystems to manufactured shorelines for ports and urban areas, and other land uses including agriculture (Collins and Sheikh 2005). Conversion of the shorelines occurred early and was extensive and considerable amounts of tidal marsh were converted to agriculture (Collins and Sheikh 2005).

In Puget Sound habitats from the marine riparian zone to the lower limit of the photic zone (to 30 m below mean low lower water (MLLW)) is the range that the strongest interactions occur between the marine environment and shoreline processes. Upland vegetation in the marine riparian habitat stabilizes beaches, provides shade habitat for the upper intertidal zone, and contributes organic matter (leaf litter, debris) to the aquatic ecosystem (Williams and Thom 2001, Williams et al. 2001). Estuaries are commonly found where streams or rivers enter marine waters, and may include the lower, tidal reaches of those freshwater ecosystems. A common definition of an estuary is "a semi-enclosed coastal body of water which has free connection with the open sea, and within which seawater is measurably diluted with freshwater from land drainage" (Pritchard 1967). Both estuaries and nearshore areas, located within a transition zone between land and sea, are incredibly dynamic environments influenced by constantly changing physical, chemical, and biological processes.

Ecological functioning of the system and the organisms that rely upon these habitats is closely linked to the structure (i.e., size, shape, species composition) of the habitat and species interactions that occur therein. These functions include refuge and feeding habitat for fishes, spawning habitat, and buffering of wave and current energy (Williams and Thom 2001). From a landscape perspective, a variety of nearshore habitats contribute a wider range of potential ecological functions to the ecosystem.

Within the Puget Sound eco-region the nearshore zone provides a number of necessary functional benefits to salmonids, including bull trout, a key species that indicates local watershed health. Some of these functions include prey production for juvenile and adult bull trout, migratory corridors, refuge for juveniles from predators, and juvenile rearing. In addition, bull trout and other salmonids transport marine-derived nutrients back into freshwater streams as they spawn, thus linking the functions of the nearshore ecosystem to the health of the entire watershed.

Generally, nearshore habitats in Puget Sound are defined by a variety of complex interactions between physical, geological, chemical, and biological components. As an ecotone between terrestrial and aquatic estuarine ecosystems, the nearshore performs a number of distinctive ecological functions including the generation, accumulation, and decomposition of detritus that can be an important part of the estuarine and terrestrial food webs (Day et al. 1989; Polis and Hurd 1996; Colombini and Chelazzi 2003; Dugan et al. 2003; Rice 2006) and as foraging,

spawning, rearing, and migration habitats for forage fish. Long-term effects are largely the result of changes in sediment dynamics where the substrate can coarsen, the beach slope steepen, and the structural complexity and organic debris accumulation decline (Macdonald et al. 1994; Williams and Thom 2001; Rice 2006).

Additionally, the reduction or elimination of the supply of detritus and terrestrial invertebrate matter from the terrestrial environment may occur, as well as changes to the spawning beach microclimate (Geiger 1965; Brosofske et al. 1997; Chen et al. 1999). These changes may in turn affect the intertidal incubating environment altering developmental rates or increasing physiological stress in fish embryos. Thermal stress and desiccation were proposed by Penttila (2001) as the causes of lower embryo survival on unvegetated beaches. Rice (2006) studying the difference between human altered and natural beaches found the proportion of surf smelt eggs containing live embryos on human altered beaches was approximately half that observed on the natural beach. This indicates shoreline modification has adverse effects on surf smelt embryos. Because physical shoreline conditions are a primary influence on biological processes (Ricketts et al. 1985; Day et al. 1989; Ricklefs and Miller 2000; Knox 2001), extensive physical modifications can potentially affect forage fish composition, abundance, distribution, and their ability to spawn, as well as embryonic survival (Thom and Shreffler 1994; Levings and Jamieson 2001; Penttila 2001; Rice 2006). The effects of anthropogenic–caused changes in physical conditions can cause a change in the structure of habitats, which will ultimately affect the habitat's function.

Biological Resources

Puget Sound's biological resources include all living organisms that inhabit the marine waters estuaries, and shorelines. These resources include both resident and migratory species of plankton, invertebrates, fish, sea birds, mammals, and aquatic vegetation. Significant alterations in the biological communities of Puget Sound have occurred in the past 30 years, including declines in forage fish, salmonids, bottomfish, marine birds, and orcas (*Orcinus orca*). Aquatic and terrestrial organisms are drawn to the Puget Sound estuary because of its high primary and secondary productivity, rich nutrients and food resources, and refuge provided by their relatively low-energy, shallow waters. The alterations in ecological structure of Puget Sound has resulted in restriction and closure of fisheries, petitions for listing species under the ESA and State programs and development of recovery and management plans for several species. Research and monitoring programs have been underway to evaluate the declines, identify the stressors affecting the populations, and develop actions and solutions to stem the declines and begin rebuilding populations of species at risk.

Many stressors are affecting or affected biota in Puget Sound in multiple ways that we are only beginning to understand. The stressors of concern include, but are not limited to climate change, toxic contamination, eutrophication (low oxygen due to excess nutrients), nearshore habitat alteration, vessel traffic, and underwater sound. A recent study (Brown and Gaydos 2007) identified 46 marine species of concern in the Puget Sound - 3 invertebrates, 22 fishes, 1 reptile, 11 birds, and 9 mammals. In status reviews conducted for the 14 species listed as threatened or endangered by Washington State or the Federal government, contaminants, habitat loss, and

over-harvest were the most frequent causes cited for species declines. Key findings included the following:

Nearly 60 percent of groundfish stocks in Puget Sound are in good condition; however, those in decline include middle-trophic level predators such as rockfishes, spiny dogfish (*Squalus acanthias*), Pacific cod (*Gadus macrocephalus*), and Pacific hake (*Merluccius productus*). The spawning potential for copper (*Sebastes caurinus*) and quillback rockfish (*S. maliger*) declined by nearly 75 percent between 1970 and 1999, and more recent study confirms continued declines in both of these species. The bocaccio (*S. paucispinis)* is currently proposed as "endangered," and canary (S. *pinniger*) and yelloweye rockfish (*S. ruberrimus)* are proposed for "threatened" status. Although the overall number of groundfish has not changed significantly in the last few decades, many popular harvest species have sharply declined while others have increased.

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

The more common fish species identified as forage fish within Washington include Pacific herring (*Clupea harengus pallasi*) (herring), surf smelt (*Hypomesus pretiosus*), Pacific sand lance (*Ammodytes hexapterus*) (sand lance), and northern anchovy (*Engraulis mordax*). The status of forage fish is important as they play a critical part in the life history of murrelets and bull trout, and they are present in the entire Keyport Extension Action Area (Figure 2). Forage fish play a key role in the food web of the marine environment and make up a significant proportion of the diets of murrelets. Forage fish are loosely defined as small, schooling fishes that form critical links between the marine zooplankton community and larger predatory fish, seabirds, and marine mammals in the marine food web (Penttila 2007; PSAT 2007). They feed mainly on zooplankton and phytoplankton and reside in the upper levels of the water column and nearshore areas (PSAT 2007). The three most common forage fish species in Puget Sound are herring, surf smelt, and sand lance. Forage fish species occupy every marine/estuary nearshore habitat in Washington State (Penttila 2007). The vitality of the aggregate forage fish resource in Washington is also a valuable indicator of the health and productivity of Puget Sound.

Within Puget Sound, each species appears to use approximately ten percent of the shoreline as spawning habitat. Some species tend to use the same beaches annually. All three species use near-shore habitats as nursery grounds (Penttila 2007). Populations of surf smelt and sand lance have not been monitored Puget Sound-wide and therefore we do not have annual abundance estimates or trends over time (Penttila 2007). Monitoring for herring has been performed in the Puget Sound and provides a sense of abundance, trends over time and stock status. An important characteristic that forage fish populations have in common is a tendency for rapid change. Forage fish populations vary considerably, primarily due to environmental conditions (Bargmann 1998).

Given the movement of sediment interactions with existing and future shoreline modifications, it is possible that areas with habitat unlikely for forage fish spawning today may one day prove suitable and vice versa (Long 2005). Additionally, nearshore areas of Puget Sound are subject to a variety of development impacts as human populations along the shoreline increase. Recognition and protection of spawning sites is critical to maintaining healthy forage fish populations. Once designated, forage fish spawning beaches are protected by the Washington

Administrative Code (WAC) "Hydraulic Code Rules" (WAC 220-110) through Washington State Department of Fish and Wildlife's (WDFW) hydraulic permit application process.

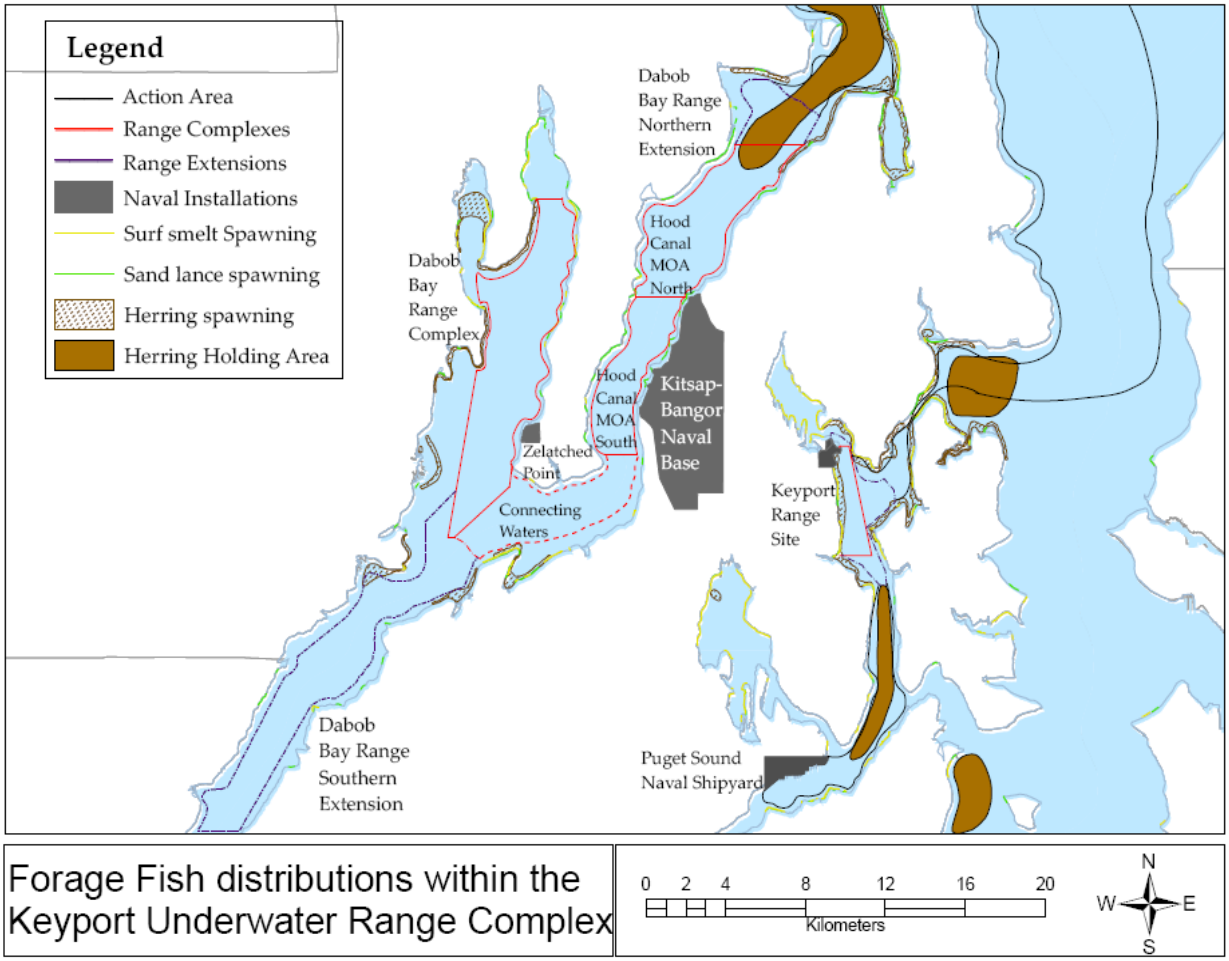

Figure 2. Forage fish distributions within the Puget Sound Keyport Range Extension
USFWS c.2009

However, the single-family residence bulkhead law (RCW 77.55.200) makes it extremely difficult for WDFW to completely deny an application for a bulkhead even with the proven existence of forage fish spawning on the beach directly impacted (Carman and Small 2005). Additionally, current regulations do not protect important shoreline processes by allowing continued armoring of sediment sources and allowing six feet of bulkhead encroachment in designated and non-designated intertidal baitfish spawning habitat (Carman and Small 2005). Further, impacts to water quality from shoreline development, marinas and moorages are other factors that can affect beach spawning forage fish. Civic storm water outfalls, single-family storm water outfalls, and runoff from cleared neighborhood shorelines laden with pesticides, septic effluent and other pollutants likely affect spawning success by altering beach salinities, temperatures, and nutrient and pollutant load. Increased algal blooms associated with increased nutrient loads can negatively impact forage fish spawning success (Shaffer 2001).

Pacific Herring

WDFW recognizes 19 different stocks of herring in Puget Sound, based on the timing and location of spawning activity (Stick 2005; PSAT 2007). Spawning grounds are well defined and the timing of spawning is very specific, seldom varying more than seven days from year to year (Bargmann 1998). Puget Sound herring are thought to be a mix of "resident" and "migratory" stocks, with the migratory populations cycling between winter spawning grounds in the inside waters and summer on the continental shelf off the mouth of the Strait of Juan de Fuca (Penttila 2007). It is not known which stocks are migratory and which are resident. It appears as though neither post-spawning adult herring nor pre-recruit herring persist in numbers in the immediate vicinity of any spawning ground during non-spawning times of year (Penttila 2007).

The only current commercial herring fishery operating in Puget Sound provides bait for sport fisheries. Fishing activity is primarily in south and central Puget Sound and mostly targets on 1.5-year old "plug-sized" herring assumed to be an aggregate of stocks within the region (Stick 2005). Most of the harvest is taken by non-tribal fishers using relatively small lampara seines. The recent size of annual landings by this fishery is generally determined by market conditions, which are heavily influenced by the length of recreational salmon seasons (Stick 2005). Similarly, Williams (1959) and Chapman et al. (1941) reported that herring landings are affected most by variability of fishing effort and that annual catch figures are not a reliable indicator of herring abundance.

Across Puget Sound, estimates of herring spawning biomass have varied from year to year but most stocks have declined in the last five years (Figure 3). In 2002, the combined biomass of Puget Sound herring stocks was estimated at 17,700 tons. In 2004, that number dropped to about 11,000 tons-a decrease of about 40 percent. In 2006, biomass estimates were 12,000 tons. While herring spawning varies from year to year, most stocks in Puget Sound have continued to decline since 2002 (PSAT 2007). Herring spawning stock size fluctuations are influenced by ecological and anthropogenic factors that affect survival, and to a smaller extent growth. Changes in sea temperature, for example, can affect herring food supplies and/or change the abundance of predators, and anoxic conditions can lead to fish kills. The WDFW rates the herring stocks as either healthy, moderately healthy, depressed, critical, unknown, or extinct (Stick 2005). The stock rating is based on quality of data that WDFW indicates is either "poor," "fair to poor," "fair," or "good"(PSAT 2007). In 2008, approximately 48 percent of the herring stocks were rated as healthy or moderately healthy. This is a reduction from 2006 (Stick, pers. comm. 2009a). The annual natural mortality rate estimates for herring in Puget Sound have increased from the 30 to 40 percent in the 1970s to the 60 to 70 percent at present and these higher rates, presently observed in Puget Sound stocks are considered unusual in comparison to those typical to the rest of the world. Stock status, as defined by WDFW, is only one of several factors important to consider in our analysis.

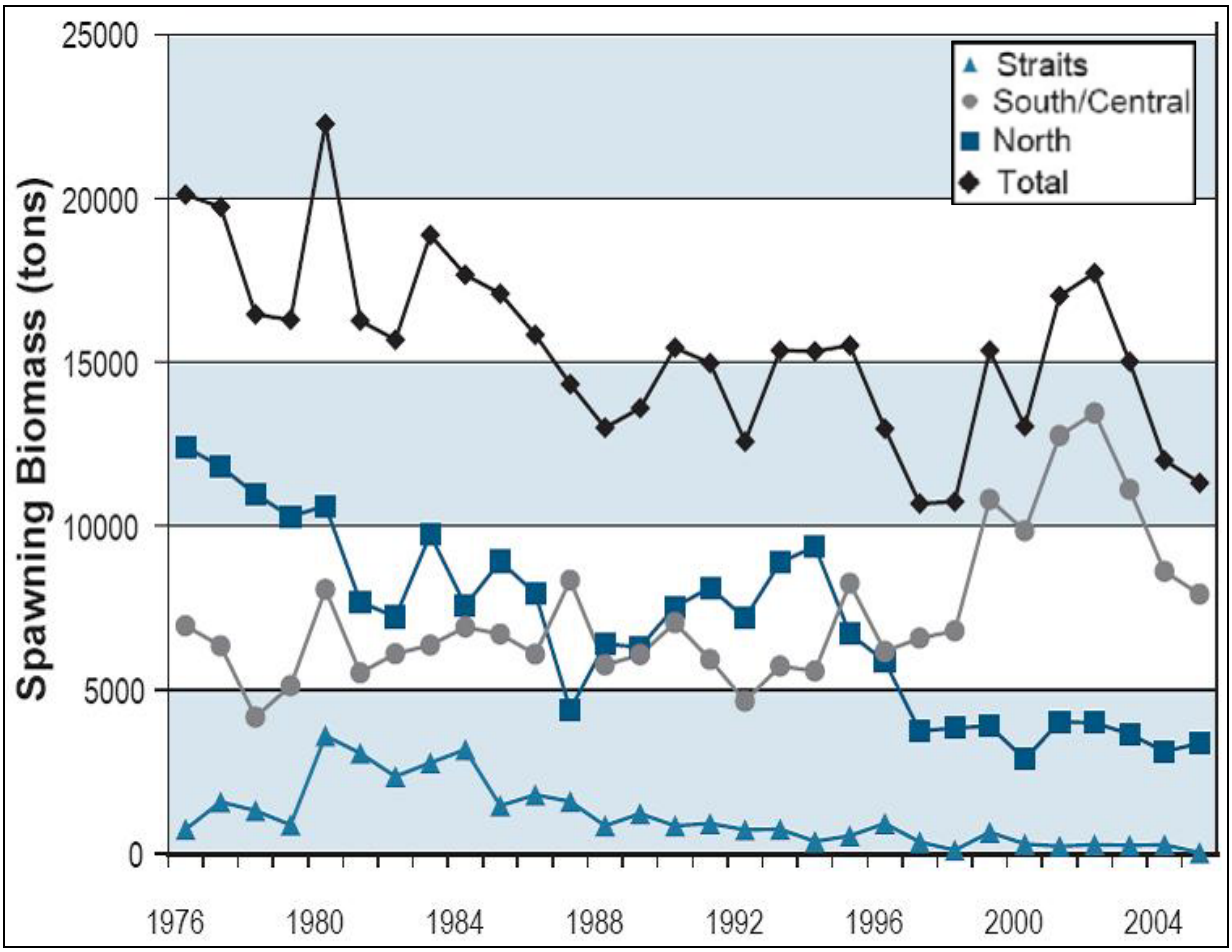

Figure 3. Estimated spawning biomass of Puget Sound herring by region, 1976 to 2005
Most herring stocks in Puget Sound have declined in the past five years. For some stocks (north Sound and the Straits), this is a continuation of a longer-term decline, while for other stocks (in the central and south Sound) this decline follows a variable trend of stock increases and declines. The causes of this decline is not well understood and may be due to a combination of changing ocean conditions, degraded water quality, nearshore habitat loss, and other factors (Source: WDFW 2005).

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

Fish survival and mortality are often expressed in terms of rates or percentages. The survival rate is the number of fish alive after a specified time (usually yearly), divided by the initial number. Natural mortality for herring has increased significantly since the 1970s (WDFW 1997), with the mortality rate estimate being reflective of total spawner biomass. The mean

estimated annual natural mortality rate for herring stocks in Puget Sound since 1987 has averaged 71 percent. The increase in adult natural mortality has resulted in a decrease in the mean and median age of adult herring in Puget Sound. Potential causes of the increased natural mortality in Puget Sound include predation, disease, and climatic changes. In addition, scientists have documented high polychlorinated biphenyls (PCBs) in herring from the central and southern basins of Puget Sound (PSAT 2007).

Surf Smelt

Surf smelt are a schooling mid-water prey species that are year-round residents in the nearshore waters of Puget Sound. They are a short-lived fish with most spawning populations comprised of 2-year old fish. They feed on plankton and macro-zooplankton (primarily arthropods), and are closely associated with the shoreline, spending their entire lives shoreward of the 10-fathom contour (60 ft). Surf smelt may be similar to herring in their predictable use of certain shorelines for spawning, at certain times of year. Though the specificity of spawning activities at certain sites and times suggests a degree of homing to their beaches of origin, this has not been proven (Penttila 2007). Their home ranges are unknown and there has been no assessment of stock status in Washington.

Over 200 miles of surf smelt spawning beaches are known to exist along Puget Sound with beaches often located at the heads of bays, inlets, or river estuaries shaded by trees and bluffs, which moderate the beach temperature and increase survival of the eggs (Penttila 2001). Surf smelt spawning occurs during high tides on beaches formed at or near the terminus of drift cells as well as on depositional beach habitats that include mixed-sand and gravel substrates in the upper tidal zone generally higher than plus 7 ft in tidal elevation. Surf smelt eggs are most often found in pea gravel like substrate mixed with sand, with medium sized gravel mixed with sand as the second most common substrate. During spawning a single female may be pursued by up to five males. Between 1,440 and 29,180 eggs are released during the spawning period by a single female (Schaefer 1936). Spawning success depends on the presence of fine sediments up to about 3 cm, a size above which eggs no longer adhere to beach substrate (Pentilla 1995). Surf smelt eggs incubate for two to six weeks (WDFW 2000). Surf smelt larvae are planktonic drifters for several weeks after hatching and therefore at mercy of the currents and tides. Spawning beaches may produce larvae continuously for many months (Penttila 2007). Coarsening of beach substrates is common along Puget Sound accretion beaches due to extensive armoring and other modifications (Hirschi et al. 2003). All known surf smelt spawning sites have been given enhanced "no net loss" protection in the application of Washington Administrative Code (WAC) "Hydraulic Code Rules."

The Puget Sound nearshore is crucial in the life cycle of the surf smelt and sand lance as well as many other forage fish species (Simenstad et al. 1979; Kozloff 1983; Simenstad 1983; Phillips 1984; Krucheberg 1991). Surf smelt are exposed to many anthropogenic perturbations, including shoreline alterations (bank hardening, bulkheads, et cetera) and removal of terrestrial vegetation (Williams and Thom 2001; PSWQUAT 2002), which ultimately impairs the biological condition of the spawners and their reproductive success.

Pacific Sand Lance

Sand lance also known locally as "candlefish", are a common ecologically important forage fish that are year-round residents in the nearshore waters of Puget Sound. They feed on macro-zooplankton, primarily arthropods. During spring and summer months, these fish are considered epibenthic, schooling pelagically during the day to forage and burrowing in the benthic substrate at night (Hobson 1986). Their home ranges are unknown and there has been no assessment of stock status in Washington.

Sand lance spawning habitat includes accretion beaches formed at or near the terminus of drift cells as well as on depositional beaches. Spawning success depends on the presence of fine sediments, such as pea gravel like substrate mixed with sand, up to about 3 cm, a size above which eggs no longer adhere to beach substrate (Pentilla 1995). Because sand lance spawn in the intertidal zone of Puget Sound, local spawning populations are vulnerable to shoreline development. Coarsening of beach substrates is common along Puget Sound accretion beaches due to construction of bulkheads, extensive shoreline armoring, and other modifications can bury the upper intertidal zone (Hirschi et al. 2003).

Sand lance spawning in Puget Sound occurs from October 15 through March 1. Spawning times are not broken out by area. Spawning may occur between November and February in multiple events without a specific peak (Bargmann 1998). Sand lance use the same stretches of beach as surf smelt at the same time of year (Bargmann 1998). Sand lance spawning is confined to the upper tidal zone, generally higher than plus five ft in tidal elevation. A single female releases around 1,400 to 16,080 eggs during the spawning period (AKNHP 2009). At the moment of spawning, sand lance eggs often take on a coat of attached sand grains making them nearly invisible. The eggs incubate for about four weeks. Upon hatching, larvae are at the mercy of the currents and tides until they are about 22 mm in length (WDFW 1997).

During the winter, these fish may remain buried in the sediment in a state of dormancy (Robards et al. 1999); however, sand lance may emerge from the sediments if oxygen conditions in the sediment become too low (Quinn 1999). Schools can be commonly encountered in waters over 100 ft deep. However, juveniles may be more closely associated with shorelines and protected bays, in mixed schools with herring and surf smelt of similar age and size.

Seabirds

According to the Puget Sound Action Team (PSAT 2007), surf scoters (*Melanitta perspicillata*), white-winged scoters (*M. fusca*), and black scoters (*M. perspicillata*) have collectively declined by approximately 57 percent between 1978 and 1999, with this decline continuing through 2005 in nearly all of the subregions of Puget Sound. The decrease in scoters represents the largest decline in biomass of marine birds over the past 25 years in Puget Sound. Loons and grebes that over-winter in Puget Sound have declined by nearly 75 percent over the past 10 years, and it is unknown whether this reflects declines in the overall populations or whether birds are over-wintering outside of Puget Sound.

Murrelets are long-lived seabirds that spend most of their life in the marine environment, but use old-growth forests for nesting. Murrelets generally forage within 1.25 miles of shore (Strachan et al. 1995). Research on murrelet populations in the early 1990s estimated murrelet abundance at 18,550 to 32,000 birds using a variety of survey methods in Washington, Oregon, and California (Ralph et al. 1995). The 2007 and 2008 estimated abundance for murrelets within the species listed range were the lowest recorded levels since surveys began.

Several threats that can lead to a significant disruption or impairment of normal murrelet behaviors have been identified and are expected to continue to contribute to the decline of the species abundance, distribution, fecundity, and reproduction. Threats to murrelets identified in the FWS's 5-year review for the species (USFWS 2009, p. 27-67) include 1) exposure to marine PCBs; changes in prey availability and quality leading to reductions in fitness; 2) harmful algal blooms and biotoxins that lead to marine "dead zones"; 3) derelict fishing gear leading to mortality from entanglement; 4) energy development projects (wave, tidal, and on-shore wind energy projects) leading to mortality; 5) disturbance in the marine environment (from exposures to lethal and sub-lethal levels of high underwater sound pressures caused by pile-driving and underwater detonations and potential disturbance from high vessel traffic); and 6) climate change in the Pacific Northwest (USFWS 2009, p. 27-67). Most threats are expected to continue into the foreseeable future and those that cause direct mortality or reduce individual fitness are likely to contribute to murrelet population declines.

Marine Mammals

Sea lions have become more abundant in Washington waters. California sea lion (*Zalophus californianus*) populations have increased by about 5 percent annually, with a current population of 4,000 to 5,000 animals. Steller sea lions (*Eumetopias jubatus*) are also increasing in population, by about 10 percent annually. Surveys conducted in 2005 of Steller sea lions during peak abundances in fall and winter recorded 1,000 to 1,500 sea lions along Washington's outer coast. This species also regularly inhabits North Puget Sound. Harbor seals (*Phoca vitulina*) have been steadily increasing in population since the early 1970s, with current populations consisting of 16,000 seals along the outer Washington Coast and 14,000 in the inland waters of Puget Sound. Southern resident orcas were listed on the Federal endangered species list in 2005. The population currently consists of 86 whales, down from a peak of 98 in 1975.

Aquatic Vegetation

Eelgrass (*Zostera marina*) is a rooted, flowering plant that occurs in the Action Area (Figures 4 and 5), which depends on the transport of eroded sediments to establish itself along the shoreline. These roots hold sediment in place to create intertidal and sub-tidal habitat for many fish and invertebrates. Eelgrass is a regionally important natural resource that provides a number of widely recognized and valuable functions, including primary production, nutrient processing, wave and current energy buffering, organic matter input, breeding and foraging habitat for fish such as herring and invertebrates like Dungeness crab, and food for birds (Blackmon 2006).

Organic carbon produced by eelgrass and other nearshore macrophytes and macro-algae enters the food web through microbial decomposition and processing of both particulate and dissolved

eelgrass. This organic matter is then incorporated in the diet of fish and other marine animals including juvenile salmon (Simenstad et al. 1988). There is also a rich epiphytic flora and associated small invertebrate fauna that forms seasonally on eelgrass leaves. Juvenile salmonids also use eelgrass for feeding, rearing, and as a migratory pathway from natal streams to the Straits and distant ocean. Herring use eelgrass as a spawning substrate and other valuable nearshore species such as Dungeness crab include eelgrass beds as primary habitat during much or all of the year. Mud flats, sand spits, and backshore habitats generally include gently sloping sandy or muddy beaches, with substrata that may be composed of a mixture of mud, silts, sand, pebbles, and cobble. Sand and mudflats provide a number of functions, including primary production by micro-algae such as diatoms, nutrient cycling, prey production for juvenile salmon, and bivalve production. Juvenile salmon prey species have been shown to be seasonally abundant on mud flats and their distribution is linked to benthic micro-algal abundances (Thom et al. 1989). Native eelgrass (*Zostera marina*) has declined in Hood Canal for four consecutive years since 2001.

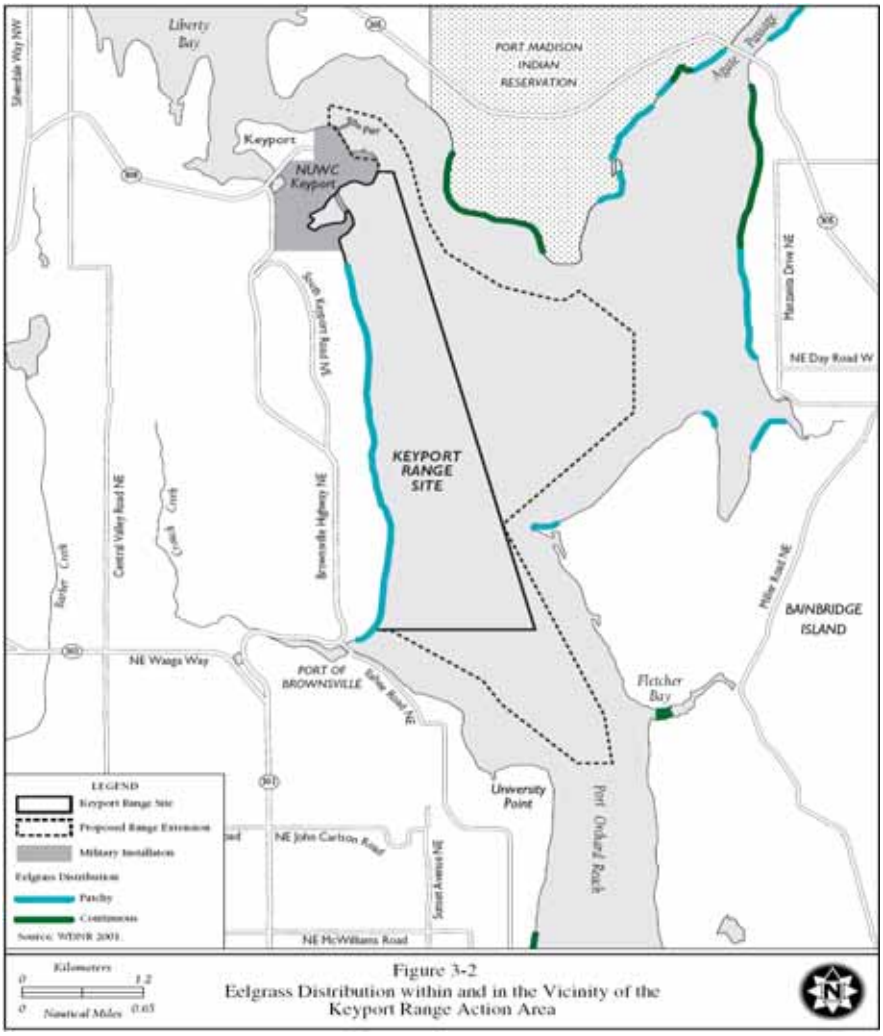

Figure 4. Eel Grass distribution within and in the vicinity of the KTR Subunit (source: U.S. Navy, NAVSEA NUWC Keyport Range Complex Extension Biological Evaluation, October 2008)

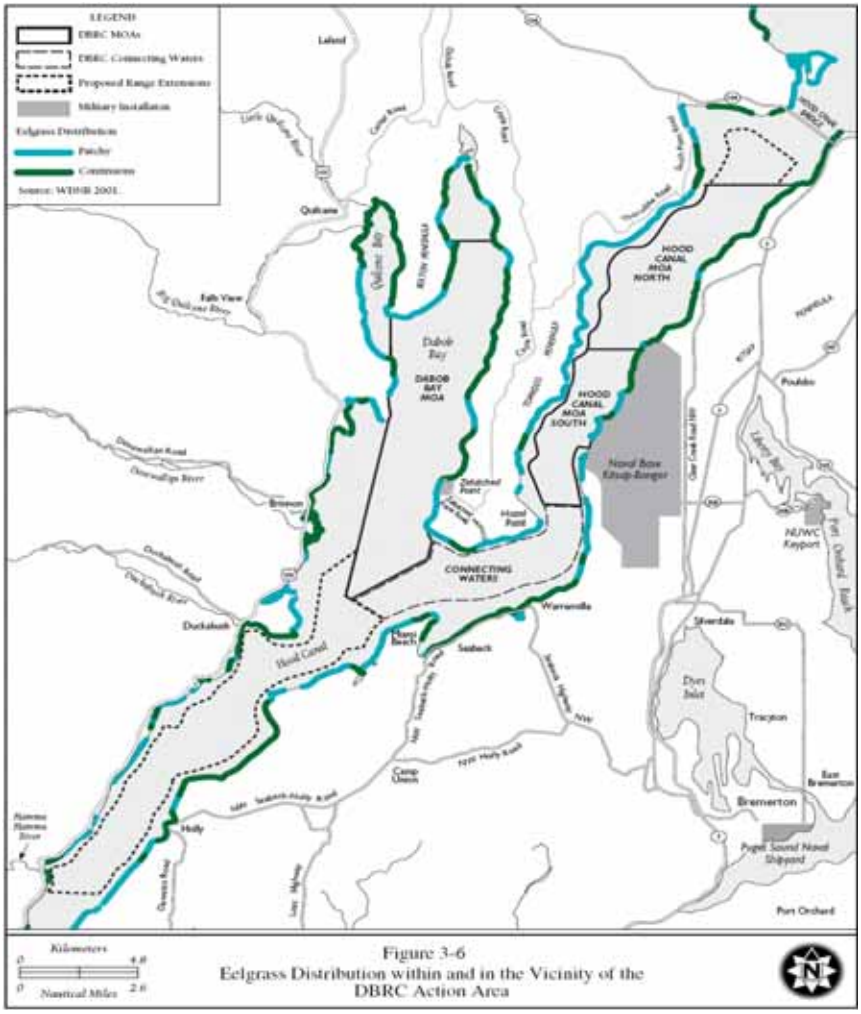

Figure 5. Eel Grass distribution within and in the vicinity of the DBRC Subunit (source: U.S. Navy, NAVSEA NUWC Keyport Range Complex Extension Biological Evaluation, October 2008)

Gillnets

Gillnet fishing has been considered a conservation issue in Washington (USFWS 1997b; Melvin et al. 1999) for many species including murrelets. There is little information available on murrelet mortality from net fishing prior to the 1990s, although it was known to occur (Carter et al. 1995). In the mid 1990s, a series of fisheries restrictions and changes were implemented to address mortality of all species of seabirds, resulting in a lower mortality rate of murrelets (McShane et al. 2004). Fishing effort has also decreased since the 1980s because of lower catches, fewer fishing vessels, and greater restrictions (McShane et al. 2004), although a resurgence in gillnet fishing is likely to occur if salmon stocks increase. In most areas, the threat from gill net fishing has been reduced or eliminated since 1992, but threats to murrelets are still present in Washington waters due to gill net mortality (McShane et al. 2004). Entanglement in derelict fishing nets, which are nets that have been lost, abandoned or discarded in the marine environment, may also pose a threat to both murrelets and bull trout. Derelict gear can persist in the environment for decades and poses a threat to marine mammals, seabirds, shellfish, and fish. A recent survey estimated 3,900 derelict nets need to be removed from Puget Sound annually

(Northwest Straits Foundation 2007) and each year the number of new derelict nets increases faster than the number removed. Over 50 percent of derelict nets in Puget Sound waters occur where murrelet densities are the highest. Derelict fishing gear may persist for years in a low energy environment like the inner Puget Sound (NRC 2007). The amount of time these nets pose a threat to marine species depends on the length and type of the net and cause of entanglement.

Toxic Contamination

Humans have released a wide variety of chemicals into Puget Sound in the past 150 years, many of which are toxic to humans, animals, and plants. While contamination by a number of toxics, such as lead, PCBs, and dioxins, has been reduced by health and safety restrictions, other unregulated chemicals continue to be used and many enter into Puget Sound through wastewater discharges, storm water runoff, and other nonpoint sources, adding to the contamination. Toxic chemicals that enter Puget Sound remain longer within the system due to its geologically deep, narrow, fjord-like structure, with shallow sills that restrict the circulation of water. Toxins are therefore trapped, leading to increased exposure of the native biota. This hydrologic isolation also puts Puget Sound at higher risk from nutrients and pathogens that may enter the system. This combination of low hydrologic mixing coupled with persistent and bioaccumulative nature of many chemical contaminants creates additional risk for the Puget Sound ecosystem.

The toxins that harm or threaten the health of the Puget Sound ecosystem include engineered and synthetic chemicals to meet industrial needs, agricultural products (e.g. pesticides), byproducts of manufacturing, combustion of fossil fuels, and naturally occurring toxic elements that may have abnormally high concentrations in the environment due to human uses or other activities. Release of these chemicals to the environment occurs through multiple pathways (e.g., application of pesticides, discharge of wastes through outfall pipes, smokestacks, and exhaust pipes) or as unintended consequences of human activities (e.g., oil and chemical spills, leaching from landfills, and runoff of chemicals from the deterioration or wear of roofs, pavement, and tires). Approximately one percent of Puget Sound sediments are highly degraded, 31 percent are of intermediate quality, and 68 percent are of high quality. The degraded sediments (as measured by toxicity, chemistry, and benthic infauna) are mainly associated with urban embayments that are often located near river deltas and other highly productive nearshore habitats of importance to Puget Sound species.

Puget Sound sediments contain polycyclic aromatic hydrocarbons (PAH) with levels greatly unchanged over the past decade, except in Bellingham Bay, Port Gardner, and Anderson Island, where levels have increased. Six endocrine-disrupting compounds (bisphenol A, estradiol, ethynylestradiol) and three phthalates were detected in more than 20 percent of surface-water samples collected in King County's lakes, rivers, streams, and stormwater discharges. Flame retardants or polybrominated diphenyl ethers (PBDE) occurred in 17 percent of sediment sites sampled in Hood Canal in 2004 and were detected in 16 percent of samples from 10 Puget Sound-wide sediment sampling sites in 2005. PBDEs are now second to PCBs in order of significance in the Puget Sound food web.

PBDE in English sole (*Parophrys vetulus*) from urban areas are almost 10 times higher than those levels measured in sole from the Georgia Basin. Herring from Puget Sound have nearly three times the levels of PBDE in Georgia Basin herring. Harbor seals from Puget Sound have over twice the PBDE found in seals near Vancouver, British Columbia. Scientists estimate that PBDE levels are doubling every four years in marine mammals, including harbor seals and orcas, and will surpass PCB levels in these species by 2020. Chinook salmon from Puget Sound have nearly three to five times the PCB levels of Chinook salmon from Alaska, British Columbia, and Oregon.

Nutrients and Pathogens

Water quality is a primary factor affecting the health of marine and freshwater species in Puget Sound. As urbanization of the Puget Sound area continues to increase, freshwater and marine ecosystems are under rising pressure from human activities associated with population growth that increase nutrient and pathogen pollution. Inputs of nutrients and pathogens affect the health and habitat of aquatic species, ecosystem functioning, and human health.

Nutrients consist of both natural and synthetic substances that stimulate plant growth and enrich aquatic ecosystems with, phosphorus considered the limiting nutrient in freshwater systems and nitrogen in marine systems. This means increased loadings of these nutrients have significant effects on the character and condition of these two systems. The Washington Department of Ecology (WDOE) 2004 *Water Quality Assessment* identified 58 freshwater sites with dissolved oxygen concerns in Puget Sound due to excessive nutrients (phosphorus and nitrogen) in the streams. In marine waters, 76 water bodies in Puget Sound have fecal coliform problems and very high levels of eutrophication. The locations of highest concern include Hood Canal, Budd Inlet, Penn Cove, Saratoga Passage, Possession Sound, Commencement Bay, and Elliott Bay, based on WDOE's index of water quality for Puget Sound.

Nutrient cycling and nutrient pollution caused by human activities have a profound effect on the Puget Sound Basin. Contribution of nutrients in Puget Sound come from natural and human sources including upwelling and inflow of oceanic waters, flows from rivers and streams, storm water runoff carrying fertilizers and other materials, discharges from sewage treatment plants, atmospheric deposition, and numerous other sources.

Vessel Traffic and Sound-Related Disturbances

In coastal and offshore marine environments, visual and/or sound disturbance from watercraft is known to elicit behavioral responses in marine animals including murrelets of all age classes (Kuletz 1996; Speckman 1996; Nelson 1997). Low flying aircraft and watercraft activity are known to cause many marine mammals and seabirds, including murrelets, to dive and are thought to especially affect adults holding fish (Nelson 1997). It is unclear to what extent this kind of disturbance affects the distribution, movements, foraging efficiency, and overall fitness of birds. It is likely this type of stress-causing disturbance is escalating as shipping traffic and recreational boat use in the Puget Sound and Strait of Juan de Fuca has continued to increase.

Marine projects that include seismic exploration, pile driving, detonation of explosives, sonar, and other activities that generate high-energy underwater sounds can expose marine species to elevated underwater sound pressure levels (SPL) and SEL. High underwater SPL can have adverse physiological and neurological effects on a wide variety of vertebrate species (Yelverton et al. 1973; Yelverton and Richmond 1981; Steevens et al. 1999; Fothergill et al. 2001; Cudahy and Ellison 2002; U.S. Department of Defense 2002; Popper 2003). High underwater SPL is known to injure and/or kill fish by causing barotraumas (pathologies associated with high sound levels including hemorrhage and rupture of internal organs), as well as causing temporary stunning and alterations in behavior (Turnpenny and Nedwell 1994; Turnpenny et al. 1994; Popper 2003; Hastings and Popper 2005).

Pacific Coast

Along the Washington coast are diverse habitats that comprise the ocean and coastal environment essential to fish and wildlife for spawning grounds, nurseries, shelter, and forage, including a disproportionate number of endangered and/or commercially important species. These habitats also provide tangible and valuable services to humanity such as filtering pollutants from runoff, buffering coastal communities against the effects of storms. However, the fishing industry has overexploited of many fish stocks, degraded habitats, and had negative impacts on many ecosystems. Non-native species have been introduced, intentionally and accidentally, resulting in significant ecological consequences that we are only beginning to comprehend.

The creation of the Olympic Coast Marine Sanctuary (Sanctuary) in 1994 off the Olympic Peninsula protected 8,570 km^2 from Cape Flattery in the north to the mouth of the Copalis River to the south and extending seaward up to 64 km. Included are three underwater canyons, the Nitinat, Quinault, and Juan de Fuca as well as rocky shores, sandy beaches, and kelp forests. The seafloor in the Sanctuary is teaming with organisms including crabs, eels, and many invertebrates, as well as the recently discovered deep-sea corals and sponges (Brancato et al. 2007). At least 29 species of marine mammals including whales, dolphins, porpoises, seals, and sea otters utilize the Sanctuary and bull trout, sea-run cutthroat, salmon, steelhead, halibut, rockfish, and cod aggregate in the nearshore (Office of National Marine Sanctuaries, 2008).

Included within the Sanctuary is the Washington Islands Wilderness, a 183-hectare area comprised of more than 600 islands, rocks, and reefs designated in 1970. The Flattery Rocks, Quileute Needles, and Copalis Rock National Wildlife Refuges comprise the Washington Island Wilderness. These areas contain habitat, forage, and breeding areas for dozens of seabird species including the marbled murrelet, harbor and fur seals, northern and California sea lions. Northern sea otters are common amongst the kelp beds (Wilderness 2009). A common concern for seabirds off the Washington coast are long-term declines in their population sizes (Wahl and Tweit 2000, Wahl et al. 2005, Raphael 2006). Although human access to most seabird colonies is restricted by the FWS's Washington Maritime Refuge Complex regulations (USFWS 2007), wildlife on the refuge islands is vulnerable to disturbance from low-flying aircraft that do not comply with the 2,000-foot elevation requirement established under the Wilderness designation and consequently the Sanctuary establishment.

Over 120 species of red, green, and brown algae coat the rocks in the rocky intertidal areas along the Olympic Coast. These are grazed upon by invertebrates such as gastropods, crabs, starfish, snails and sea urchins. Additionally, abundant kelp forests of large brown algae (*Laminariales*) occur in the subtidal areas of the coast serving as habitat for the invertebrates described above. These areas are also utilized by northern sea otters that forage, loaf, and play among the kelp.

Sediment contamination levels (i.e., heavy metals and organic pollutants) in the coastal waters of Washington are generally low; with polycyclic aromatic hydrocarbons (PAHs; found in oils and byproducts of petroleum combustion) and metals found in the sediment along the entire coastal region (WDOE 1995). There has been no widespread or persistent contamination from petroleum documented outside of major oil spills, the most recent of which occurred in 1991. Oil contamination of marine animals can cause eye irritation, impairment of thermal regulation, loss of buoyancy, toxicity, reproductive abnormalities, and ultimately death. Oil spills can deplete food sources and destroy habitat characteristics essential for survival of marine species. Concentrations of contaminants in tissues provide an integrated measure of bioavailability of compounds that are present at low or variable levels in the marine system (Office of National Marine Sanctuaries, 2008). Recently chemical concentrations were measured in a variety of invertebrates and sea otters in a study on sea otter fitness. Low contaminant concentrations were reported, but high levels of exposure to morbillivirus and toxoplasma were found. The latter has been a significant cause of mortality in sea otters in the southern California population (Brancato et al. 2006), but is not currently found in Washington.

Most large ships are powered by marine diesel engines using fuels containing high concentrations of contaminants (Corbett and Fischbeck 1997) and are the main source of anthropogenic noise within sanctuary waters, with a certain contribution from military activities. In the ocean, sound emanates from natural sources, such as storms, volcanic eruptions, and earthquakes, and human-generated sources, including shipping, scientific and commercial surveys, and commercial and military sonar. Scientific information is increasing in the fields of the biological, psychological, and behavioral changes that are caused by human-generated sound, and activities such as commercial shipping, construction, geological exploration, and low, mid, and high frequency sonar certainly can produce noises intense enough to elicit reactions from animals in the marine environment (USCOP 2004).

Climate Change

Average global temperatures have been rising over the last several decades. Scientists believe these changes are probably due primarily to the accumulation of greenhouse gases in Earth's atmosphere from human activities, although natural variability may also be a contributing factor. The Intergovernmental Panel on Climate Change reports that the average near-surface temperature of the Earth increased by about 1°F between 1861 and 1990, but is expected to increase by another 2.5 to 10.4°F by the end of this century (Houghton et al. 2001). According to model predictions for the Pacific Northwest, average temperatures in Washington State are likely to increase between 1.7 °C and 2.9 °C (3.1 °F and 5.3 °F) by 2040 (Casola et al. 2005). As oceans warm, marine organisms that are sensitive to temperature must either alter their geographic distribution or face extinction. Already, changing ocean conditions in the North Pacific have altered ecosystem productivity and have been associated with poor ocean survival

of young salmon and modifications in the composition of nearshore fish populations (NRC 1996). Salmon stocks are declining not just from overfishing but because lower oxygen levels resulting from increased water temperatures boost susceptibility to disease and disrupt breeding (IUCN 2009; Crozier et al. 2007).

Listed Resources

The status of listed resources will be described below at the scale of the subunits of the Action Area. However, a description of bull trout critical habitat is provided here specifically for the entire action because of the close correspondence of the entire Critical Habitat Unit (CHU) to the entire Action Area.

Bull Trout Critical Habitat

The KRCE Action Area includes the area to which the extent of the physical, chemical, and biotic effects of the action may extend. The effects of the Action considered for bull trout critical habitat in areas where bull trout critical habitat has been designated within the subunits.

Areas that may be affected by the proposed action are entirely within the Olympic Peninsula designated CHU 27.

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

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

Critical habitat has been designated in the marine nearshore of the Pacific Ocean, Strait of Juan de Fuca, and Hood Canal. Roads and rural development have impacted the condition of critical habitat in the Pacific Ocean. However, human population density is low, there is little industrial

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

Conservation Role of Critical Habitat Unit 27 (Olympic Peninsula)

The Olympic Peninsula Critical Habitat Unit 27 is essential to the conservation of amphidromous bull trout, which are unique to the Coastal-Puget Sound bull trout population (USFWS 2004a, p. 45). Additionally, these marine waters are considered critical to the persistence of the anadromous life history form of the Coastal-Puget Sound Interim Recovery Unit (USFWS 2004a, p. 20) as a result of providing essential and biologically important foraging and migration habitat. These habitats, outside of core areas, contain primary constituent elements (PCEs) that are critical to adult and subadult overwintering, migration, and foraging.

Subunits within the Keyport Range Complex Extension Action Area

The Keyport Naval Undersea Warfare Complex contains three distinct project areas composed of the Keyport Testing Range (KTR), Dabob Bay Range Complex (DBRC), and Quinault Underwater Tracking Range (QUTR). Additionally, the areas in which the Navy transits from base to range and range to range are also considered because transit is considered to be an interrelated action.

<u>Keyport Testing Range</u>

Keyport Testing Range Action Area

The KTR in Port Orchard Reach currently provides approximately 5.1 km^2 of testing area, which is approximately 30 m in depth. It is adjacent to NUWC Keyport and includes in-shore shallow water sites and a shallow lagoon. The proposed Action extends the KTR boundaries from NUWC Keyport north into Liberty Bay, east into Agate Passage, and south to University Point in Port Orchard Reach, increasing the size of the range from 5.1 km^2 to 11.0 km^2 and average annual days of use from the current 55 days to 60 days (Figure 6).

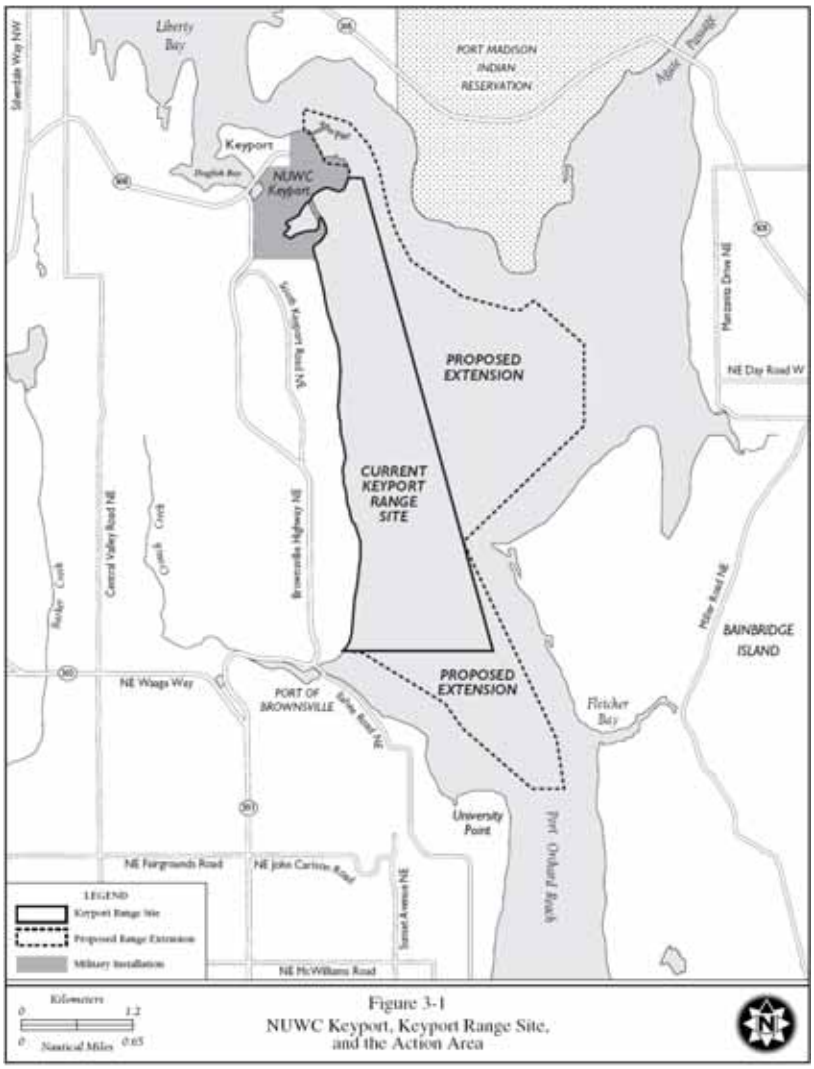

Figure 6. Keyport Testing Range
(source: U.S. Navy 2008b)

Primarily these operations support undersea warfare RDT&E program requirements, but also general equipment test and military personnel training needs, including fleet activities. The majority of the proposed activity types addressed in the Navy EIS and BE are not described in useful terms for the purpose of our analysis. Table 4 provides our summary of relevant information for the analyses of activities that may occur in KTR, based on the project description in BE and EIS, as well as clarification and information received in response to our requests to the Navy through the consultation process. Typical activities include 1) an Unmanned Underwater Vehicle's (UUV) capability to detect bottom target shapes with side-scan sonar while collecting the electric, magnetic, and acoustic signature based upon the type of propulsion system utilized by a particular UUV, 2) detection, classification, and localization test objectives, and 3) magnetic measurement programs. Several of these RDT&E activities may occur in a single day.

Table 4. Specific activities the U.S. Navy plans to conduct at the KTR – each year for the next five years (Table 2-5 U.S. Navy 2008b).

Range RDT&E activities	*Platform/System Used*	*Activities in KTR*	*Frequencies (kHz)*	*Maximum Source Level (dB re 1 μPa @ 1 m)*
Active Sonar				
	low frequency	-	-	-
	mid frequency	45*	1 - 10	233
	high frequency		10- 2,500	235
Countermeasures		5		
	Sonar		100-700†	238†
	continuous sound		.05-10†	170†
Other Testing				
	static in-water	10	.8-2500†	238†
	targets	45**	5-100	195-238
	target simulator		.1-10	170
	inert mine detection	20	100-700	235
Vessel Activity				
	aircraft	0	-	225
	surface – fleet, surface launch craft, barges	76	.05-10‡	170‡
	underwater diver	45	-	-
	submarine	0	5-100‡	195 -238‡
	torpedoes: non-explosive exercise weapons	45	10-100‡	233‡
	UUV tracking		10-100‡	195‡
	UUV/ special UUV		10-2500‡	235‡

* Based on total number of underwater tests and assuming that all of the activities will occur in a 365 day year and that all of the activities will utilize either or both sonar types

** Assuming that all UUV tests have a target involved

† Frequencies and dB level assumed as the information on countermeasures is classified

‡ Submarines, torpedoes, and surface vessels produce both continuous sound (vessel) and sonar signatures

Environmental Baseline in the Keyport Testing Range

The KTR located in Kitsap County and includes portions of Liberty Bay and Port Orchard Reach, is a unique and important part of the overall Puget Sound ecosystem, providing a diverse and significant array of estuarine and nearshore habitats for fish and wildlife. These habitats are utilized by several species of salmon and forage fish as well as a myriad of other ecologically significant organisms. The combination of physical factors and dominant species types create an identifiable structure for the habitat. Historically, the natural nearshore areas within the watershed were a complex mosaic of tidal wetlands, rocky beaches, sand spits, eel grass meadows, small-stream estuaries, sub-estuaries, brackish lagoons, marine riparian areas, and eroding bluffs (Kruckeberg 1991). The Kitsap Peninsula watershed is unique, dominated by numerous short, low-order, low-gradient streams flowing into Puget Sound. Their flows are supported almost exclusively by precipitation and groundwater.

Under natural historic conditions, the watershed was almost entirely forested, with native conifers (fir, spruce, cedar, and hemlock) dominating the upland landscape (Kruckeberg, 1991). Patches of hardwoods (alder, willow, madrona, and maple) were common in areas of natural where stochastic events (fire, wind-throw, landslides, and flooding) had recently occurred

(Kruckeberg, 1991). Blackberry and scotch broom, introduced about 150 years ago, have contributed to decreased native vegetation, increased fire risk, and loss of native faunal habitats.

Due to the pressures of shoreline development and watershed land-use activities, the natural resources of Liberty Bay and Port Orchard Reach have been stressed. The loss of natural forest cover, native soil structure, wetlands, and riparian vegetation all contribute to the disruption of the natural landscape. Shoreline development has resulted in the loss or degradation of physical habitat. Nonpoint-source (NPS) pollution, generated by septic drain fields and carried by stormwater runoff, has degraded water quality in Liberty Bay and Port Orchard Reach and its tributaries (May 2005).

Marine nearshore and estuary habitats are important to many species living in Puget Sound such as murrelets, bull trout, sea-run cutthroat, salmon, steelhead, herring, sand lance, and surf smelt. Docks, jetties, bulkheads, and breakwaters have disrupted the natural nearshore circulation and sediment transport processes leading to loss of nearshore and estuarine habitats and properly functioning nearshore ecosystem conditions (May 2005).

Modifications to the Liberty Bay and Port Orchard Reach nearshore include loss and alteration of shallow water habitats, degradation of sediment quality, degradation of water quality, and loss of riparian vegetation along the shoreline. Nearshore habitat has been significantly altered due to extensive armoring and alteration of the marine shoreline. Roadways across or along the mouths of streams and marine shorelines have significantly altered or eliminated estuarine and nearshore function. Extensive upland development and armoring of the shoreline has reduced the quality of intertidal habitat in the Action Area. Modifications to the nearshore include loss and alteration of shallow water habitats, degradation of sediment quality, degradation of water quality, and loss of riparian vegetation along the shoreline (WSW 2005).

The cumulative effects of urbanization have threatened water availability and water quality while many streams and fisheries are in jeopardy of cumulative pollution. There is also increasing pressure from developers and local government to urbanize more of the formerly rural areas with major commercial and residential developments planned to accommodate the growing influx of residents to this area (Williams and Thom 2001; May 2005).

Mud substrates are found in the shallow waters of Liberty Bay and Port Orchard Reach with sediments considered highly degraded. Many of the inlets and bays are listed as impaired by total PCBs for 1,4-Dichlorobenzene, 2,4-Dimethyophenol, Aldrin, Arsenic, Benz(a)anthracene, Benzo(ghi)perylene, Benzoic acid, Bis(2-ethylhexyl)phthalate, Butylbenzyl phthalate, Cadmium, Chrysene, Copper, Dieldrin, Fluoranthene, Indeno(1,2,3-cd) pyrene, Lead, Mercury, PCB- 1254, PCB-1260, Phenanthrene, Zinc, and exceedance of the fecal coliform standards on WDOE's 303(d) list (WDOE 2006).

From an ecosystem perspective, there is a continuous decline in water quality, biological integrity, and habitat complexity on land and in the Liberty Bay and Port Orchard Reach nearshore vicinity as natural vegetation and soil structure are lost to urbanization. This loss of native terrestrial habitats and soil structure leads to a loss of function within the terrestrial

ecosystem. This directly impacts the nearshore marine environment and changes its ecological integrity, lowering its ability to support marine life (May 2005).

Species Status in the Keyport Testing Range

Bull Trout Status in Keyport Testing Range

Based on the information in the draft bull trout recovery plan (USFWS 2004a), bull trout are unlikely to occur in the KTR Action Area. There are no core populations nearby and the habitat is severely degraded. Due to the low numbers of bull trout and the expected infrequent use of the KTR of the Action Area, we anticipate exposure of bull trout to the effects from RDT&E in the KTR to be extremely unlikely, and potential effects are considered discountable.

Bull Trout Critical Habitat in the Keyport Testing Range

No designated critical habitat is designated within or in proximity to the KTR therefore there will be no effect to bull trout critical habitat within KTR.

Marbled Murrelet Status in Keyport Testing Range

The FWS recently completed a 5-year review on the status of the murrelet (U.S. Fish and Wildlife Service 2009) and concluded that the murrelet population trend is precipitously declining (2.4 to 4.3 percent annually) within the listed portion of the species' range (U.S. Fish and Wildlife Service 2009, p. 18). The overall abundance of birds in the coterminous U.S. has decreased 26 percent since 2002, adding to the dramatic decline in the 1980's and 1990's that led to the species' listing (U.S. Fish and Wildlife Service 2009, p. 19). Population factors that have led to this decline are poor reproductive success and direct and indirect anthropogenic sources of mortality (U.S. Fish and Wildlife Service 2009, pp. 26-50, 55-59, 68). The FWS concluded that the reproductive success of the murrelet population is too low to sustain the population and continued declines are expected if these factors are not addressed (U.S. Fish and Wildlife Service 2009, p. 68). As a result, the FWS believes increasing murrelet breeding success is one of the highest conservation needs of the species.

Conservation Needs of the Marbled Murrelet in the Action Area

The Marbled Murrelet Recovery Plan (U.S. Fish and Wildlife Service 1997) outlines the conservation strategy for the murrelet. Of the primary recovery plan recommendations, the following are most pertinent to the needs of murrelets within the Action Area:

1) Protect the quality of the marine environment essential for murrelet recovery.
2) Reduce adult and juvenile mortality in the marine environment.

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

Likelihood of Species Presence in the Action Area

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

During the pre-basic molt, flightless murrelets must select foraging sites that provide adequate prey resources within swimming distance (Carter and Stein 1995). During the non-breeding season, murrelets typically disperse and are found farther from shore (Strachan et al. 1995). The proposed action is located within Conservation Zone 1 (Puget Sound). Murrelet presence in the vicinity of the Action Area is documented by several sources. The U.S. Forest Service (USFS) and the WDFW have conducted at-sea surveys for murrelets and other seabirds in Washington for many years. However, murrelet use in portions of the Action Area is not well described, because surveys have not been conducted specifically to describe murrelet use of the Action Area.

The USFS, Pacific Northwest Research Laboratory, conducts boat surveys to determine population size and trends under the Northwest Forest Plan Marbled Murrelet Effectiveness Monitoring Program. The KTR occurs in Conservation Zone 1 (Washington Inland Marine Waters) within stratum 3 (Figure 7). Stratum 3 does not include the San Juan Islands, Saratoga Passage, the south side of Admiralty Inlet or northern Hood Canal. Each stratum is divided into "Primary Sampling Units" or PSUs. Each PSU is a rectangular area approximately 20 km long composed of inshore and offshore subunits. PSUs are sampled between May 15 and July 31 (Bentivoglio et al. 2002). Since 2000, the estimated population size for Conservation Zone 1 has ranged from a low of 5,500 murrelets in 2004 to a high of 9,700 in 2002. The most recent (2007) estimated population size for Conservation Zone 1 is 6,985 murrelets (4,105 - 10,382) (95 percent CI). Since 2000, the estimated murrelet density in Conservation Zone 1 has ranged from 1.56 to 2.78 murrelets per km^2. Specifically, in stratum 3, murrelet densities (Table 5) have ranged from 0.29 to 2.07 murrelets per km^2 (Huff et. al 2002).

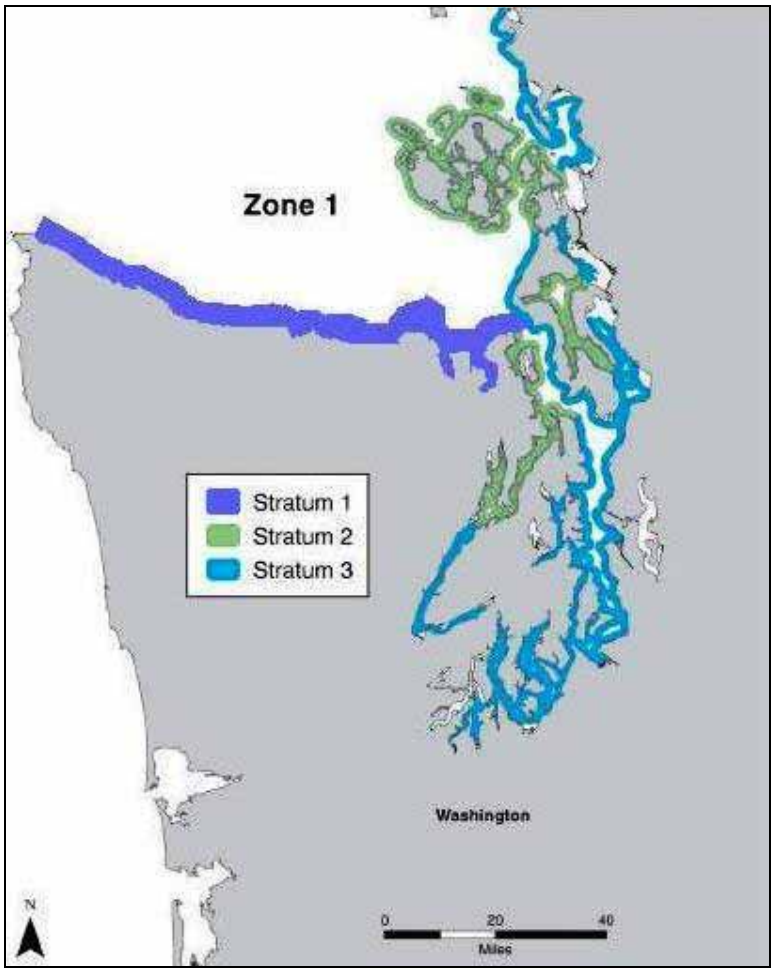

Figure 7. Marbled murrelet Conservation Zone 1 Strata (from Huff 2002)

Table 5. Marbled murrelet observations in Conservation Zone 1, Stratums 1-3, based on Effectiveness Monitoring for the Northwest Forest Plan (summer at-sea boat surveys).

Year	Stratum	Density (birds/km^2)	Source
2000	3	1.00	Huff et al. 2002
2001	3	2.07	
2002	3	0.97	
2003	3	0.79	Lance 2004
2004	3	0.29	Falxa et al. 2009
2005	3	2.02	
2006	3	1.28	
2007	3	1.80	
2008	3	0.42	

The WDFW, in cooperation with the Puget Sound Ambient Monitoring Program, conducts aerial surveys for seabirds in Puget Sound. Because these surveys are not specific to murrelets, and because of the small size of murrelets compared to other seabirds, they probably underestimate murrelet presence; however, they provide useful information on the seasonal distribution of murrelets. Winter surveys were conducted in December and January from 1993 to 2006. During winter surveys, small numbers of murrelets were sighted in Sinclair Inlet near the U.S. Naval Shipyard. Densities averaged 0.5 murrelet per km^2 with individuals may originate from either Conservation Zones 1 or 2.

Forage fish

The status of forage fish is described here due to their importance to murrelets and their presence in the Action Area (Figure 8). Small schooling fish and large pelagic crustaceans play a key role in the food web of the marine environment and make up a significant proportion of the diets of murrelets. Sand lance, northern anchovy, immature herring, capelin, Pacific sardine, juvenile rockfishes (*Sebastas* spp.) and surf smelt are the most common forage fish species eaten by murrelets. Squid (*Loligo* spp.), euphausiids (krill), mysid shrimp, and large pelagic amphipods are the main invertebrate prey. Of particular importance are prey that provide higher lipid content, such as herring and sand lance.

Pacific Herring

A portion of the pre-spawn holding area for the Port Orchard/Madison herring stock is located within the Action Area. The Port Orchard/Madison herring stock abundance has been fairly stable since a low point in the 1990s, with a mean spawning biomass of over 1,500 tons in the last ten years (Stick 2005). The Port Orchard/Madison stock currently has a healthy status. The estimated average Port Orchard herring stock biomass for 2001 through 2008 is approximately 417 metric tons. In 2008, 70 percent of the Port Orchard/Madison herring stock biomass was composed of two-year herring (Stick, pers. comm. 2009a).

Spawning activity has been documented along the entire KTR shoreline (Stick 2005). Spawning occurs between early January and mid-April. Some months before the onset of spawning activity, fish begin to assemble adjacent to spawning sites in pre-spawning holding areas (Penttila 2007). Adult herring may stage in or migrate through the Action Area. Eggs incubate for 10-14 days before hatching. Following hatching the larvae drift in ocean currents (Bargmann 1998). Larval, juvenile, and adult herring maybe present in the Action Area.

Surf Smelt

Surf smelt occur throughout Puget Sound and spawn on upper intertidal, gravel-sand beaches (Schaefer 1936; Thompson et al. 1936; Loosanoff 1937), and are unique among Puget Sound fishes in their obligate spawning use of these habitats. The entire shoreline associated with the KTR is used heavily by surf smelt for spawning (Waldbillig, pers. comm. 2009), with additional suitable spawning habitat identified throughout the Action Area and within the zone of effect of the RDT&E associated with the KTR. Surf smelt are believed to spawn year-round in Sinclair Inlet with peak spawning in November through mid-January.

Surf smelt spawn in Liberty Bay and Port Orchard Reach starting around September 1 thru March 31st with the heaviest spawn occurring in mid October through December. We would expect more fish to congregating in the KTR during the peak spawning time (Waldbillig, pers. comm. 2009). Adult, juvenile, and larval surf smelt are likely present in the Action Area year round.

Pacific Sand Lance

Sand lance spawning habitat has been identified within the Action Area along a small section of the KTR shoreline. Other spawning habitat is also documented in the surrounding vicinity. Adult, juvenile, and larval sand lance are expected to be present in the Action Area throughout the year.

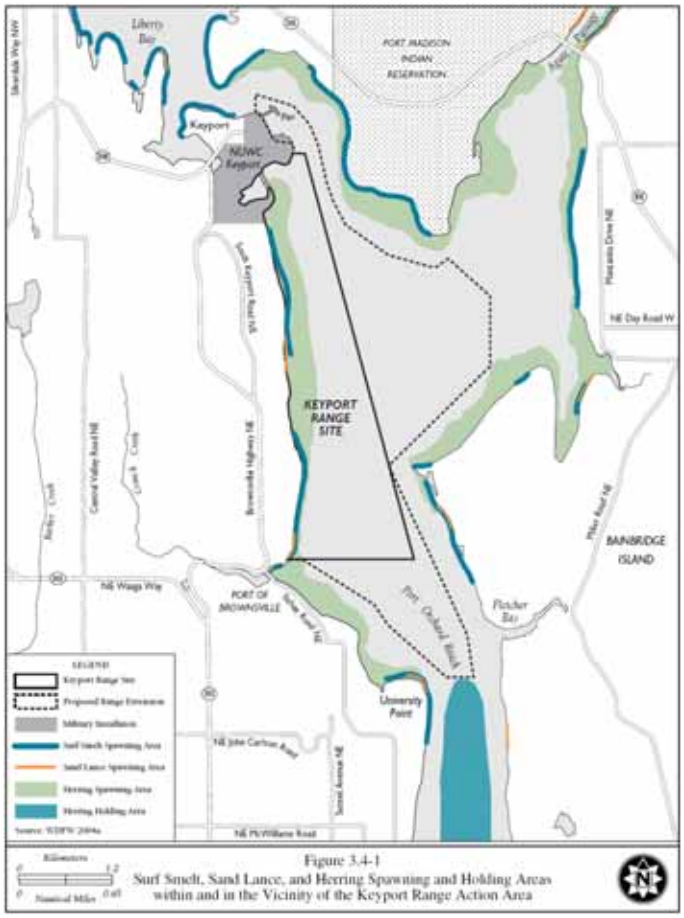

Figure 8. Forage fish locations in the vicinity of KTR (source: U.S. Navy 2008b)

Dabob Bay Range Complex

Dabob Bay Range Complex Action Area

Dabob Bay and Hood Canal are fjord-like bodies of water in the Puget Sound lowland that exhibit the classic U-shaped cross-sectional profile of a glacial trough including relatively steeply sloping walls that become less steep with increasing depth. The canal is the result of periodic glaciation, erosion, and deposition known to have occurred during the Pleistocene epoch, about 2 million to 10,000 years ago (Burns, 1985). Water depth reaches 360 ft (110 m) MLLW. The DBRC is the Navy's principal location within the United States for RDT&E of underwater systems such as torpedoes, countermeasures, targets, and ship systems.

The DBRC subunit Action Area is defined as the northern portion Hood Canal, beginning at the southern boundary of the Hamma Hamma River to the south end of Toandos Peninsula where it branches into Dabob Bay and the North Hood canal with a northern boundary 2 km south of the Highway 104, Hood Canal Floating Bridge. To the east is the Great Peninsula with the Toandos and Olympic peninsulas to the west. The current operating area will be expanded from 112.1 km^2 to approximately 156.7 km^2 of deep-water range in Jefferson County. There are currently three distinct Military Operating Areas (MOA) within the DBRC subunit: the Dabob MOA, Hood Canal MOA north and south, and Connecting Waters. Each of these areas has distinct oceanographic features that offer the Navy particular conditions conducive to RDT&E activities. With the exception of Unmanned Aerial System (UAS) tests, the number of proposed activities and average annual days of use would remain the same as the current levels in the DBRC Site.

The Dabob MOA is a deep-water range in Jefferson County approximately 49.9 km^2 in size with a maximum depth of approximately 183 m. RDT&E in the Dabob MOA are monitored at Zelatched Point an 11-ha area of land owned by the Navy overlooking Dabob Bay with a landing pad to support helicopter activities. Acoustic monitoring instrumentation is installed on the seafloor in an area approximately 13.4 by 2.3 km, allowing for object tracking, communications, passive sensing, and target simulation. The Hood Canal MOA north and south are two deep-water operating areas adjacent to the Kitsap-Bangor Naval Base with a combined area of 42.4 km^2 with an average depth of 61 m. The Hood Canal MOA is used for vessel sensor accuracy tests, and launch and recovery of test systems where tracking is not necessary as occurs in the Dabob MOA. The Connecting Waters MOA of the DBRC subunit connects the Dabob Bay MOA with the Hood Canal MOA north and south and has an operational area of 19.8 km^2. The Connecting Waters are not only used only for transit between MOAs, but are also an area where sensor accuracy tests and launch and recovery of test systems are performed.

The proposed Action extends the southern boundary of this range an additional 19 km increasing the area of operation to 112.1 km^2. Additionally, extension of the northern boundary of 2 km is also included in the DBRC for a total increase of 156.7 km^2 total expansion of the operational area (Figure 9). Primary activities include the proofing of underwater systems, research and development test support, Fleet training and tactical evaluations involving aircraft, submarines, and surface ships, as well as supporting acoustic/magnetic measurement programs. These programs include underwater vehicle/ship noise/magnetic signature recording, radiated sound investigations, and sonar evaluations. In the course of these activities, various combinations of

aircraft, submarines, and surface ships are used as launch platforms. The proposed range extension would allow the opportunity to test systems in areas where freshwater comes from large rivers forming layers, changing the dynamics of underwater sound and buoyancy. The majority of the proposed activity types addressed in the Navy BE are not described in useful terms for the purpose of our analysis for threatened and endangered species, or their critical habitat. Table 6 provides our summary of relevant information for the analyses of activities that may occur in DBRC, based on the project description in BE and EIS, as well as clarification and information received in response to our requests to the Navy through the consultation process. Still, certain assumptions concerning RDT&E activities were necessary.

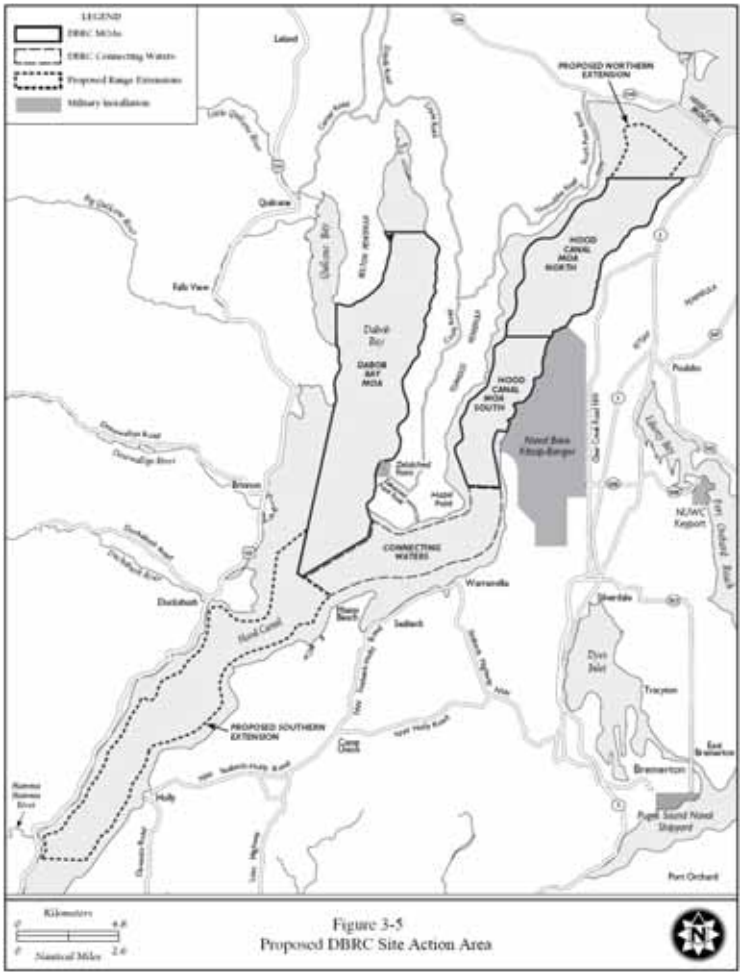

Figure 9. Dabob Bay Range Complex
(source: U.S. Navy 2008b)

Table 6. Specific activities the U.S. Navy plans to conduct at the DBRC – each year for the next five years (Table 2-7 U.S. Navy 2008b).

Range RDT&E activities	*Platform/System Used*	*Activities in DBRC*	*Frequencies (kHz)*	*Maximum Source Level (dB re 1 µPa @ 1 m)*
Active Sonar				
	low frequency	-	-	-
	mid frequency	120*	1 - 25	235
	high frequency		25- 250	235
Countermeasures				
	sonar	50	1-2500	235
	continuous sound		.05-10	170
Other Testing				
	static in-water	10	.8-2500†	238†
	targets	120**	5-100	195-238
	target simulator		.1-10	170
	inert mine detection	20	100-700	235
Vessel Movements				
	aircraft	20	2-20	225
	surface – fleet, surface launch craft, barges	285	.05-10	170
	underwater diver	5	-	-
	submarine	30	5-100‡	195 -238‡
	torpedoes: non-explosive exercise weapons	120	10-100	233
	UUV tracking		10-100	195
	UUV/ special UUV		10-2500	235

* Assuming that all of the activities will occur in a 365 day year and that all of the activities will utilize either or both sonar types
** Assuming that all UUV tests have a target involved
† Frequencies and dB level assumed as the information on countermeasures is classified
‡ Submarines, torpedoes, and surface vessels produce both continuous sound (vessel) and sonar signatures

Environmental Baseline in the Dabob Bay Range Complex

Dabob Bay is an embayment, approximately 62 km long and 2 km wide, located across from Misery Point in Hood Canal, within Puget Sound, Washington. The sill at the entrance to Dabob Bay is at approximately 120 m water depth, with a maximum depth in the bay of 193 m. The deep channel on the western edge of the entrance to Dabob Bay has a maximum depth of approximately 123 m. The substrate is mud, with sand and cobble. Intertidal areas are composed of sand, mud and small gravel. The general area is composed of unconsolidated glacial sediments overlying volcanic bedrock (URS Consultants, Inc. 1994, U.S. Navy 1999).

Assuming that the average advection, or horizontal movement of water, over the tidal cycle in and out of Dabob Bay is minimal (Welschmeyer and Lorenzen 1985), Dabob Bay is effectively a closed system - that is, advection is negligible. The water column in this estuarine fjord system is highly stratified, with low tidal mixing; salty, dense water flows in at depth, and warm, fresh water flows out at the surface (McAlister et al. 1959). The major contribution of freshwater to Dabob Bay comes from the Dosewallips River, which discharges an average 10.7 m^3s^{-1} directly at the sill (Staubitz et al. 1997). Dabob Bay is ecologically important as one of the largest high-quality salt marsh estuaries and sand spit complexes in the Puget Sound.

Intertidal and sub-tidal areas with extensive areas of eelgrass encircle Dabob Bay and provide breeding sites for many fish species and habitat for amphipods, copepods and other aquatic invertebrates. Copepods and other zooplankton represent the major food base for Puget Sound specifically for small and juvenile fish (Mauchline 1998), including Pacific herring, sand lance, surf smelt, and salmonids. These species play an important role in marine trophic systems, serving as a link between primary production and higher trophic levels (Mauchline 1998; Sackmann 2000).

September 2006 marked the discovery of the largest dead zone in the history of Hood Canal. Oxygen levels were lowest in south Hood Canal, with depressed oxygen levels extending into central Hood Canal (Newton et al. 2007). The dead zone is characterized by low oxygen levels due to algal blooms. Algal blooms occur in part due to warm weather, possibly caused by global climate change, and minimal advection causing the build-up of nutrients from fertilizers and leaky septic systems. When the algae die, bacteria feed and their populations explode, robbing the water of oxygen. Because most benthic organisms are relatively immobile, the hypoxic conditions that occur seasonally in Hood Canal, reach levels of DO that do not sustain a healthy biological community. Consequently, survival for species at higher tropic levels is also adversely affected with documented cases of dead shrimp, Dungeness crab, lingcod, flounder, sea-run cutthroat trout, Pacific herring, surf smelt, and sand lance (PSAA 2008, PSAT 2007).

Species Status in the Dabob Bay Range Complex

Bull Trout Status in the Dabob Bay Range Complex

The Action Area is within the Coastal-Puget Sound Interim Recovery Unit (IRU). Bull trout from the Skokomish core area, a watershed that drains into marine waters near the Action Area, are most likely to utilize the DBRC Action Area. Core areas consist of habitat that could supply all the necessary elements for every life stage of bull trout (e.g., spawning, rearing, migration, overwintering, foraging) and are the basic units upon which to gauge recovery within the IRU (USFWS 2004a). Bull trout historically occurred in the DBRC, and based on recent studies and observations in the Duckabush, Quilcene, and other rivers and estuaries over the past 10 years, it is likely that bull trout from the Skokomish core area may be present in the Action Area (Brenkman et al. 2007; Brenkman and Corbett 2005; Goetz et al. 2004; Goetz et al. 2007; Goetz et al. *in litt.* 2007), but their use of the DBRC is limited by degradation of nearshore habitat from natural and human sources (Geotz 2004; PSP 2007; PSAT 2007a; PSWQAT 2002).

A small number of adult and subadult anadromous bull trout from the Skokomish core area use the DBRC for foraging, migration, and overwintering. Considering the overall current low numbers of bull trout and their expected infrequent use of the DBRC, we anticipate the risk of exposure to the effects from RDT&E activities in the DBRC to be low. Should bull trout be exposed to elevated levels of sound, it is unlikely that it would be in the near field of the sound source, where there could be potential direct effects. Indirect effects to bull trout from impacts to prey are not expected to be measurable, because adequate prey is not expected to be limiting in the context of the numbers of bull trout numbers present and their limited use of the of the Action Area. Therefore direct and indirect effects to bull trout from exposure to KRCE activities from RDT&E activities are considered insignificant.

Bull Trout Critical Habitat Status in the Dabob Bay Range Complex

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

The DBRC is an area that encompasses holding and spawning areas. Historically the DBRC supported a moderately large spawning population of Pacific herring (PCE 7-Abundant food base). Abundance trends of pre-spawning concentrations in the Port Gamble holding area indicate a linkage between the Port Gamble herring stock and Quilcene Bay stock (Stick 2005). While adult herring survival rates of 60-70 percent are considered typical for herring worldwide (Lemberg et al. 1997), the average survival rate for the Port Gamble herring stock is approximately 31 percent based on the 2004 Washington State Herring Stock Status Report (Stick 2005). The commercial herring fishery in south and central Puget Sound targets 1.5-year old (juvenile) herring, which are assumed an aggregate of stocks within the region (Stick 2005). The size of annual landings by this fishery is generally determined by market conditions, which are heavily influenced by the length of recreational salmon seasons (Stick 2005). This fishery may contribute to the dwindling stock numbers in Puget Sound.

The draft recovery plan states that maintaining viable populations of the bull trout is essential to the conservation of species within each of the core areas, the interim recovery units, and the coterminous listing (USFWS 2004a). To maintain or restore the likelihood of long-term persistence of self-sustaining, complex, interacting groups of bull trout within the DBRC, the FWS has identified the following needs:

1) maintain the current distribution of bull trout and restore distribution in previously occupied areas;
2) maintain stable or increasing trends in abundance of bull trout;
3) restore and maintain suitable habitat conditions for all bull trout life history stages and strategies; and
4) conserve genetic diversity and provide opportunities for genetic exchange.

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

(1) Water temperatures that support bull trout use.

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

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

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

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

A majority of the Navy's RDT&E activities associated with the KRCE occur in the Action Area for DBRC and proposed extensions. The DBRC and its proposed extensions are located within or directly adjacent to bull trout critical habitat (Figure 10). Because of this close proximity and overlap with bull trout critical habitat, it is expected that the primary constituent elements (PCEs) of the critical habitat will be exposed to the activities described in the proposed action.

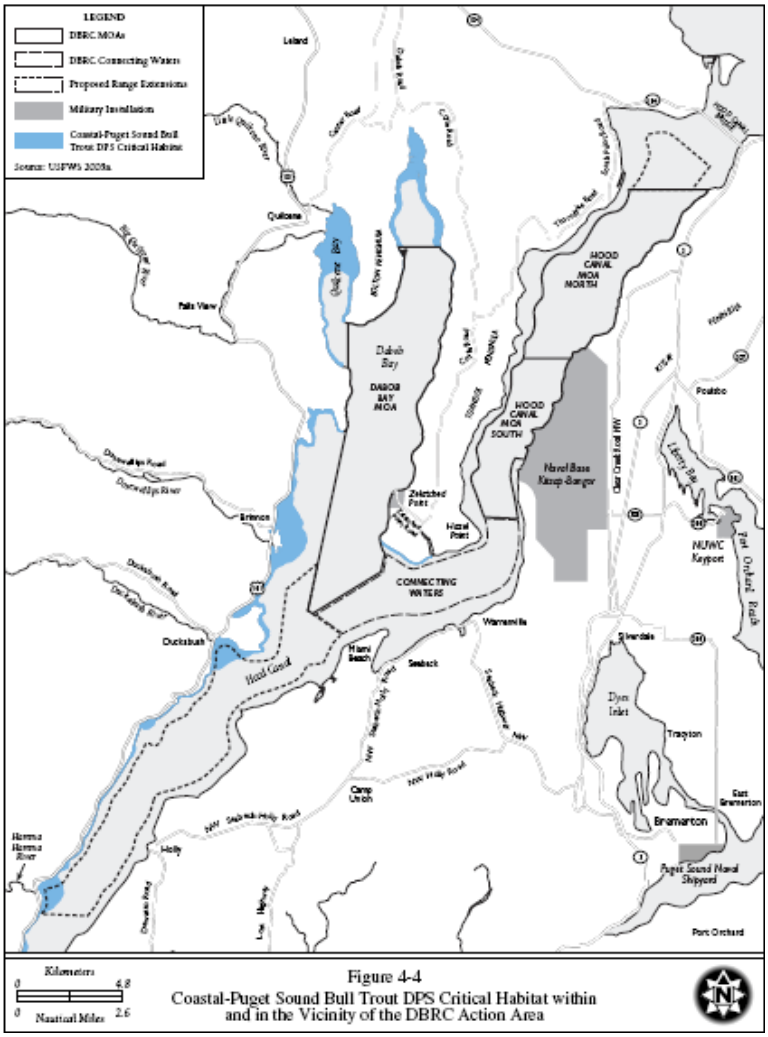

Figure 4-4
Coastal-Puget Sound Bull Trout DPS Critical Habitat within and in the Vicinity of the DBRC Action Area

Figure 10. Bull trout critical habitat within the DBRC (source: U.S. Navy 2008b)

Status of Marbled Murrelet in the Dabob Bay Range Complex

Use of Dabob Bay by murrelets is expected to be typical of use described elsewhere. During the breeding season, murrelets forage in well-defined areas of relatively shallow marine waters in Puget Sound during all times of the day, and in some cases at night (Strachan et al. 1995). During the pre-basic molt, flightless murrelets must select foraging sites that provide adequate prey resources within swimming distance (Carter and Stein 1995). During the non-breeding season, murrelets typically disperse and are found farther from shore (Strachan et al. 1995).

The DBRC is located within Conservation Zone 1 (Zone 1). Murrelet presence in this subunit has been described by the USFS and WDFW, who have conducted marine surveys for murrelets and other seabirds in Washington for many years. While use of the DBRC by murrelets is well documented, surveys targeted to describing murrelet use of the DBRC have not been conducted during specific seasonal and diurnal periods, different life stages, or breeding conditions.

The most comprehensive surveys are conducted under the Northwest Forest Plan Marbled Murrelet Effectiveness Monitoring Program (Murrelet Monitoring Plan), which divides the State of Washington into two Conservation Zones, Zone 1 (Puget Sound) and Zone 2 (Washington's outer Coast). Zone 1 is subdivided into three stratums and each stratum is divided into a PSU. Each PSU is a rectangular area approximately 20 km long composed of inshore and offshore subunits (Raphael et al. 2007).

The USFS, Pacific Northwest Research Laboratory conducts boat surveys to determine population size and trends under the Murrelet Monitoring Plan. PSUs are sampled between May 15 and July 31 (Bentivoglio et al. 2002). For the purpose of this Opinion, density estimates are applied to April and August as these months are also part of the murrelet breeding season and the densities should not vary greatly from the estimates derived during the middle of the breeding season by Raphael et al. 2007. Since 2000, the estimated murrelet density in Conservation Zone 1 has ranged from 1.34 to 2.78 murrelets per km^2, with the estimated population size ranging from a low of 4,699 murrelets in 2008 to a high of 9,700 in 2002. The most recent (2008) estimated population size for Conservation Zone 1 of 4,699 murrelets (3,132 to 6,201 at 95 percent CI) shows an overall annual decline of 2.7 to 4.3 percent per year, which includes the area within the Dabob subunit. Population demographic models have predicted a much larger population decline in the range of 3 to 7 percent for this area (USFWS 1997; McShane et al. 2004).

Estimation of murrelet density in the Dabob Bay Range Complex

A variety of sources provide murrelet density estimates for the DBRC and throughout Puget Sound. The density estimates calculated for a larger area such as a stratum or Conservation Zone are more precise and less variable than using a density observed at a specific KRCE. However, the estimated densities in each PSU vary greatly within each Zone, which is obscured at the larger scale. The level and type of RDT&E activities activities in each of the KRCE also varies greatly thus, we chose to base our expected densities for each subunit on the estimated density at the stratum level.

The WDFW, in cooperation with the PSAMP is the only consistent source for winter density information. While these surveys are not specifically designed to monitor murrelets, and likely underestimate murrelet presence, they provide useful information on the seasonal distribution of murrelets. Winter surveys were conducted in December and January from 1993 to 2006, and these density estimates can be used to infer numbers likely to occur in November and February. An "equal density change between study estimates" can be used to interpolate density estimates for March, September, and October as well. Based on the information described here, this interpolation builds on the at-sea survey data and indicates that murrelets will be in the Dabob subunit year-round in significant numbers, and numbers vary seasonally and from year to year.

Surveys conducted within the DBRC evaluated associations between marine distribution and use of suitable nesting habitat (Raphael et al. 1999). Merizon et al. (1997) focused on marbled murrelet numbers and distributions in areas where fall tribal fisheries take place. The PSAMP undertaken by the WDFW estimated murrelet densities as a by-product of their summer (1992-1999) and winter (1993-2004) aerial sampling of seabird populations. The DBRC occurs in

stratum 2 in Zone 1. The density estimate for this stratum varied from 0.90 to 2.43 murrelets per km^2 between 2000 and 2008 (Table 7).

Table 7. Marbled murrelet observations in Conservation Zone 1, Stratums 1-3, based on Effectiveness Monitoring for the Northwest Forest Plan (summer at-sea boat surveys).

Year	Stratum	Density (birds/km^2)	Source
2000	2	1.11	Huff et al. 2002
2001	2	1.76	
2002	2	1.86	
2003	2	1.44	Lance 2004
2004	2	1.52	Falxa 2009
2005	2	2.43	
2006	2	1.42	
2007	2	1.22	
2008	2	0.90	

Stein and Nysewander (1999) observed murrelet densities between 0.0 and 23.7 per km^2, the highest densities occurring in 1993 to the south (23.7) and east (17.8) of Toandos Peninsula. Conversely, 1994 and 1995 surveys exhibited consistently lower densities. USFS surveys conducted during the summers of 1999 to 2003 in the DBRC encountered a range of 2 to 163 murrelets or 0.03 - 2.47 murrelets per km, the highest numbers encountered in July of each year (Raphael and Bloxton unpub. data 2004). PSAMP summer aerial surveys between 1992 and 1999 estimated densities of 0 - 5 murrelets per km^2. The DBRC overlaps with PSU 34 of stratum 2, Zone 1, where density estimates ranged from 0.0 to 3.87 murrelets per km^2 between 2000 and 2007, with an average of 1.00 murrelets per km^2 (Falxa 2009). Fall surveys in the DBRC during 1996 by Merizon et al. (1997) consistently detected 0.75 to 3.55 murrelets per km, a higher number of murrelets than other locations they surveyed in Washington. In the DBRC, murrelets tend to form loose aggregations, but there is little predictability in the distribution of these aggregations (Merizon et al. 1997); where the PSAMP winter aerial surveys between 1993 and 2004 estimate densities between 0 and 5 murrelets per km^2.

In summary, most areas of the DBRC provide suitable foraging habitat and murrelets move throughout the area depending on local conditions. Based upon the Northwest Forest Plan Effectiveness Monitoring, it appears that murrelets occur here year-round with densities of 1 to 5 per km^2, while the number of murrelets may vary within and between years.

Conservation Needs of the Marbled Murrelet in the Action Area

The Marbled Murrelet Recovery Plan (U.S. Fish and Wildlife Service 1997) outlines the conservation strategy for the murrelet. Of the primary recovery plan recommendations, the following are most pertinent to the needs of murrelets within the Action Area:

1) Protect the quality of the marine environment essential for murrelet recovery.
2) Reduce adult and juvenile mortality in the marine environment.

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

The majority of the known murrelet nesting occurs on the Olympic Peninsula, with a large percentage on or near the Hood Canal/Dabob Bay area. The high percentage of nesting that takes place in the area can be attributed to the occurrence of stands of contiguous old-growth forest, and foraging opportunities available in Hood Canal, with over 13 percent of the total Washington murrelet population foraging there during the summer months (Shelley pers. comm. 2009).

Many fish populations have been depleted in the DBRC due to overfishing, reduction in the amount or quality of spawning habitat, pollution, and other anthropogenic stressors. Shipping, bulkheads, and other shoreline developments have contributed to the reduction in eelgrass beds and other spawning and rearing areas for forage fish species. Spawning habitat for sand lance, surf smelt and pre-spawning holding for herring are within and immediately adjacent to the Action Area. These declines in forage fish stocks may be affecting the forage base for murrelets in the Action Area.

The DBRC is an area that historically supported a moderately large spawning population of Pacific herring, with pre-spawning holding areas where murrelets could feed. Abundance trends of pre-spawning concentrations in the Port Gamble holding area indicate a linkage between the Port Gamble herring stock and Quilcene Bay stock. Adult herring survival rates of 60 to 70 percent are considered typical for herring worldwide (Lemberg et al. 1997). Conversely, the average survival rate for the Port Gamble herring stock is approximately 31 percent based on the 2004 Washington State Herring Stock Status Report (Stick 2005). The commercial herring fishery in south and central Puget Sound targets 1.5-year old (juvenile) herring assumed to be an aggregate of stocks within the region (Stick 2005). The size of annual landings by this fishery is generally determined by market conditions, which are heavily influenced by the length of recreational salmon seasons (Stick 2005). This fishery may contribute to the dwindling stock numbers in Puget Sound.

Forage fish

Pacific Herring

As of 2004, only 50 percent of the Puget Sound herring stocks were classified as healthy or moderately healthy (WDFW 2005). There are two stocks in the DBRC: Port Gamble and Quilcene Bay. A portion of the pre-spawn holding area for these two herring stocks is located within the proposed northern extension of the Action Area. The Quilcene Bay herring stock is currently one of the largest in Puget Sound. Abundance has been fairly stable since a low point in the 1990s, with a mean spawning biomass of over 2,000 tons in through 2004 (Stick 2005). Much of the stock's spawn deposition in recent years has occurred at the south end of the Bolton Peninsula, along with significant deposition from Jackson Cove to Point Whitney.

Additionally, the Port Gamble herring stock partially occurs in the DBRC northern extension. It is one of the larger stocks in Puget Sound, with growth rates, spawning timing, and other stock characteristics considered "typical" for a Puget Sound stock. The previous 25-year mean spawning biomass was over 2000 tons for the Port Gamble herring stock, but it is now is considered depressed with a declining population trend and an spawning biomass estimate of less than 1000 tons. The Quilcene Bay stock and the Port Gamble stocks may be linked to some degree (Stick 2005).

The estimated average Quilcene Bay herring stock biomass for 2001 through 2008 is approximately in 1971 metric tons, with no estimation of age or size composition of the herring stock biomass (Stick, pers. comm. 2009b, Figure 11). The estimated average Port Gamble herring stock biomass from 2001 through 2008 is approximately 1024 metric tons, with no estimation of age or size composition of the herring stock biomass for 2008 (Stick, pers. comm. 2009b). In 2008, the total spawner biomass was reported at 208 metric tons, which is a precipitous reduction from 2005.

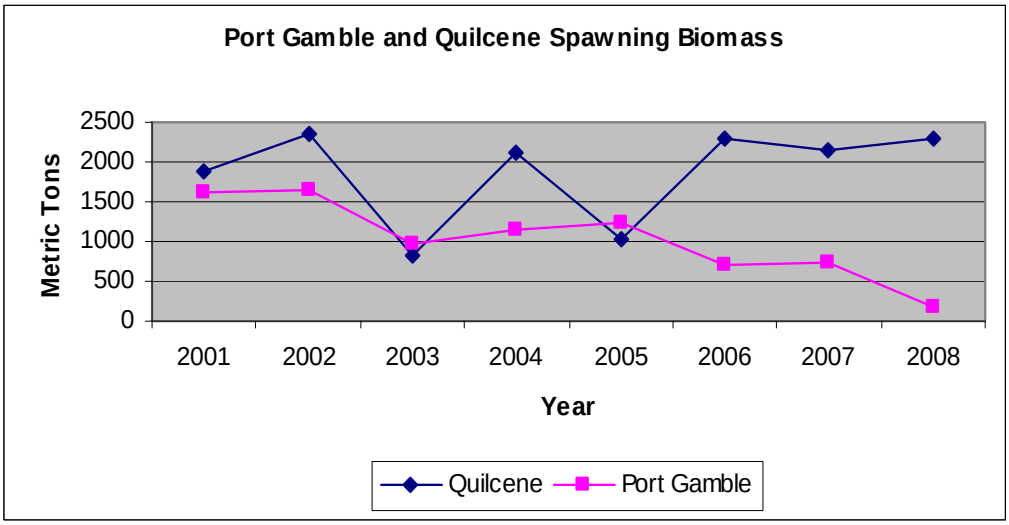

Figure 11. Herring spawning biomass trend for 2001 – 2008
Created by USFWS from data provided by K. Stick (Stick, pers. comm. 2009b)

Spawning activity has been documented along large sections of the DBRC shorelines (Stick 2005, Figure 12). Spawning occurs between early January and mid-April. Some months before the onset of spawning activity, fish begin to assemble adjacent to spawning sites in pre-spawning holding areas (Penttila 2007); thus adult herring may stage in and/or migrate through the Action Area. Eggs incubate for 10-14 days before hatching. Following hatching the larvae drift in ocean currents (Bargmann 1998). Larval, juvenile, and adult herring maybe present in the Action Area.

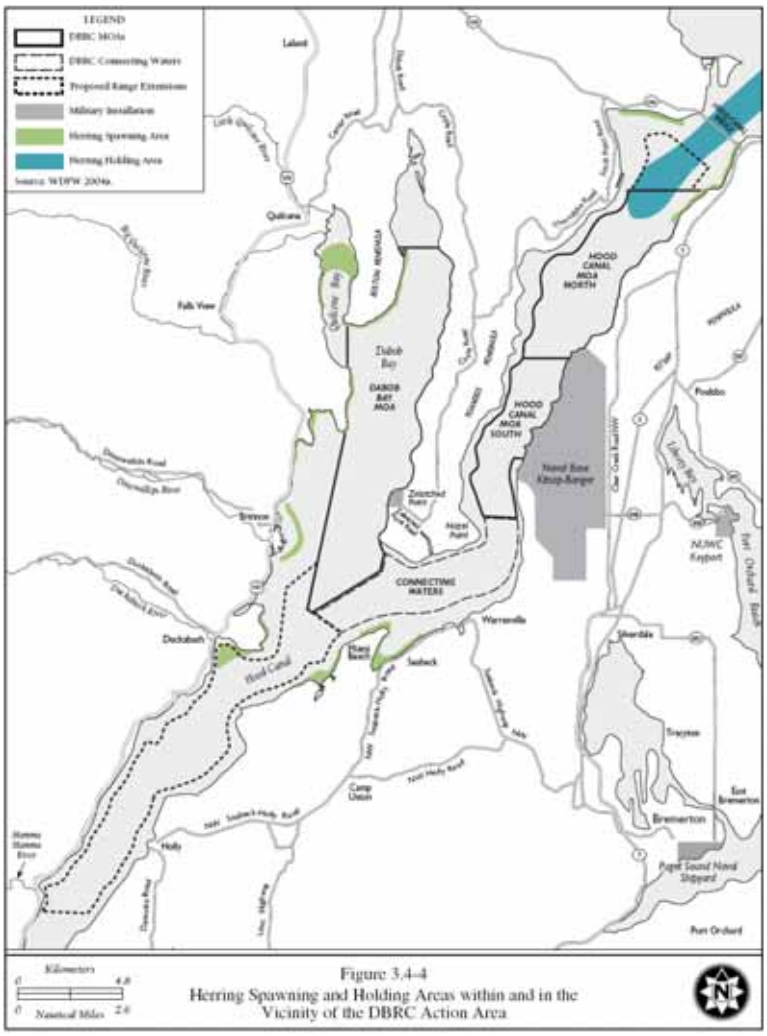

Figure 12. Herring Spawning and Holding areas within the DBRC (source: U.S. Navy 2008b)

Surf Smelt

Sampling has revealed that surf smelt spawn on the west side of Quilcene Bay and confirmed that surf smelt utilize most of the east shore (Long et al. 2005). A majority of shoreline associated with the DBRC Action Area is used heavily by surf smelt for spawning, with additional suitable spawning habitat identified throughout the Action Area and within the zone of effect of the RDT&E activities associated with the DBRC subunit (Figure 13). Surf smelt are believed to spawn year-round in the DBRC with peak spawning starting September 1 through March 31, with the heaviest spawn occurring in mid October through December.

We would expect more fish to congregate in the Action Area during the peak spawning time, with adult, juvenile, and larval surf smelt likely present in the DBRC year round.

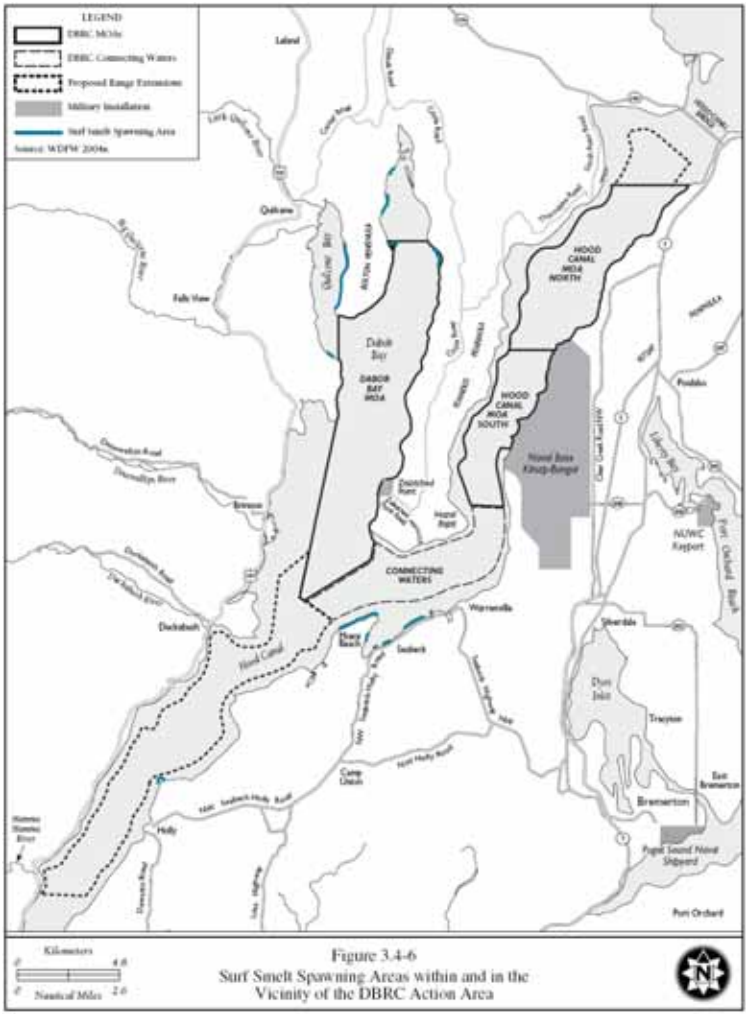

Figure 13. Surf smelt spawning areas within the DBRC
(source: U.S. Navy 2008b)

Pacific Sand Lance

Sand lance is a critical link in marine food webs in the Puget Sound Basin. Spawning habitat has been identified within the Action Area along most of the upper intertidal sand-gravel beaches in the DBRC (Penttila, 1999; Figure 14). Excellent documented spawning substrate and nearly pristine backshore (Long et al. 2005) in the vicinity justifies conservation efforts to preserve spawning habitat. Adult, juvenile, and larval sand lance are expected to be present in the Action Area throughout the year.

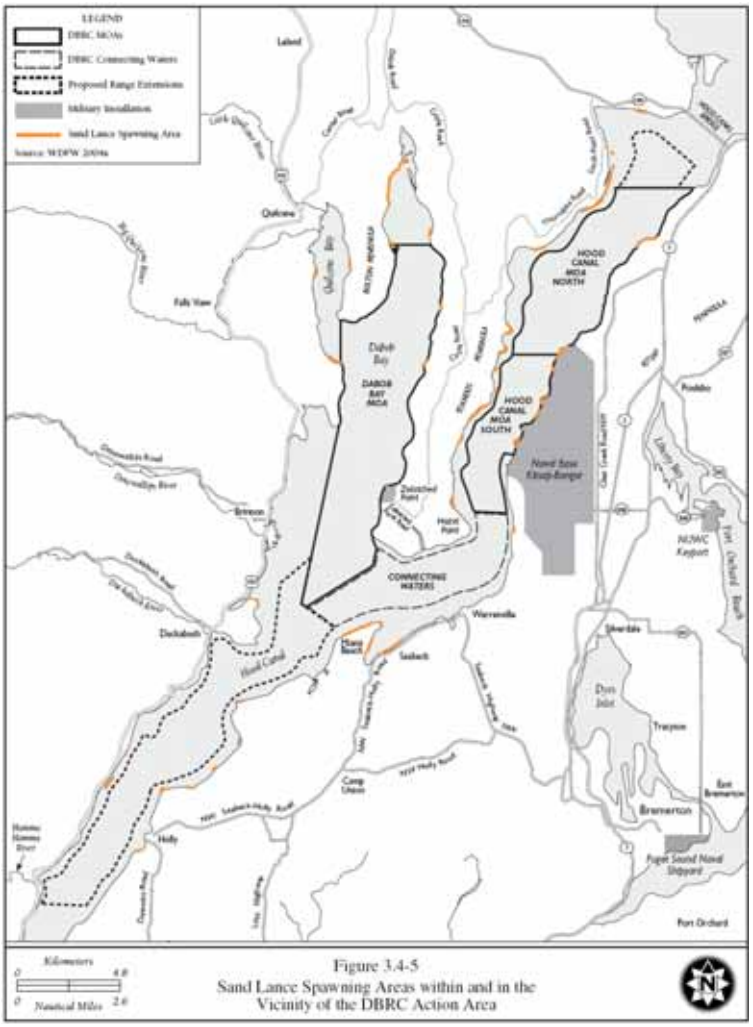

Figure 14. Pacific sand lance spawning areas within the DBRC (source: U.S. Navy 2008b)

<u>Quinault Underwater Tracking Range</u>

Quinault Underwater Tracking Range Action Area

The proposed QUTR extension offers multiple types of underwater substrate with mud, rocks, and canyons as deep as 1,829 m and surface areas in the intertidal surf zone enabling shallower and deeper runs and variations in substrate types and acoustic characteristics, as well combined RDT&E and training activities. The shore has only been used minimally in the past to maintain cabling for permanently installed bottom sensors for the tracking site. Surf-zone activities would be conducted from an area on the shoreline and seaward.

RDT&E and training activities typically involve a wide variety of platforms; submarines, surface ships, and aircraft can be involved in undersea warfare exercises. The type of activities within the extended QUTR would include vehicle propulsion tests (thermal, chemical, electrical), inert mine detection, submarine testing, aerial overflights (fixed wing (propeller and jet), rotary,

gliders, unmanned drones) countermeasure tests, impact testing (high velocity objects striking each other or a stationary target), active and passive target systems and transponders (producing vessel and high-intensity underwater continuous and impulsive wave sound), anti-surface ship warfare, acoustic and non-acoustic sensors (conductivity, temperature, magnetic, laser), mine warfare, deployment of sonobuoys, static in-water tests (the types of systems tested is not disclosed), tracking/testing of UUV (floating, swimming, crawling – carrying acoustic emitters) and, navigational and search capabilities in deep water (Table 8). All vehicles assessed will be recovered as part of the testing procedures, but many expended materials such as sonobuoys, guidance wire and parachutes are not retrieved.

Realistic Fleet activities do occur within the QUTR to provide sailors the opportunity to train with actual naval assets in a controlled range environment. Explosive warheads are not placed on test units or tested within the KTR or DBRC. The average annual uses for offshore activities related only to Keyport testing, research and development is currently 14 days per year and are to increase to 16 days. Activities in the intertidal surf zone will increase from 0 days to an average of 30 days per year. Testing activities typically occur during daylight hours on weekdays; however, there are periodic tests that may occur overnight or over multiple days (e.g., a 72-hour endurance run).

The majority of the proposed activity types addressed in the Navy BE are not described in useful terms for the purpose of our analysis. Table 8 provides our summary of relevant information for the analyses of activities that may occur in QUTR, based on the project description in BE and EIS, as well as clarification and information received in response to our requests to the Navy through the consultation process.

Table 8. Specific activities the U.S. Navy plans to conduct at the QUTR – each year for the next five years (Table 2-8 U.S. Navy 2008b).

Range RDT&E activities	*Platform/System Used*	*Activities in QUTR*	*Frequencies (kHz)*	*Maximum Source Level (dB re 1 µPa @ 1 m)*
Active Sonar				
	low frequency	-	-	-
	mid frequency	20*	1 - 25	235
	high frequency		25- 250	235
Countermeasures				
	sonar	5	100-700	235
	continuous sound		.05-10	170
Other Testing				
	static in-water	5	.8-2500†	238†
	targets	20**	5-100	195-238
	target simulator		.1-10	170
Vessel Movements				
	aircraft	10	2-20	225
	surface – fleet, surface launch craft, barges	70	.05-10‡	170-235‡
	submarine	30	5-100‡	195 -238‡
	underwater diver	15	-	-
	Torpedoes: non-explosive exercise weapons	20	10-100	233
	UUV tracking		10-100	195
	UUV/ special UUV		10-2500	235

* Assuming that *all* of the activities will occur in a 365 day year and that all of the activities will utilize either or both sonar types
** Assuming that all UUV tests have a target involved
† Frequencies and dB level assumed as the information on countermeasures is classified
‡ Submarines, torpedoes, and surface vessels produce both continuous sound (vessel) and sonar signatures

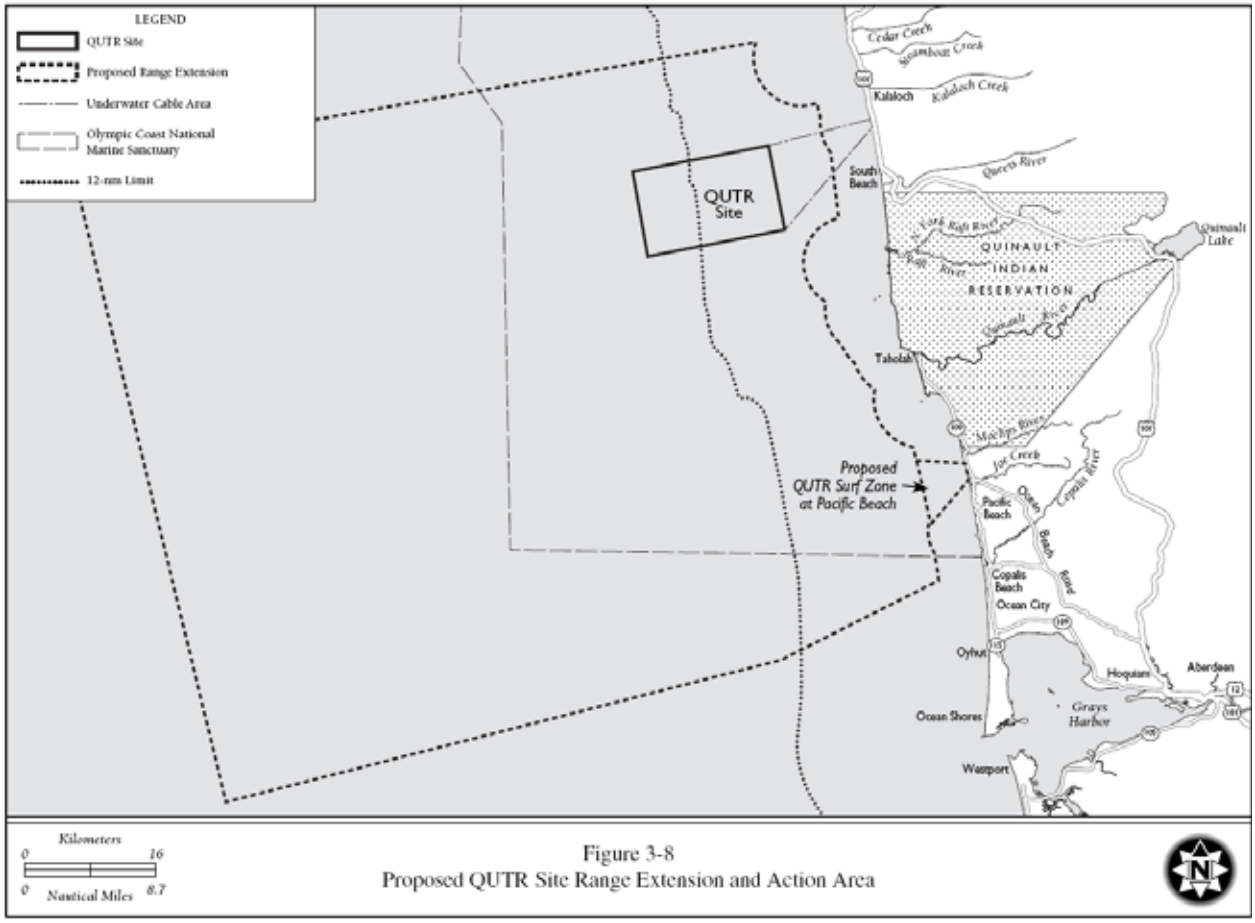

Figure 15. Quinault Underwater Tracking Range
(source: U.S. Navy 2008b)

Environmental Baseline in the Quinault Underwater Tracking Range

The existing QUTR subunit is a rectangular-shaped test area of 165.5 km^2 located approximately 12 km off the Pacific Coast at Kalaloch, Washington, with a portion of the Range within the boundaries of the Sanctuary. Water depths in the current QUTR, do not exceed 122 m. The Action would extend the range boundaries to coincide with the overlying special use airspace of W-237A of the Northwest Training Range Complex (NWTRC) operated by the U.S. Pacific Fleet. The expansion includes an additional 26.6 km^2 triangular area, which acts as a corridor between the offshore area and a 1-km wide area of intertidal surf zone at Pacific Beach. The total area of the QUTR extension is 6,312.4 km^2 of area, an increase from the 165.5 km^2 of the current range off Washington's coast (Figure 15).

The QUTR is a permanently instrumented tracking site with bottom sensors mounted on the hard sand bottom sea floor in relatively shallow water of 46-91 m. The Navy configures and maintains the sensors for tracking surface vessels, submarines, and various undersea vehicles via cables that connect the QUTR sensors to the shore under the beach at Kalaloch and end at a Navy communications trailer. In the intertidal surf zone the testing of UUV shallow water

bathymetry sensing, sub-bottom profiling, and surveillance would be the typical activities. The proposed range extension would not result in additional permanent bottom-deployed instrumentation.

Species Status in the Quinault Underwater Tracking Range

Bull Trout Status in Quinault Underwater Tracking Range

Coastal/Puget Sound Bull Trout Interim Recovery Unit (IRU) is relevant to the coastal Washington waters, with critical habitat designated in 2005 between the Quillayute River basin and Gray's Harbor. Three core areas of bull trout have been identified within the vicinity of the QUTR - Hoh River, Queets River, Quinault River (WDFW 2004c) - with all of these stocks embodying the anadromous life history (Figure 16). Anadromous individuals from this IRU inhabit, forage, and migrate throughout the QUTR in productive estuarine and nearshore habitat.

The Hoh core area is comprised of the Hoh River (above the confluence with the South Fork Hoh River) and the South Fork Hoh River local populations. Snorkel surveys and more recently radio telemetry studies have been performed demonstrating that bull trout undergo complex movements within and out of the system into marine waters (Brenkman and Corbett, *in litt*. 2003), with the majority of adult bull trout migrating seasonally from freshwater to saltwater and back to freshwater. The upper reaches of the Queets River system contain one local spawning population of bull trout. Migration into saltwater by bull trout from the Queets core area has been verified using mineral ratios in otoliths from fish that had also been genetically identified as bull trout (Leary and Allendorf 1997; Volk 2000). The Quinault core area is comprised of two local populations. Although bull trout spawning sites have not been located in the Quinault Core Area, the presence of multiple age classes of bull trout indicates spawning and rearing does occur (S. Brenkman, pers. comm. 2004). There is insufficient information to determine the status of bull trout in the Quinault core area.

The QUTR expansion includes an additional 26.6 km^2 triangular area, which acts as a corridor between the offshore area and a 1-km wide area of intertidal surf zone at Pacific Beach. This corridor allows for the deployment and landing of special UUV associated with KRCE RDT&E activities. A small portion of designated bull trout critical habitat is present within this segment of the QUTR extension. Activities in QUTR Site include, but are not limited to, shallow water bathymetry sensing, sub-bottom profiling, UUV surveillance, or UAS testing. UUV testing could include a bottom-crawling robotic vehicle in the surf-zone area in water depths from 0 to 31 m (photic zone) carrying a payload of several acoustic emitters, including communication and navigation equipment, as well as active sonars operating at frequencies of 10-2,500 kHz with source levels of 195-233 dB_{SPL} re 1 μPa @ 1 m. Baseline environmental conditions and habitat function in the coastal region are degraded from their historical state by from natural and human sources (Collie et al. 1997; ONMS 2008; NEETF 1999; Turgeon 2002; NRC 1995; USCOP 2004).

Considering the 1) type of activities; 2) source levels associated with the activities; and 3) location of the described activities in relation to when low abundances of bull trout are likely to be present in the QUTR, we anticipate exposure to bull trout from KRCE, RDT&E activities in the QUTR is extremely unlikely, and potential effects are therefore discountable.

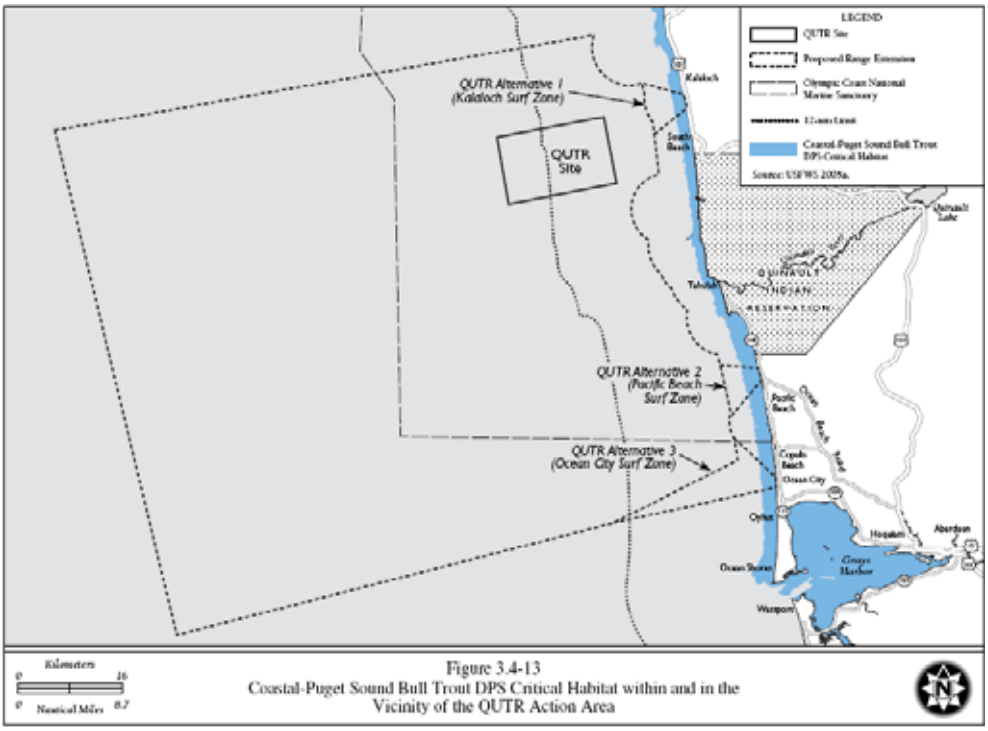

Figure 16. Bull trout occurrence within the QUTR (source: U.S. Navy 2008b).

Bull Trout Critical Habitat in the Quinault Underwater Tracking Range

Potential effects would be limited to the nearshore areas of the QUTR. However, there would be insignificant effects to critical habitat throughout QUTR due to the lack of testing in those areas and/or the distance from designated critical habitat at which RDT&E activities would occur.

Marbled Murrelet Status in Quinault Underwater Tracking Range subunit

The proposed project is located within Conservation Zone 2 (Western Washington Coast Range; Figure 17). The recovery plan has identified all waters of the Washington coast as essential for murrelet foraging and loafing. Conservation Zone 2 extends 1.2 miles off the Pacific Ocean shoreline from the U.S.-Canadian border near Cape Flattery extending to the southern border of Washington (the Columbia River) and 50 miles inland from the Pacific Ocean shoreline. Most of the forest lands in the northwestern portion of Zone 2 occur on public lands, while most forest lands in the southwestern portion are privately owned. Extensive reductions of nesting habitat have occurred throughout Conservation Zone 2 in the last century, with the southwest portion, dominated by private lands, incurring the greatest loss (USFWS 1997b). Thus, terrestrial murrelet conservation is largely dependent upon public lands in northern portion of Zone 2 and

non-Federal lands in the southern portion. In the marine environment the majority of the nearshore foraging areas occupied by murrelets are within the Sanctuary boundaries. The more than 600 islands, rocks, and reef habitat, provide essential foraging, breeding, loafing, and molting areas for murrelets.

Marbled Murrelet Presence in the Action Area

The WDFW conducts boat surveys during the breeding season to determine population size and trends under the Murrelet Effectiveness Monitoring Program using a uniform survey protocol (Huff 2006; Miller et al. 2006; Raphael et al. 2007b). The QUTR subunit occurs in Conservation Zone 2 (Western Washington Coast Range) (Figure 17). Zone 2 is divided into "Primary Sampling Units" or PSUs. Each PSU is a rectangular area approximately 20 km long composed of inshore and offshore subunits. PSUs are sampled between May 15 and July 31 (Bentivoglio et al. 2002). Conservation Zone 2 has the lowest average density of the coastal Zones; most birds in this Zone 2 are located in waters off the Olympic Peninsula.

For 2008, the estimated population of murrelets in all five Conservation Zones was 17,800 (± 3,200 at 95 percent confidence interval; Falxa et al. 2009). The 2007 and 2008 estimates represent the smallest population estimates since monitoring began with results indicating a steep population decline since 2000 of approximately 2-to-4 percent per year (Miller et al. 2006; pg. 57) with McShane et al. (2004, p. 3-58) estimating a 4-to-7 percent decline. The most recent (2008) estimated population size for Conservation Zone 2 is 1,944 murrelets (1,187 - 2,843) (95 percent CI) and a density of 1.18 birds/km^2 (Falxa et al. 2009).

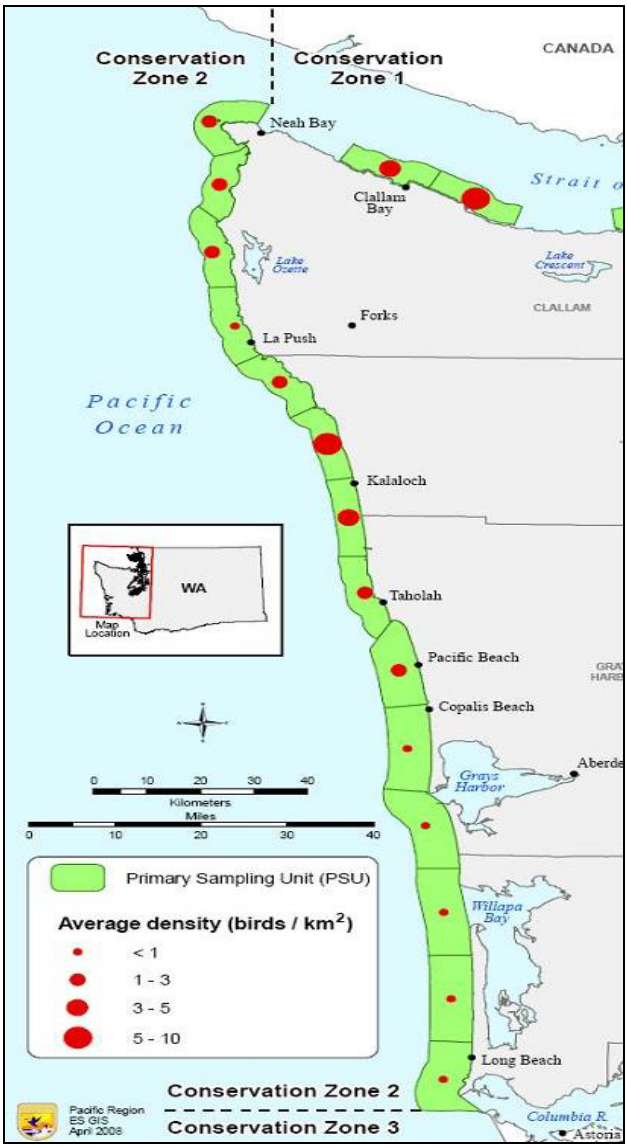

Figure 17. From Effectiveness Monitoring for the Northwest Forest Plan (from Falxa et al. 2008).

Forage fish

The status of forage fish is described here due to their importance to murrelets and bull trout and their proximity in the Action Area. Many fish populations have been depleted in the marine Pacific nearshore waters due to overfishing, reduction in the amount or quality of spawning and rearing habitat, pollution, shoreline development, and other anthropogenic stressors. Declines in forage fish stocks could affect the forage base for murrelets in the Action Area.

Pacific Herring

Because of the overwhelming importance of herring as prey for seabirds and salmonids, particularly the juvenile stage, any changes in the distribution and abundance of juvenile herring

when they weigh less than 20 g (Vermeer & Butler 1989) is of great concern. In fact, distributions of some seabirds have been shown to change in response to changes in herring spawning distribution (Sullivan *et al.* 2002).

From the middle of the 1980's the Pacific coastal herring spawner abundance increased to historical high levels in 2003, followed by a considerable decline over the last half decade (Stick 2005 and pers. comm. 2009b), possibly in response to climate change, pollution, or other environmental causes, with conservation implications to seabird populations. Regardless of the mechanisms causing the declines in herring stocks throughout Zone 1 and 2, these changes could have significant implications to the continued survival of the marbled murrelet.

Much less is known about coastal herring populations than Puget Sound populations. However, spawning populations have been documented in the coastal embayments of Willapa Bay and Grays Harbor, with the first documentation of spawning activity for Grays Harbor in 1998 in intertidal and shallow subtidal areas. Spawning occurs mainly in February and March, although the range of spawning times extends from February to May (Therriault et al. 2009). Herring stock assessment by WDFW has traditionally been focused on presumed larger Puget Sound stocks and limited assessment of coastal herring stocks currently takes place (Stick 2005). Herring populations spawned in coastal locations are likely components of large late spring and summer herring aggregations that feed in shelf waters in coastal offshore areas, including the western end of the Strait of Juan de Fuca and the west coast of Vancouver Island. Additionally, overwintering concentrations make diurnal migrations, from deepwater strata in daylight hours (>50 m) to surface waters during nighttime hours. The limited information available for the coastal herring populations indicates that they are currently at a relatively high level of abundance. However, sampling effort for these areas has been sporadic. Available spawning biomass estimates for both stocks are 400 tons or less (Stick 2005).

The estimated average Grays Harbor Herring Stock biomass from 1998 through 2003 is approximately 139 metric tons, with no estimation of age or size composition of the herring stock biomass for 2003 (Stick, 2005). The projected total spawner biomass for five years is 132 metric tons in 2008 (Figure 18).

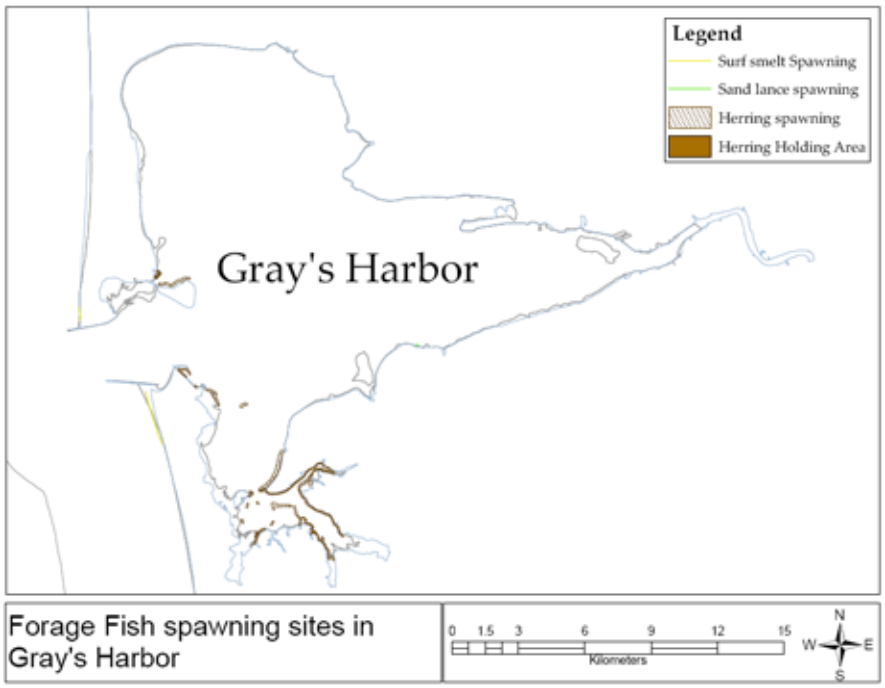

Figure 18. Map by USFWS November 2009

Little is known about the Willapa Bay stock's life history, although it is likely that these fish spend significant time in ocean waters. The spawning biomass for the Willapa Bay herring stock appears to be relatively high at an estimated 298 metric tons for the years between 1998 and 2003. The projected total spawner biomass for five years is 256 metric tons in 2008 (Figure 19).

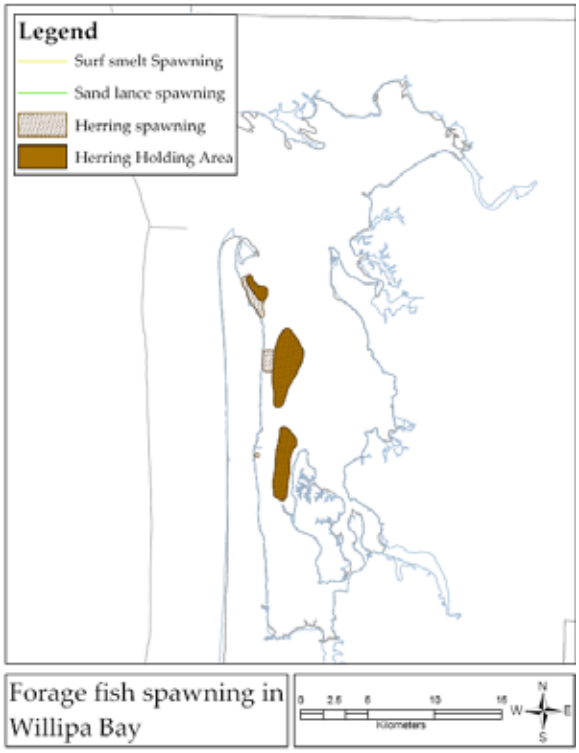

Figure 19. Map by USFWS November 2009

Surf Smelt

Surf smelt is one of seven representatives of the Family Osmeridae in the Pacific Northwest, which is a pelagic schooling species distributed from California to Alaska that occurs on the outer coast of the Olympic Peninsula, Washington. Surf smelt have specific spawning habitat requirements, with 80 percent of surf smelt spawn found on pocket beaches with gravel substrates ranging in size form 1 to 7 mm in diameter (Middaugh et al. 1987 and Thompson et al. 1936). Coastal spawning surf smelt only do so in the summer and utilize a lower tidal of 2.8 to 3.0 m in elevation corresponding to a zone with a these fairly fine gravel substrates (Middaugh et al. 1987 and Thompson et al. 1936). Surf smelt spawning beaches on the coast tend to be associated with the mouth of large river systems and the stock(s) may home to these beaches for spawning (Penttila 2001 and Hay et al. 2001; Figure 20). These fish provide piscivorous seabirds, including murrelets, additional feeding opportunities when herring are not available, particularly in Puget Sound (Quinn 1999). There is evidence that surf smelt populations are declining but it is mostly anecdotal, making it difficult to forecast future stock trends at this time.

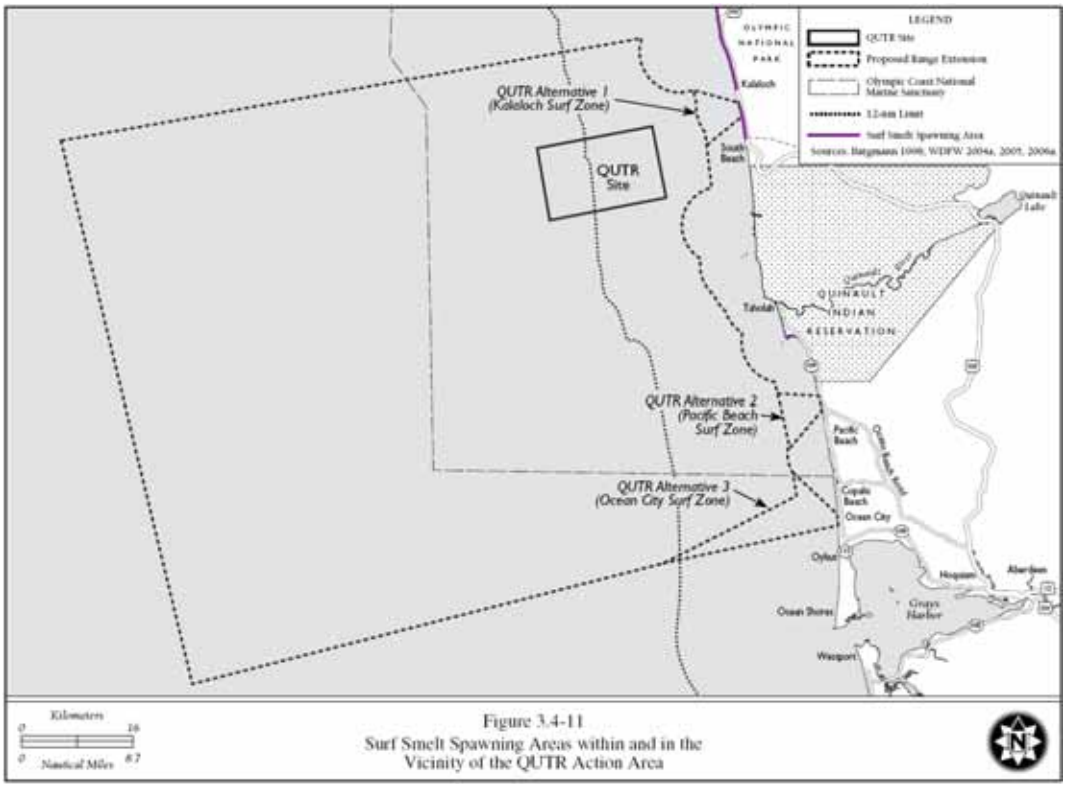

Figure 20. Surf smelt spawning occurrences within the QUTR (source: U.S. Navy 2008b)

Pacific Sand Lance

Sand lance are found from the intertidal zone to a depth in the order of 200 m; feed in the upper water column during the day and bury in the sand substrate during the night (Hobson 1986). Sand lance populations appear to be obligatory upper intertidal spawners, depositing their eggs in

sand-gravel substrates between the mean high-tide line and about 5 ft (2 m) in tidal elevation (WDFW 1997).

Sand lance are an important part of the trophic link between zooplankton and larger predators in the local marine ecosystem, and is likely a key forage species in the Pacific nearshore, but quantitative data on their temporal patterns of abundance or distribution are lacking. Quinn (1999) describes the winter intertidal and shallow subtidal habitats used by sand lance in which densities may reach a maximum of five fish per square meter. The accessibility of benthic sand lance in the winter months may be especially important for murrelets, because other forage species appear to move to deeper water in winter months and become less accessible to seabirds.

Northern Anchovy

Northern anchovy are small, short-lived schooling species of fish that primarily inhabit the photic zone near the surface from British Columbia to Baja California. Northern anchovy are an important part of the food web for fish, seabirds, including marbled murrelet, and marine mammals (PFMC 2008).

Observed numbers of northern anchovy in marine waters of Washington vary, with most occurring along the coast and well offshore, while at times they are common in Puget Sound. During the summer months, anchovies may be found in Grays Harbor, Willapa Bay, or the Columbia River mouth. Observed numbers vary from year to year, with this variation theorized to be caused by changes in behavior and not changes in abundance (WDFW 1997; Bargmann 1998).

Little is known about the life history of the anchovy in Washington, if they spawn in Washington waters, or are merely transient visitors. Pelagic eggs have not been found in numbers suggesting spawning, but larval anchovies have been observed in the Strait of Juan de Fuca. Anchovies are thought to move inshore in the spring and summer and offshore in the fall and winter, and are particularly susceptible to changes in water temperature. A single female may spawn several times each year with an annual fecundity of about 25,000 eggs with a small percentage of the larvae reaching maturity at the end of the first year (WDFW 1997; Bargmann 1998).

EFFECTS OF THE PROPOSED ACTION

Effects to Bull Trout Critical Habitat

The regulations implementing the ESA define "effects of the action" as "the direct and indirect effects of an action on the species or critical habitat together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline" (50 CFR 402.02). This section addresses the direct and indirect effects of the proposed action and its interrelated and interdependent activities on designated bull trout critical habitat.

First, we identified aspects of the proposed action that are likely to generate stressors that result in direct and indirect effects to the PCEs within the Action Area. Stressors are considered to be any physical, chemical, or biological effect on the environment resulting directly or indirectly

from the proposed action (USFWS 2004c). The subsequent analysis will identify and characterize stressors associated with the proposed action.

The next step is to describe the nature of the exposure and how the PCEs are likely to respond to those stressors. The response analysis requires a thorough examination of the available scientific and commercial data and an analysis of the consequences to individual PCEs exposed to stressors. Prior to arriving at our conclusion, the final steps involve evaluating the ability of the CHU to continue to function in providing for the conservation and recovery of the listed species. The analysis concludes with an assessment of the consequences of action at the listed entity scale. In this case, the scale of the coterminous listed range of designated bull trout critical habitat.

Insignificant Effects

There is no designated bull trout critical habitat within or in proximity to the KTR subunit or within the interconnecting waters between the KTR, QUTR, or DBRC. Therefore, there will be no effect to bull trout critical habitat within these areas. Within the QUTR, the nearshore waters designated as bull trout critical habitat are generally outside of the area where testing activities occur. Due to the lack of testing in the nearshore waters designated as bull trout critical habitat and/or the distance from designated critical habitat at which RDT&E activities would occur, effects to PCEs within the QUTR subunit are expected to be discountable or insignificant.

Within the designated critical habitat areas of the DBRC subunit, the PCEs for bull trout are those habitat components that are essential for the primary biological needs of migration, foraging, dispersal, or sheltering. The following PCEs apply to marine nearshore waters identified as critical habitat (70 FR 56212, [September 26, 2005]):

(1) Water temperatures that support bull trout use.

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

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

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

The primary stressors of the Action are derived from the nature, extent, and duration of the underwater research, development, and testing operations in the Dabob subunit and include the effects of interrelated and interdependent actions. We analyzed the effects of the proposed action on the PCEs that apply to marine nearshore waters within the designated critical habitat areas of the Dabob subunit. We determined that effects from the proposed action would have no effect on PCE (1) water temperatures that support bull trout use and (6) migratory corridors. We also determined that effects from vessel traffic and underwater sound from sonar and countermeasures have the potential to affect PCEs (7) an abundant food base and (8) permanent water of sufficient quantity and quality.

Vessel Operation

Vessel operations related to this Action include interrelated and interdependent actions and, in general, consist of bringing personnel and equipment from base to the operational site within a subunit, UUV operations (including torpedoes, submarines, and crawlers), chase and recovery boats (small watercraft). These activities could impact the substrate and consequently the aquatic communities that support a forage base for bull trout. These impacts may result in direct effects to PCE (7), an abundant food base, because of increased disturbance and turbidity that could temporarily displace forage or limit foraging effectiveness. Sediment disturbance and the associated turbidity are likely to produce changes in the chemistry of the water depending on the proximity to contaminant sources. Increased turbidity or mobilization of contaminants would be a direct effect to PCE (8) permanent water of sufficient quantity and quality. However, considering the frequency, extent and duration of the potential effects from vessels we are not anticipating significant (adverse) effects to bull trout critical habitat PCEs from this stressor.

Potential Adverse Effects

High-intensity Underwater Sound

Intertidal and sub-tidal areas with extensive areas of eelgrass encircle Dabob Bay and provide breeding habitat for many fish species as well as amphipods, copepods and other aquatic invertebrates. Copepods and other zooplankton represent the major food base of Puget Sound, especifically for small and juvenile fish (Mauchline 1998), including Pacific herring. These species play an important role in marine trophic systems, serving as a link between primary production and higher trophic levels (Mauchline 1998; Sackmann 2000).

Herring, sand lance, surf smelt, and juvenile salmonids provide the primary forage base important for subadult and adult bull trout within the marine environment. Of primary concern are herring populations, as the DBRC is an area that historically supported a moderately large spawning population of herring.

The Keyport Extension employs a wide variety of high-intensity underwater sound types within the DBRC for research, development, and testing of naval equipment (Table 6). High underwater SPLs are known to have negative physiological and neurological effects on a wide variety of vertebrate species including fishes and birds (Cudahy and Ellison 2002; Yelverton et al. 1973; Yelverton and Richmond 1981; Steevens et al. 1999; Fothergill et al. 2001; U.S. Department of Defense 2002). Effects will vary depending on a number of variables.

Mortality of 20 to 30 percent has been documented for certain age classes of juvenile herring (24 to 31 mm) that were exposed to high-intensity sonar (179-189 dB SPL_{rms}) in a controlled laboratory experiment (Jørgensen et al. 2005). Although histological examinations of sections of eyes, brain and otic organs did not reveal differences between control groups and exposed individuals (Jørgensen et al. 2005). Herring seem to be more sensitive towards sonar signals than other species (Kvadsheim and Sevaldsen 2005). Injury may result from a receptor or organ such as a swim bladder intercepting the sound, which resonates at the frequency of the sound source (Jørgensen et al. 2005; Kvadsheim and Sevaldsen 2005), However, the age class (24 to

31 mm) that sustained injury in this study, would not have fully developed swim bladders at this stage. It is therefore speculative as to the cause of mortality, but these data were used to describe a measurable, although small, effect to a herring stock (Kvadsheim and Sevaldsen 2005).

Because of the large number of RDT&E activities within the DBRC (approximately 220 sonar tests per year) and the likelihood that they could closely co-occur in herring spawning areas and pre-spawn holding areas, we anticipate direct effects with measurable mortality of exposed juvenile herring during events when herring are exposed to sonar sources exceeding 179-189 dB SPL_{rms}. Absent any information on the potential for overlap between sonar and herring that are spawning and/or holding, we believe it is reasonable to assume that there will be measurable effects to individual herring, including mortality. However, we are unable to quantify the magnitude of effects to the herring at a population scale.

Effects to Critical Habitat and the CHU

Three PCE's (1, 6, and 8) will not be significantly affected. However, we expect measurable effects to individual Pacific herring, a component of PCE 7 (abundant food base). Although individual herring may be injured or killed by activities authorized under this action, we cannot establish that these effects will result in a measurable reduction of PCE 7. We therefore we do not anticipate a reduction in the function of the CHU as a whole.

Effects to Marbled Murrelet

In the previous section, we presented evidence that demonstrates that murrelets are likely to occur in the marine waters encompassed within the three military test ranges and the proposed extensions associated with the Action. In this section, we examine the Action in greater detail to assess the effect the Action is likely to have on individual murrelets. We begin the analysis by attempting to quantify the number of individuals that are likely to co-occur with the Action along with a description of the specific stressors caused by the Action (*Exposure Analysis*). We conclude this section with a *Response Analysis* which includes a description of the most probable response (or range of responses) exhibited by the individuals exposed to the Action stressors and to what extent the response of individuals will affect the murrelet population in Conservation Zones 1 and 2.

Throughout this section, we rely on scientific studies that have examined the direct and indirect effects of stressors caused by the Action and the response of murrelets to those stressors. These studies often address murrelets, but studies of other bird species or vertebrates are included in order to address uncertainty through inductive reasoning. The findings presented here in the Effects section will be used to assess the extinction risk posed by the Action in Conservation Zones 1 and 2 in the section entitled *Integration and Synthesis of Effects.*

General Approach to the Effects Analysis

The FWS used a simple exposure-response framework to assess whether the effects on a listed species, either individually or collectively, would be expected to be significant. We assess the

significance of potential effects in the context of two objectives: 1) to identify whether any listed resources may be exposed to any project stressors and 2) describe the extent (magnitude, duration, and frequency) of all potential direct and indirect effects on each listed resource from an exposure to the project stressors. Stressors are considered to be any physical, chemical, or biological entity that can induce an adverse response to a listed resources in the area affected by the action.

To assess exposure, we first identify any listed species that might be exposed to potential stressors arising from the proposed Navy testing activities. Project-caused stressors, if of sufficient magnitude, duration, or frequency, can adversely affect (suppress) a species' habitat use, reproduction, survival, or distribution. If exposure to the potential stressor is extremely unlikely, we conclude the effect is discountable. If we are unable to conclude the effect is discountable, we assume the listed resource will be exposed to the potential stressor(s) and we evaluate the consequence of the exposure.

The consequence of a stressor to one or more listed individuals (or designated critical habitat) is evaluated in terms of significance. We define significant effects as any measurable or detectable effect on the listed resource and they often relate to the size of the impact.

If we conclude, for a given listed entity, that all stressors will have effects that are either discountable or insignificant, we then have reached an endpoint in our analysis. Thus, the basis for our decision to "concur" with the Navy's determination of "may affect, not likely to adversely affect" is linked to both the effect(s) being discountable or insignificant, and we conclude the consultation for all listed entities so affected.

Potential Significant Effects

To assess significant effects from the Navy' proposed action on murrelets, we first describe any physical, chemical, or biological factor, directly or indirectly caused by any one or multiple testing activities, that may affect any listed resource within the *Action Area*. The *"Action Area"* is the maximum geographic extent where the potential stressors will occur and provides a reference area where we analyze the individual, interactive, and cumulative direct and indirect effects of these stressors on listed resources. Depending on the stressor, stressors can extend beyond the physical limits of the activity that gives rise to the stressor. Thus, the Action Area can encompass more space (land, air, water) than the area encompassed by the proposed action.

We next conduct an *Exposure Analysis.* In this step we identify the threatened and endangered species known or expected to occur during the Navy's testing activities. Each stressor of interest is then described, to the extent possible, in terms of its' timing, duration, frequency, intensity, and location. For those Navy-caused stressors that co-occur with the listed resources, we attempt to identify the number, gender, age or life stage, and the populations or subpopulations of the listed species exposed.

Then, using the best available scientific and commercial data, we describe the likely response of all affected individuals (directly and indirectly) in the *Response Analysis*. Secondarily, we collate the effects on individuals and summarize them at the scale of the population(s) those

individuals represent. This population-level summary of effects is then evaluated in terms of the likelihood of extinction posed by the Action, commonly referred to as the jeopardy analysis. We present the jeopardy analysis in the *Integration and Synthesis* section.

Information Sources and Weight

The FWS uses the best scientific and commercial evidence available to support the analyses and finding within Biological Opinions. Species monitoring reports from survey efforts by research entities associated with Federal, State, and Tribal agencies, as well as non-governmental organizations, are often key sources of evidence. Additional information includes reports and other documents such as Federal Register notices, recovery plans, and scientific reviews and summaries. To complete our search for evidence, we conduct a search of peer-reviewed scientific journals (global) and other literature, including doctoral dissertations and master's theses to capture recent advancements in scientific knowledge.

All information sources are weighted according to the strength of evidence in the document. That is, we assign the highest weight to studies that are robust and contain a high degree of scientific rigor. Field experiments, particularly those where potentially confounding variables are controlled, are given the greatest weight when compared to field studies where those variables are not controlled. Field studies with larger sample sizes and smaller variances are generally considered stronger evidence than those with smaller sample sizes and larger variances. Well designed field experiments are also generally considered to be stronger evidence than the conclusions from computer simulations – particularly those simulations that have little or no supporting evidence from field studies.

Potential Stressors

From the information presented in previous sections, several stressors are expected to occur in the marine environment during the 5-years of RTD&E activities. The FWS expects visual, auditory, and physical stressors on individual murrelets caused by vessel traffic, aircraft overflights, and elevated SPLs (Table 9).

Table 9. Summary of the stressors and location within the Action Area of the proposed Keyport Range Complex Extension (KRCE) affecting the marbled murrelet.

Stressors	Test Ranges with the KRCE		
	QUTR	DBRC	KTR
Vessel Traffic (surface)	X	X	X
Inert Ordnance and Expended Materials	X	X	X
Elevated SPLs (Air)	X	X	X
Elevated SPLs (Underwater)	X	X	X

Vessel Operation

Vessel operation related to this Action generally includes bringing personnel and equipment from base to the operational site within a subunit, UUV operations (including torpedoes, submarines, and crawlers), chase and recovery boats (small watercraft). These activities could affect marbled murrelets through effects to the physical environment or through direct disturbance.

These activities could impact the substrate and consequently the aquatic communities that support a forage base for marbled murrelets. Substrate effects include disturbance of fine sediments, dislodging and burying of benthos, and turbidity. Substrates can become scoured and rearranged, disrupting the detrital food webs that provide food for the epibenthic prey of juvenile salmonids. Sediment disturbance and the associated turbidity could produce changes in the chemistry of the water, depending on the proximity to contaminant sources. Contaminants can also be mobilized just like other constituents. However, the resulting water quality changes in the vicinity of the disturbance are very site specific and depend upon the physical mixing of the sediment with the water, the sediment's chemical and physical composition, flushing at the site, the tidal cycle, whether the water body is eutrophic (nutrient rich), and the amount of organic matter in the sediment. These effects could affect marbled murrelet prey base and foraging effectiveness. However, we expect the potential for these types of effects to be limited spatially and temporally. We also expect the potential for contaminants to be low, given the location of the majority of these activities. Therefore, we are not anticipating significant adverse effects to marbled murrelets from this element of the project.

Responses to vessel operation by murrelets could include diving, swimming away from a vessel, or abandoning a foraging area. However, the potential for behavioral effects from U.S. Navy vessel movements are low given that the exercises and testing events are transitory in time, with few vessels moving over large areas. In addition, if behavioral disruptions result from the vessel operation, they are expected to be temporary. Murrelets are expected to resume their loafing, breeding, foraging bouts with minimal disruption. Therefore, effects are expected to be insignificant.

Non-explosive exercise weapons and expended materials

Testing activities always involve non-explosive exercise weapons. Torpedoes are the primary undersea warfare weapons used by surface ships, aircraft, and submarines to search out a range target. The guidance systems of these weapons may be autonomous or controlled from the launch platform. The autonomous guidance systems use either 'passive' acoustics, detecting the sound energy emitted from the target, or active acoustics, finding the target with sonar and using the received echoes for guidance. All torpedoes, mines, and other weapon systems tested within the range sites of the NAVSEA NUWC Keyport Range Complex are in exercise configuration (i.e., inert); no live warheads are used.

Expended materials include items such as suspension bands, air stabilizers (parachute), release wire, guide wire, target parts, sonobouys, and propeller baffle. The possibility that these materials could entangle murrelets is remote. The materials are negatively buoyant and will sink rapidly to below the murrelet maximum diving depth.

The likelihood of a non-explosive exercise weapon colliding with a murrelet underwater or disturbing its behavior during an RDT&E activity is negligible, given on the density of the species in the KRCE, the guidance system of the non-explosive exercise weapon, the depths that the non-explosive exercise weapons are operated, as well as the small cross-sectional areas of the torpedo and individual murrelets. Therefore, the potential for injury or behavioral effects from U.S. Navy non-explosive exercise weapon use is considered discountable.

Overflights

Submarines, surface ships, and aircraft can be involved in undersea warfare exercises. The types of aircraft that may be used during the course of the action include Fleet helicopters, fixed wing airplanes, and UAS. Fixed-wing aircraft used in Navy tests are primarily P-3s and float planes; launch helicopters are SH-60s; and recovery helicopters are Hughes 500s, or equivalent. Activities involving aircraft typically last from 2 to 4 hours each.

RDT&E activities that utilize aircraft include: 1) deployment of sonobuoys; 2) deployment of helicopter dipping sonars (which are active or passive devices that are lowered on cable by helicopters to detect or maintain contact with underwater targets); and 3) deployment of torpedoes.

The Range Operating Procedures flight rules for helicopters and fixed wing aircraft associated with KRCE, RDT&E activities are: 1) flights overland must be at a minimum elevation of 305 m; 2) flights over water must be at a minimum elevation of 152 m; and flights within 457 m of shore must be at a minimum elevation of 305 m. These rules are expected to minimize possible disturbance of murrelets by helicopter noise that has propagated from the source through the air, across the air-sea interface, and into the water. Propagation of sound from air into water is minimal. At a source level of 150 dB_{SPL} @ re 20 μPa @ 1 m from a hovering helicopter, at 76 m, the sound in water at the depth of 1 m would be 119 dB_{SPL} re 1 μPa (Navy 2008b), well below levels considered to cause disturbance.

Due to the transient nature of sounds from aircraft involved in at-sea operations, such sounds would not likely cause physical effects, but would have the potential to affect behaviors. Airborne sound from a low-flying helicopter or airplane will be heard by murrelets, while at the surface or underwater. Responses by murrelets could include hasty dives, swimming away, or abandoning a foraging area. However, if behavioral disruptions result from the presence of aircraft, it is expected to be temporary. Murrelets are expected to resume their loafing, breeding, foraging bouts, or other behaviors with limited disruption to their normal behavior. It is also expected that the potential for behavioral effects from U.S. Navy aircraft movement is extremely low, given that the exercises and testing events are transitory in time, with few aircraft moving over large area. Therefore, effects are expected to be insignificant.

Sound Pressure Waves

The final stressor under consideration in this Opinion is sound pressure waves, referred to as acoustic waves, caused by the Navy's use of sonar and, separately, countermeasure testing. These sound pressure waves will occur underwater. We begin with a brief and general introduction into the physics and terminology associated with topic of underwater acoustics.

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. Acoustic waves can be described either by the speed at which a small piece of the medium vibrates, called the particle velocity, or by the corresponding pressure associated with the vibration. 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 it may include a broad range of frequencies. The sonar ping lies between these two types of signals by resembling a continuous tone with respect to its frequency content, and by resembling an impulse with respect to its time duration, making these sounds different from both pulses and tones."

This disturbance is an adequate stimulus to excite the ear, a synapomorphy (derived or specialized character shared by two or more taxa) of vertebrates (Northcutt and Gans 1983), or other sensory organs in fishes (lateral line or neuromasts) and invertebrates (gravity, pressure, tension, and motion detectors or chordotonal organs) (Sebeok 1977). Therefore, hearing is not confined to pressure waves alone but also includes a small particle displacement component of mechanical disturbance. Sound includes frequencies ranging from the infrasonic to ultrasonic. Thus the perception or hearing, 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.

Underwater sounds for this consultation are classified according to whether they are transient or continuous with respect to the duration of a murrelet foraging bout (30 minutes). In this analysis, we considered both acoustic impulse (non-sonar) and sonar pings (tone bursts) as transient signals.

Transient sounds are of short duration and may occur singly, irregularly, or as part of a repeating pattern. Pulsed sounds are measured in terms of their total energy, rather than just their pressure or intensity. Underwater sounds also can be classified as continuous; that is, they occur without a pause or hiatus. The underwater sound from countermeasure testing is considered as a continuous sound. Continuous sounds are further classified as periodic or aperiodic (IWC 2004).

Sound is usually measured in decibels. A decibel (dB) is a relative measure that must be accompanied by a reference scale. When describing underwater SPL, the reference is usually 1 micro-pascal (μPa) and is expressed as "dB re: 1 μPa". For in-air sound pressure, the reference amplitude is usually 20 μPa. One pascal is the pressure resulting from a force of one newton exerted over an area of one square meter. In this document, underwater sound is referred to in units of decibels re: 1 μPa and will be denoted as dB. In-air sound, measured on an A-weighted scale (which approximates human hearing), will always be re: 20 μPa in this document and will

be denoted as dBA. For this document, in air the peak sound emitted from a source is referred to as L_{max}, while sound averaged over a measured period of time is referred to as L_{eq}.

Sound pressure levels (SPL) - sound pressure that is expressed in dB. In this document, underwater SPLs are referred to in units of dB re: 1 μPa and are denoted as dB.

- Peak pressure (Peak) - the highest level or amplitude or greatest absolute sound pressure level during the time of observation. Sound pressure levels expressed as peak are used in discussing injury or mortality to aquatic species.

- Sound exposure level (SEL) - a metric that incorporates both sound pressure level 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 μPa^2-sec. Using this metric, 0-dB SEL corresponds to a continuous sound whose RMS sound pressure equals the reference pressure of 1 μPa at a duration of 1 s (Morfey, 2001).

- Root mean square (rms) - The rms is the root mean square of a waveform. It is calculated by computing the mean (average) of the waveform squared (waveform energy), then taking the square root of that value. Sound pressure levels expressed as rms are commonly used in discussing behavioral effects. Behavioral effects often result from auditory cues and may be better expressed through averaged units than by peak pressures.

As sound propagates away from a source, several factors change its amplitude. These factors include 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 surfaces such as the sea floor and air-water interface (in the case of underwater sound). The sum of all propagation and loss effects on a signal is called the transmission loss. A major component of transmission loss is spreading loss. From a point source in a uniform medium (water or air), sound spreads outward in spherical waves. Spherical spreading implies that intensity varies inversely with the square of the distance from the source. With spherical spreading, sound levels diminish by 6 dB with every doubling of distance. Sound transmission in shallow water is highly variable and site specific. Refraction can result in either reduced or enhanced sound transmission in shallow water (Richardson et al. 1995).

Ambient noise is the background noise that incorporates the broad range of individual sources. In the ocean, sources of ambient noise include wind, waves, organisms, shipping traffic, rain, industrial activity, and others.

Analysis Framework for Underwater Acoustic Waveforms

The FWS considered the effects of two types of underwater acoustic signals in this analysis: the intermittent acoustic signals (pings) from sonar use and continuous signals from countermeasure testing.

Sonar

The Navy classified the various sonar sources into eight representative types for this Action (Appendix C of the BE). The source SPL (dB), directivity (degrees), and center frequency (kHz) for each is summarized in Table 10.

Table 10. Description of Representative Acoustic Sources Used at NAVSEA NUWC Keyport Range +Complex (*from Table C-3 of the DEIS/OEIS*).

Source Designation	Center Freq	Source Level *(dB re 1 µPa @ 1 m)*	Emission Spacing	Vertical Directivity	Horizontal Directivity
S1	4.5 kHz	207 dB	0.2 m	20 deg	20 deg
S2	15 kHz	205 dB	1.9 m	30 deg	50 deg
S3	10 kHz	186 dB	45 m	60 deg	360 deg
S4	150 kHz	220 dB	1.9 m	9 deg	15 deg
S5	5 kHz	233 dB	93 m	60 deg	360 deg
S6	20 kHz	233 dB	45 m	20 deg	60 deg
S7	25 kHz	230 dB	540 m	20 deg	60 deg
S8	30 kHz	233 dB	617 m	20 deg	60 deg

To address the risk of physical and behavioral impacts on murrelets from sonar, we applied thresholds (draft) developed by the FWS (USFWS 2009) to specifically assess the underwater effects of impulsive sounds on murrelets such as those generated from pile driving and detonations (USFWS 2009). Impulsive signals exhibit extremely rapid rise followed by exponential decay (U.S. Navy 2009). For this analysis, the FWS analyzed the effects of sonar pings as an impulsive signal even though the signal from a sonar ping resembles a continuous tone with respect to its frequency content and resembles an impulse with respect to its time duration and rise time, making these sounds somewhat different from both impulsive and continuous tone signals[1].

We applied the dual thresholds of 206 dB_{peak} and/or 183 dB_{SEL} for the onset of physical injury, derived largely from the work of Kastak et al. (2005, p. 3162) and Ryals et al. (1999). We assessed the onset of potential[2] behavioral effects at 150 dB_{rms} based upon the work of Turnpenny (1994) and Turnpenny and Nedwell (1994). To facilitate this analysis, the Navy computed the horizontal attenuation distances (m) of all eight representative sound sources to all three critical threshold levels (U.S. Navy 2009; Table 3).

[1] The U.S. Navy submitted a report to the FWS, dated November 2009, where sonar signals used in the KRCE were classified as a "gated sinusoids," differentiating them from impulsive or continuous wave forms. Due to the similar rise time and duration of sonar signals, the FWS evaluated Sonar using the same metrics and threshold criteria developed for impulsive signals generated by pile driving.

[2] We differentiate the onset of behavioral effects from the onset of physical injury with the term "potential" because establishing behavioral responses depends upon other factors that are context-dependent, such as the expected normal behavior of exposed murrelets during the acoustic event, duration of the acoustic event, and the number of exposures to the acoustic event.

Countermeasure Testing

Unlike impulsive sound, the FWS has not previously established a metric or threshold to evaluate the potential the physiological or behavioral consequences on murrelets from acoustic waves generated from continuous sound sources, such as those expected from countermeasure testing. Therefore, the FWS gathered the best available scientific information and assigned the highest weight to field studies specifically describing the effects of continuous sound on a variety of vertebrates with higher weight given to studies involving birds and amphibious mammals (due to the presumed similarities in the adaptive forces that led to similarities in the role and anatomical structure of the ears). We also assign high weight to robust, lab-based studies with high scientific rigor characterized by controls against the influence of confounding variables, large sample sizes, and lower variance in the results. This effort resulted in adopting a 183dB$_{SEL}$ and 150 dB$_{rms}$ metrics to evaluate the likelihood and extent of physical injury and potential for behavioral effects on murrelets from continuous sound. We explain the basis for adopting these metrics and thresholds in detail in the *Response* section.

Exposure Analysis

Murrelets are year-around residents in the marine waters of the Action Area; therefore murrelets are expected to occur in the vicinity of all marine-based activities of the Action (Falxa et al. 2009, WDFW 2004, US Navy 2009). Further, we conclude the timing and nature of the Navy's proposed activities may adversely affect individual murrelets throughout the 5-yr duration of the Project at the Navy's Dabob Bay Range and Keyport Range Complexes.

The objective at this stage of the analysis is to predict the number of murrelets exposed to each acoustic stressor. However, prior to developing these predictions we must first establish whether or not there is a sufficient likelihood that murrelets will encounter an underwater sound field.

Based upon the species' behavior in the marine environment, we expect murrelets will be engaged in foraging, loafing, breeding and other social behaviors. Of particular interest in this analysis is the foraging behavior due to the species' sole dependence upon fish and other aquatic organisms from marine waters. So it is important to determine the likelihood of murrelets encountering an underwater sound field from sonar use and countermeasure testing while foraging underwater in the vicinity of the Navy's proposed RTDE activities.

<u>Objectives</u>

We organized this analysis broadly into two categories of effects: physiological and behavioral. Each is expected to vary as a function of the distance foraging murrelets are located from the source of the acoustic field. For this analysis, we use the term "critical field" to describe the spatial extent of expected physical or behavioral impacts on foraging murrelets from the acoustic waves transmitted underwater from Navy RTD&E activities. The FWS established the following two objectives for this exposure analysis:

1) Estimate the probability of encountering murrelets within the area ensonified with 183dB SEL and 150 dB$_{rms}$ for each acoustic stimulus greater than these levels at the source.

2) Estimate the number of murrelets ensonified when the probability exceeds 10 percent for any of the criteria in objective 1.

Current Population Structure

The first step towards meeting Objective 1 is to describe the structure of the murrelet population in Conservation Zone 1. This will serve as a basis to predict the probable age structure and seasonal abundance of murrelets in the Action Area.

The investigators for the marine component of the Northwest Forest Plan Effectiveness Monitoring Program annually report the abundance and density of murrelets in Conservation Zones 1 to 5. These efforts, along with a coordinated effort in Conservation Zone 6 implementing the same sampling protocol, have resulted in annual predictions of murrelet abundance for each Conservation Zone (Falxa et al. 2009) during the summer season. Using the most recent population estimates from Falxa et al. (2009), Conservation Zone 1 has a predicted murrelet population size of 4,699 during the summer of 2008 (Table 11). The number of young-of-year birds (less than 1 yr old), subadults (1-2 years old), and adults (3 years old and greater) are predicted using a juvenile ratio of 0.061 young/after-hatch year pair, overall juvenile survival rate of 0.6 (McShane et al. 2004), and an adult breeding rate of 0.77.

Table 11. The estimated number of marbled murrelets in each age class in Conservation Zone 1 in northwest Washington during 2008 (derived from Falxa et al. 2009).

Population Size[1]	Breeding Adults[2]	Breeding Pairs[3]	Non-breeding Adults[4]	Subadults[5]	Juveniles[6]
4,699	3,447	1,724	1,030	83	139

[1] 2008 Conservation Zone 1 population size with a 95% CI is 3,132 - 6,201 (Falxa et al. 2009).
[2]No. of adults (4,477) x adult breeding rate (0.77).
[3]No. of breeding adults/2.
[4][No. of birds (4,699) – No. of breeding juveniles (139) – No. of subadults (83)] x Non-breeding Rate (0.23)
[5]No. of Juveniles (139) x 0.60 survival.
[6]No. of pairs of after-hatch-year murrelets (6,778/2) x 0.061 young/pair.

From the information in Table 11, the murrelet population in Conservation Zone 1 may be comprised of 95.2 percent adults, 1.8 percent subadults, and 3.0 percent juveniles. For this analysis, the density and distribution of murrelets in the Action Area are assumed to follow the overall composition of the predicted 2008 population structure in Conservation Zone 1 (Table 11).

Methods

Murrelets commonly occur in the marine environment in flocks that vary in size and by season (Speich et al. 1992; Nysewander et al. 2005, p. 65; Falxa et al. 2008). The distribution of murrelet flocks in Puget Sound also appears to vary by season (Speich et al. 1992; Nysewander et al. 2005, p.68).

Summer density for the Project was approximated using the murrelet marine survey results for survey strata 2 and 3 conducted in July and August 2008 in Conservation Zone 1 (Falxa et al. 2009). The portion of the Action Area within Conservation Zone 1 is contained within these two strata. Stratum 2 largely encompasses the DBRC and stratum 3 entirely encompasses the Keyport Range. The authors report the predicted population size with 95 percent confidence intervals, but we chose to use the predicted population without confidence intervals to reduce the overall number of computations.

To approximate murrelet winter density in the Action Area, an index was constructed using the results of 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, an index was developed from a close examination of the changes in seasonal abundance of murrelets in Puget Sound reported from summer and winter surveys.

From 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 rarest alcids observed during the surveys, comprising just 1.5 percent of all alcids in the summer observations.

An 8-year average density of 59.36 marine birds/km^2 was calculated from density information reported by Nysewander et al. (2005, p. 12) for the northern two-thirds of the study area, an area encompassing the Action Area. The 8-year average was then multiplied by the maximum murrelet occurrence rate of 0.219 percent (0.00219 is the product of 14.6 percent (0.146) maximum alcid occurrence rate x 1.5 percent (0.015), the proportion of the alcids that were murrelets). The result was an average maximum murrelet summer density of 0.130 murrelets/km^2 (59.36 birds/km^2 x 0.00219) for the 1992-1998 survey period. We then compared the maximum summer density (0.13 murrelets/km^2) to the maximum winter density (0.35 murrelets/ km^2, Nysewander et al. 2005, p. 65) and calculated a 2.7-fold increase (0.35/0.13) in winter density over summer density.

Flock Size

A flock size of three birds was assigned to the 6-month summer season (April to September) and five birds to the 6-month winter season (October to March) and the seasonal flock density (flocks/km^2) within each stratum was computed from Equation 1.

Equation 1: $\mathbf{d_f = [(n_t)/(f_n)] / (a_s)}$

Where $\mathbf{d_f}$ is the flock density (flocks/km^2); $\mathbf{n_t}$ is the annual population size (# murrelets) during year **t** in the stratum of interest; **f** is a murrelet foraging group of size **n**; and **a** is the area of stratum **s** (km^2).

Likelihood of Occurrence

We used a Poisson probability model based upon murrelet density in the Action Area to evaluate the likelihood of one or more murrelet flocks occurring within a given 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 occurrence, is the output of interest (for a more thorough discussion, see Ewart et al. 1974, pp. 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.

In this analysis, murrelet foraging was viewed as a Poisson process with an average daily flock density (flocks/1 km^2, represented by λ) of birds foraging in Puget Sound. Different values for λ (flock density) were used for the winter and summer periods as defined above. The sizes of the critical fields associated with the periodic RTD&E tests involving sonar use or countermeasure testing were standardized and treated as independent samples, each having a probability of a "success" (i.e., containing 0, 1, or more murrelet flocks foraging within the "sample area" at the time of the test). In this case, a success was defined as a "flock encounter" with a sound wave within a critical field.

Test durations (sample periods) were standardized to 30 minutes (i.e., acoustic events lasting from 1 to 30 minutes were treated as 1 sample) to correspond to the duration of a murrelet foraging bout and to allow comparisons among samples. Acoustic events exceeding 30 minutes were prorated according to the duration by adjusting the value of μ in Equations 4 – 7 (e.g., a 2-hour test contains 4, 30-minute periods so μ was increased by a factor of 4).

Equation 2 was used to estimate the seasonal probabilities of 0, 1, 2,…x flocks occurring within a critical field located in murrelet survey strata 2 or 3.

Equation 2: $$f_p(x|\lambda, t) = [(\lambda t)^x e^{-\lambda t}] / x!$$

where f_p is the probability of x = 0, 1, or 2 flock encounters; e is the natural logarithm base approximately equal to 2.7183; λ = the mean number of flock encounters within a critical field; and t = the number of time units under consideration (Ewart et al. 1974, p. 189,190).

Defined in this manner, λt is the mean number of flock encounters within a given critical field for every t unit of sonar use or countermeasure testing. For example, when $t = 1$, the mean number of flock encounters in a 30-minute period is equal to λ (i.e., $\lambda t = \lambda$), where flock encounters for each season is derived from the winter or summer flock density (flocks/km^2) x area ensonified (km^2).

To meet assess the likelihood of murrelet exposure as described above, the following assumptions were made about murrelet foraging bouts: 1) murrelets were assumed to occur at random points in space (but remain spatially constrained to the sample space during the 30 minute sample period); 2) any occurrence of a murrelet flock in a sample period was independent of all other murrelet flocks; 3) there was a zero chance of two or more flocks being

simultaneously encountered (i.e., two flocks will not be foraging at the same location at the same time) during one, 30-minute sample period in each sample area; and 4) λ remains constant throughout the given season of interest (i.e., there is a constant mean number of flock encounters for the winter and a separate mean for the summer).

Although underwater sound waves can continue for distances exceeding several kilometers (depending on the propagation characteristics, frequency, source levels, etc.), it is of foremost interest to predict the probability (**p**) of **x** flock encounters occurring within a critical sound field where $0 > \mathbf{p} < 1.0$. Values of $\mathbf{p} \geq 0.1$ were selected as the range in **p** values where the probability of encountering a murrelet flock is "likely." For values of $\mathbf{p} < 0.1$, we consider the event "unlikely" and conclude a flock encounter is not expected.

In these types of exposure analyses for section 7 consultations, we use a probability of 10 percent as the break point at or above which we consider 1 or more murrelet flock encounters with a sound wave may occur. For probabilities below 10 percent we will consider a flock encounter will not occur. We chose 10 percent for the following reasons:

- There is currently insufficient recruitment of juveniles to sustain the murrelet population in the listed range of the species (i.e., murrelet metapopulations are currently not self-sustaining);
- Murrelet populations throughout the listed range have little resilience to deleterious population-level effects and are at high risk of extirpation in the foreseeable future;
- The species' capability to recover from lethal perturbations at the population or metapopulation (Conservation Zone) scale is low;

The FWS therefore assumes that actions resulting in mortality of breeding adults, eggs, or nestlings will contribute to the population decline of murrelets in the coterminous United States. The low resilience of the murrelet population suggests use of a conservative approach.

Using a 50 percent threshold may appear to be a simple, logical course of action from a mathematical standpoint given there is an equal likelihood that a murrelet will or will not occur within the critical zone of an underwater sound wave. However, under this scenario, if the estimated probability was 0.50, there is also an equal chance of being wrong. Given the species status, the consequences of a Type II error was unacceptably high. On the other hand, use of a threshold less than 10 percent was unreasonably low. Therefore, we chose 10 percent as a reasonable and adequately conservative value.

The shape, size, orientation, and location of the underwater sound fields associated with Navy's RTD&E activities are determined by the magnitude of the source level (dB), frequency (Hz), directivity, and the location (x, y, and z coordinates) of the sound sources. Determining the probability of a murrelet foraging group to encounter an underwater sound wave requires explicit knowledge of ensonified volumes within the foraging depth of murrelets. To reduce this three-dimensional complexity, the following simplifying assumptions were adopted:

1) The directivity of the underwater acoustic sources are omnidirectional,
2) All acoustic sources occur at depth of 25 meters and have a theoretical "floor" at 50 meters below the water surface to correspond to the maximum foraging depth of murrelets. With an omnidirectional wave propogation, the result is a cylinder-shaped sound field with the "top" of the cylinder corresponding to the water's surface and the bottom of the cylinder corresponding to the 50-meter maximum foraging depth of a murrelet.
3) Due to the duration of the acoustic events under consideration in this consultation (10 min up to 24 hours), the mean surface density of murrelets is the same as the subsurface density of murrelets within a given critical field (i.e., the mean number of murrelets above and below the water during an RTD&E test is the same over the 30-minute sample period).

These assumptions simplified the 3-dimensional spatial frame to a 2-dimensional spatial frame (i.e., the area of a circle corresponding to the top of the cylinder) for the purposes of calculating the mean number of flock encounters per 30-minute timeframe. By this means, the probability of **x** flock encounters underwater could be approximated by with the murrelet flock density within a given critical field on the water's surface.

Although murrelets spend a considerable amount of time on top of the water (not foraging), the ensonification events are projected to endure 10 minutes to more than 24 hours. Murrelets are aggressive feeders during a foraging bout, spending up to 22 minutes of a 30 minute bout (72 percent) foraging. Given the range in test durations, there is a reasonably high likelihood that all birds in the forage group would be exposed to one or more sound "doses" when foraging within a critical field. We assumed that murrelets will continue foraging during the exposure period.

The size of critical fields was determined by Equation 3, using radii associated with a given attenuation distance for a given sound source (U.S. Navy 2009, Table 2) to two critical thresholds: 183 dB SEL and 150 dB_{rms}[3].

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 acoustic thresholds (183 dB SEL and 150 dB_{rms}).

Equation 3 was substituted for **t** in Equation 2, resulting in Equation 4. Equation 4 then could be used to calculate the likelihood of encountering **x** flocks during any given acoustic event.

Equation 4: $\mathbf{f_p(x|\lambda, A) = [(\lambda \pi r^2)^x e^{-(\lambda \pi r^2)}] / x!}$

(note: the symbology **r^2** in the exponent of **e** is used to denote $\mathbf{r^2}$).

[3] The critical threshold of 150 dB_{rms} is limited to sound sources that were within the assumed hearing range of the marbled murrelet (0.8 to 12.5 kHz).

The general form of Equation 4 was then simplified (Equations 5 - 8) to calculate the probabilities of 0, 1, 2, 3, etc. murrelet flocks 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 flocks)

Equation 6: $P(X=1) = (\mu)\, e^{-\mu}$ (Probability of 1 flock)

Equation 7: $P(X=2) = (\mu^2)\,(e^{-\mu})/2!$ (Probability of 2 flocks)

Equation 8: $P(X=3) = (\mu^3)\,(e^{-\mu})/3!$ (Probability of 3 flocks)

where **x** = the number of murrelet flock encounters and $\mu = \lambda\pi r^2$ (the expected seasonal murrelet flock encounters within a circular area of a critical field with radius **r** corresponding to a given attenuation distance (Table 12) in each stratum).

The Navy included several important descriptors of the various sonar sources in the BE (U.S. Navy 2009 p. c-4, c-33), including center frequency (kHz), source levels (dB), and duration of use. The Navy also provided the estimated attenuation distances (m) (Table 12) for the eight sound sources modeled in the DEIS/OEIS (US Navy 2008).

Table 12. The attenuation distances (m) to three critical thresholds for sonar sources S1 – S8 modeled in Appendix C of the 2009 Keyport Range Complex Extension DEIS/OEIS (data provided by the U.S. Navy 2009).

	Descriptive Parameters			**Radius (m) to:**		
Source	Center Frequency (kHz)	Source Level (dB re 1 µPa @ 1m)	Deployment duration (minutes) per 24 hr Period	206 dB re 1 µPa (SPL)	183 dB re 1 µPa^{2}s (SEL)	150 dB rms re 1 µPa
S1	4.5	207	240	1	6	253
S2	15	205	120	< 1	< 2	46
S3	10	186	120	< 1	< 3	24
S4	150	220	120	5	7	133
S5	5	233	20	23	123	691
S6	20	233	10	23	119	2,060
S7	25	230	10	16	84	571
S8	30	233	10	22	115	684

Results

Summer Flock Density in the Action Area

The overall summer density estimates for Conservation Zone 1 and each survey stratum are summarized from Falxa et al. (2009) in Table 13. From Equation 1, the calculated summer flock

densities for Dabob Bay Range Complex (Stratum 2) and Keyport Range (Stratum 3) are presented in Table 14.

Table 13. Reported murrelet density and population size (95 percent confidence interval (CI)) in Conservation Zone 1 and within each stratum during the 2008 breeding season (Falxa et al. 2009, p. 11).

Conservation Zone 1 (Strata)	**Density** (birds/km^2)	**Coefficient of Variation** (% Density)	**Population Size Estimates with 95% CI**			**Survey Area** (km^2)
			Number of Birds	Lower	Upper	
ALL	**1.34**	**17.0**	**4,699**	**3,132**	**6,201**	**3,497**
1	3.57	24.1	3,019	1,586	4,339	845
2	0.90	27.2	1,073	571	1,631	1,194
3	0.42	31.1	607	227	953	1,458

Table 14. Approximate summer murrelet flock density at the Dabob Bay Range Complex and Keyport Range during the 2008 breeding season in Murrelet Conservation Zone 1.

Range	**Survey Stratum (s)**	$\mathbf{n_{2008}}$ (# of birds)*	$\mathbf{f_n}$ Flock Size	Number of Flocks	$\mathbf{a_s}$ Area of Stratum **s** (km^2)*	$\mathbf{d_f}$ (flocks/km^2)
Dabob Bay Complex	2	1,073	3	358	1,194	0.30
Keyport	3	607	3	203	1,458	0.14

*from Falxa et al. (2009)

Winter Flock Density in the Action Area

We simulated the increase in winter season murrelet density in Conservation Zone 1 by increasing summer densities by a factor of 2.7 as explained in the *Methods* section. However, the relative distribution of murrelets observed during the summer changes in a non-linear fashion during the winter (Nysewander et al. 2005, pp. 23, 68). In other words, simply multiplying the summer density estimates of the strata by 2.7 is not appropriate because the spatial distribution within strata differs between summer and winter. Thus, we applied a 2.7-fold increase at the scale of the Conservation Zone to approximate the flock encounter rate because little is known about the winter distribution of murrelets.

Using the summer abundance of 4,699 murrelets for Conservation Zone 1 (Table 13, Falxa et al. 2009), winter abundance is estimated at 12,687 murrelets (4,699 x 2.7). Using a winter flock size 5, (approximated from Nysewander et al. 2005, p. 65) resulted in a winter flock density of 0.726 flocks/ km^2 ([12,687 murrelets/5 murrelets per flock]/3,497 km^2) throughout Conservation Zone 1 (i.e., all strata in Conservation Zone 1 surveyed by Falxa et al. 2009, Table 13, with a total area of 3,497 km^2). Using a winter flock size of 5, an estimated 2,538 flocks (3,497 km^2 x 0.726 flocks/ km^2) occur during the winter in Conservation Zone 1. The large increase from 4,699 murrelets in the summer to 12,687 murrelets in the winter is attributable to murrelets from coastal areas of British Columbia (outside the listed range of the species) and Washington (Conservation Zone 2 with a projected abundance of 1,944 murrelets and a 95% CI = 1,187 – 2,843) wintering in Puget Sound which would not have been present during summer surveys.

Sonar Use

Simulated Exposure to Injury-producing Sound Fields

All probabilities associated with murrelet flocks encountering injury-producing levels of sonar (i.e., 183 dB_{sel} re1 $\mu Pa^2 s$[4] ; Table 12) were all less than 0.10. The largest distance to a received level of 183 dB_{sel} reported by the Navy in Table 12 is 123 m for S5. Using Equation 6 [P(X=1)] and the largest value of $\mu = 0.0345$ (calculated during the winter period using the maximum radius (r) of 123 m in Table 12 and the maximum (winter) murrelet flock encounter rate (λ) of

[4] The FWS adopted these reference thresholds for Sonar from the standard approach we use to assessing the effects of underwater acoustic waves generated by pile driving (USFWS 2009). These thresholds, along with the threshold of 150 dB_{rms} used as a threshold for assessing potential behavioral responses in murrelets, were deemed appropriate for use due to the similarities in rise times and source levels, although impulsive sound waves at these levels may have more severe effects.

0.73 flocks/km^2), $p < 0.10$ ($p = 0.0333$, the probability that murrelets would be exposed to injurious levels of sonar). The probabilities for the other seven sonar sources ranged from 0.0000 (S2) to 0.0310 (S6).

Simulated Exposure to Behavior-modifying Sound Fields

The probability of murrelet flocks encountering a potentially-behavior modifying level of sonar was evaluated using the threshold criterion of 150 dB_{rms} and limited to sonar sources within the expected hearing range (0.8 to 12.5 kHz) for the murrelet. Thus, S1, S3, and S5 (Table 12) were evaluated using Equations 5 through 8 to simulate the likelihood of ensonifying murrelets (Table 15). To adjust for the 240-minute (4 hr) duration of S1 and 120-minute duration of S3, the value of μ in Equations 5 through 8 was increased by a factor of 8 (**t** = 8 in Equation 2 for S1) and 4 (**t** = 4 in Equation 2 for S2) for computation of the probability associated with S1 and S3.

Results (Table 15) for the summer simulation period suggest S1 and S5 would encounter 1 murrelet flock (3 murrelets) each time they occur at either KTR (S1: P(X=1)=0.1789; S5: P(X=1) = 0.1694) or DBRC (S1: P(X=1)=0.2976; S5: P(X=1) = 0.2867). Source 1 has a slightly higher probability to encounter a flock than S5 due to the longer duration, despite having a much shorter attenuation distance than S5. Source 3 is unlikely to encounter murrelets at either location during the summer.

During the winter, S1 and S5 again are expected to encounter foraging murrelets (flock size = 5) at both KTR and DBRC (Table 15) within the critical fields. However, due to the higher winter density of murrelets in the Action Area, S1 and S5 are also expected to encounter 2 flocks (S1: P(X=2) = 0.2119; S5: P(X=2) = 0.1994), or 10 murrelets during each event. S3 is unlikely to encounter winter-foraging murrelets at either location ($p < 0.10$).

Table 15. The computed probability of 0, 1, 2, or 3 murrelet flocks encountering sonar levels that may cause potential behavioral effects during winter and summer foraging bouts within the Keyport Range and Dabob Bay Range Complexes.

Sonar Source	Distance (m) to 150 dB_{rms}	Range Site	Summer Season Probabilities of Flock Encounters[1]			Winter Season Probabilities of Flock Encounters[1]			
			Number of Flocks[2]			Number of Flocks[2]			
			0	1	2	0	1	2	3
S1	253	KTR	0.7995	0.1789	0.0200	0.3155	0.3633	0.2119	0.0824
		DBRC	0.6177	0.2976	0.0717				
S3	24	KTR	0.9990	0.0010	0.0000	0.9948	0.0052	0.0000	0.0000
		DBRC	0.9978	0.0022	0.0000				
S5	691	KTR	0.8116	0.1694	0.0177	0.3369	0.3365	0.1994	0.0723
		DBRC	0.6380	0.2867	0.0644				

[1]Values of $p \geq 0.10$ indicate a likelihood that murrelet flocks will be foraging within the identified attenuation distances (to 150 dB_{rms}) at the time when testing occurs. Flock size was set at 3 birds for the summer and 5 birds for the winter for these computations.

[2]The estimated number of flocks exposed to each sound source was derived from Equations 5-8 on the basis of 1) a 30-minute foraging bout and 2) the area of a circle using the attenuation distances as the radius. S1 and S3 exceed the 30-minute foraging duration (S1 has a duration of 240 minutes and S3 has a duration of 120 minutes), thus **t** from Equation 2 (and thereby **μ** from Equations 5-8) was increased by a factor of 8 for S1 and by a factor of 4 for S3 to simulate the likelihood of a flock encounter during the winter and summer.

Number of Murrelets Exposed to Sonar

Our second objective concerning murrelet exposure to sonar is to estimate the number of murrelets ensonified, derived from those acoustic events that are expected to encounter murrelet flocks. The FWS does not expect murrelets to encounter injurious levels of sonar (all values of $p < 0.10$ for S1 – S8). However, the probabilities from Table 15 suggest S1 and S5 are likely have one to multiple encounters for each acoustic event.

Sonar sources S1 and S5 are expected to have one encounter (each) during the summer and two encounters (each) during winter (Table 15). Table 16 below summarizes the annual and total number of flock encounters from S1 and S5 sound sources. During the winter, the FWS estimates that up to 220 murrelets per year (100 murrelets by S1 and 120 murrelets by S5) will be ensonifed with acoustic over pressures >150dB_{rms}. Up to 66 murrelets per year (30 murrelets by S1 and 36 murrelets by S5) are expected to be ensonified by sonar during the summer-conducted RTD&E activities.

Table 16. . The estimated annual and total number of murrelet exposures to underwater sound levels >150dB$_{rms}$ from RTD&E activities involving S1 and S5 sonar at the Keyport Range and Dabob Bay Range Complexes.

		Range Site	Use Days Each Year					Totals
			1	2	3	4	5	
RTD&E Activity Schedule Involving Sonar Use (S1 and S5 only)[1]		S1: KTR	20	20	20	20	20	100
		S1: DBRC	20	20	20	20	20	100
		S5: KTR	4	4	4	4	4	20
		S5: DBRC	20	20	20	20	20	100
Murrlet Exposure Rates	**Flock encounters per event[2]**	S1: Winter	2	2	2	2	2	2[5]
		S1: Summer	1	1	1	1	1	1[5]
		S5: Winter	2	2	2	2	2	2[5]
		S5: Summer	1	1	1	1	1	1[5]
	Flock encounters per yr[3]	S1: Winter	20	20	20	20	20	100
		S1: Summer	10	10	10	10	10	50
		S5: Winter	24	24	24	24	24	120
		S5: Summer	12	12	12	12	12	60
	Individual encounters per yr[4]	S1: Winter	100	100	100	100	100	500
		S1: Summer	30	30	30	30	30	150
		S5: Winter	120	120	120	120	120	600
		S5: Summer	36	36	36	36	36	180

[1]This distribution of the RTD&E testing is an approximation based on information provided by the Navy. Actual testing locations, timing, and number may vary.
[2]The number of flocks encountered with each S1 or S5 underwater sound event at with an SPL > 150dBrms derived from Table 5.
[3]The number of flocks encountered/yr was computed by multiplying half of the total number of use days for each sound source (10 for S1 and 12 for S5) in each season by the flocks encountered/event for each respective season. In other words, half of the total number of use days would occur in the summer and the other half in the winter.
[4]Individual murrelets may be exposed from one to multiple times per year. Thus, the total number of encounters are expected to exceed the total number of individual murrelet encounters.
[5]Total presented is the mean rate over the 5-year duration of the Action.

The lack of specificity on the timing and relatively large number of tests involving the use of S1 and S5 sonar (320 acoustic events/use days) introduces significant uncertainty and therefore difficulty into determining the actual number of individual murrelets that may be exposed (annually or over the 5-year Action). Murrelet flocks that regularly forage in the vicinity of the KTR or DBRC could encounter sonar pings multiple times in one day or successive days due to the species' fidelity to foraging areas. Thus, the total murrelet encounters are expected to exceed the total number of individual murrelet encounters. However, we are not aware of a reliable way to quantify the number of individual murrelets at this time.

Countermeasure Tests

The Navy proposes to conduct 55 countermeasure tests per year for 5 years (275 tests total) in Puget Sound, most having a source level approximated by S5 (Table 12). However, the predicted distance to 183dB$_{SEL}$[5] and 150dB$_{rms}$[6] for countermeasure tests

[5] The reference 183dB$_{SEL}$ was adopted from the work of Kastak et al. (1999) and discussed in detail in the *Response* section that follows.

could not be released by the Navy, so the likelihood of a flock encounter was not possible.

An alternative approach to calculating flock encounters was developed for countermeasure testing by identifying the maximum attenuation distance (radius) for which a flock encounter would be less than 0.1 for the winter and summer periods. By adopting S5 as a surrogate for a sound wave from a countermeasure test, we could then simulate the likelihood for flock encounters at different locations and during different sesasons. This resulted in a radii of 221 m during the winter period (P(X=1) = 0.0999), 345 m during the summer period at DBRC (P(X=1) = 0.0999), and 505 m during the summer period at KTR (P(X=1) = 0.0997).

The Navy also intends to conduct five countermeasure tests per year within the Quinault Underwater Tracking Range, but the low abundance of murrelets in the coastal areas of murrelet Conservation Zone 2 resulted in the likelihood of a flock encounter well below 0.10. Consequently, murrelet exposure to countermeasure testing in the QUTR is not expected.

The Navy provided the following information about countermeasure tests (not included in the BE associated with this Action) to assist our assessing the likelihood of a flock encounter:

1) 97 percent of the countermeasures tested will have a distance of less than 221 m to $183dB_{SEL}$ (i.e., 3 percent of the 275 countermeasure tests (9 tests) will exceed the threshold values of $183dB_{SEL}$ at 221 m, the levels used to determine the onset of injury for murrelets);
2) 100 percent of the countermeasures tested will attenuate to below $183dB_{SEL}$ within a distance of 345 m; and
3) 95 percent of the countermeasures tested will have a duration of less than 30 minutes (i.e., 5 percent of the 275 countermeasures tests (14 tests) will last longer than 30 minutes).

Simulating Exposure to Injury-producing Sound Fields

The FWS assumed five of the nine potentially injurious countermeasure tests would occur during the winter (evenly distributed among the 5 years) and four during the summer[7]. With this assumption, and the information in the preceding section, we used Equations 6 – 8 and determined the probability exceeds 0.1 for 1 flock to encounter injurious levels of sound for each countermeasure test less than 30-minutes and 2 flocks for each countermeasure test exceeding 30 minutes.

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[6] The reference 150dBrms was adopted from the work of Turnpenny and Nedwell (1994) and discussed in detail in the *Response* section that follows.
[7] The Navy informed the Service that approximately one-half of all RTDE tests would be conducted during the each season.

We assumed the two flock encounters for the longer duration countermeasure test were two different flocks. We made this "worst-case" assumption because the severity of the sound pressure level was sufficient to result in injury.

This approach resulted in 5 total individual murrelet encounters per year (30 total over the 5 years) that are expected to lead to injuries for each bird (1 of the 9 injurious countermeasure tests was assumed to exceed 30 minutes[8]; Table 16). With the Navy's determination that countermeasure sound fields will attenuate to below $183dB_{SEL}$ within a distance of 345m ($p < 0.10$), we determined that countermeasure tests are unlikely to encounter murrelet flocks during any of the four summer countermeasure tests at either DBRC or KTR[9]. To make this determination, we used the probabilities of flock encounters for S5 from Table 15.

Table 17. The approximated annual and total number of murrelet exposures to underwater sound levels $>183dB_{SEL}$ from countermeasure testing at the Keyport Range and Dabob Bay Range Complexes.

			Year					Totals
Countermeasure Test Schedule[1]		Season	**1**	**2**	**3**	**4**	**5**	
		Winter	1	1	1[2]	1	1	5
		Summer[3]	1	1	0	1	1	4
Exposure Rates	**Flock encounters per CM**	Winter	1	1	2[4]	1	1	1 to 2[6]
		Summer	0	0	0	0	0	0
	Flock encounters per yr	Winter	1	1	2	1	1	6
		Summer	0	0	0	0	0	0
	Individual encounters per year	Winter	5	5	10[5]	5	5	30
		Summer	0	0	0	0	0	0

[1]This distribution of these 9, potentially injurious countermeasure tests is an approximation. The actual season and number may vary slightly.
[2]This countermeasure test was analyzed as the one which would exceed the normal 30-minute duration, resulting in two flocks encountering injurious levels of sound as a result of increasing μ (Equations 5-8) by a factor of 24 to account for up to a 12-hr test duration (24, 30-minute forage bouts could occur during a 12-hr period).
[3]It was assumed in this analysis that countermeasure testing could occur at either DBRC or KTR during the summer.
[4]Assuming a 123 m distance to $183dB_{sel}$, the following winter-time probabilities for **x** flocks, where x = 1, 2, or 3 flocks, were calculated with Equations 6, 7, and 8: $P(X=1)= 0.3617$; $P(X=2)= 0.1495$; and $P(X=3)=0.0412$.
[5]Because murrelets have fidelity to foraging areas, the duration of this countermeasure test (longer than 24 h) may result in exposing the same murrelet flock multiple times during the test. Nonetheless, we assumed for the analysis of effects that under a "worst-case" scenario, these 10 individual encounters may represent 10 individual murrelets.
[6]Total presented is the range over the 5-year duration of the Action.

[8] Based on a proportional allocation, the remaining 13 countermeasure tests (from a total of 14) expected to exceed 30 minutes were evaluated among the proportion of the countermeasure tests that would not be injurious.
[9] The one countermeasure test that may exceed the 30-minute duration was assigned to the winter period for the purposes of analyzing a reasonable worst-case analysis.

Simulating Exposure to Behavior-modifying Sound Fields

All 275 countermeasure tests were considered likely to generate sound levels that may result in a behavioral response in murrelets[10]. The first step was to evenly distribute the 275 countermeasure tests between seasons (137 in winter and 138 in summer), between the Ranges as described in the proposed action, and then allocate them across the 5 years of RTD&E testing (Table 18)[11].

The likelihood of 1, 2, or more flock encounters within the threshold sound level for behavior changes ($150db_{rms}$) was determined using Equations 5 - 8, but with the assumption that the maximum distances to the two threshold criteria did not exceed those reported in Table 12 for S5. Referring to Table 15, S5 is likely to result in 2 flock ecounters (10 individual murrelets) during each wintertime event (P(X=2) = 0.1994) and 1 flock encounter each time S5 occurs during the summer at either KTR (S5: P(X=1) = 0.1694) or DBRC (S5: P(X=1) = 0.2867).

The number of flock encounters with $150dB_{rms}$ minimum sound levels was estimated at 412 during the 5-yr duration of the Action (approximately 83 flock encounters per year; Table 8). The estimates were higher during the winter than the summer due to the higher winter density of murrelets in Puget Sound, with an estimated 274 flock encounters (67 percent) during the winter. With a winter flock size of 5 birds, an estimated 1,370 murrelet encounters (77 percent of all expected encounters) are expected from the $150dB_{rms}$-minimum sound levels (Table 18).

As with sonar use, the lack of specificity on the timing and relatively large number of countermeasures tests (275 countermeasure tests total) introduces significant difficulty into determining the actual number of individual murrelets that may be encountered (annually or over the 5-year Action). A given murrelet flock may encounter sound waves from multiple countermeasure tests in one day or successive days due to the species' fidelity to foraging areas. Thus, the total individual encounters are expected to be significantly more than the total number of individual birds that encounter a sound field greater than $150dB_{rms}$.

[10] As discussed in the previous section, 9 countermeasure tests were projected to have injurious levels of underwater sound. These 9 countermeasure tests were included in this section because all 9 tests have the potential to significantly affect murrelet behavior as well.

[11] The p-values for the remaining 13 countermeasure tests (from a total of 14) expected to exceed 30 minutes could not be calculated due to model limitations. This was deemed to be an acceptable accommodation due to non-injurious sound fields associated with these countermeasure tests.

Table 18. The approximated annual and total number of murrelet exposures to underwater sound levels >150dB$_{rms}$ from countermeasure testing at the Keyport Range and Dabob Bay Range Complexes.

		Season	Year 1	2	3	4	5	Totals
Countermeasure Test Schedule[1]		Winter	27	27	29	27	27	137[2]
		KTR Summer	2	3	2	3	2	12
		DBRC Summer	25	25	26	25	25	126
Exposure Rates	**Flock encounters per CM[3]**	Winter	2	2	2	2	2	2[5]
		KTR Summer	1	1	1	1	1	1[5]
		DBRC Summer	1	1	1	1	1	1[5]
	Flock encounters per yr	Winter	54	54	58	54	54	274
		KTR Summer	2	3	2	3	2	12
		DBRC Summer	25	25	26	25	25	126
	Individual encounters per yr[4]	Winter	270	270	290	270	270	1,370
		KTR Summer	6	9	6	9	6	36
		DBRC Summer	75	75	78	75	75	378

[1]The distribution of the 275 countermeasure tests (137 + 12 + 126) is an approximation used to generate estimates and averages 55 per year over five years. The actual testing locations, timing, and number may vary slightly.
[2]The total of 137 countermeasure tests includes an assumed 13 countermeasure tests at KTR and 124 countermeasure tests at DBRC during the winter over the 5-year duration of the action. However, the murrelet flock density during the winter at KTR and DBRC is assumed to be the same; therefore no differentiation in location is made during the winter.
[3]The number of flocks encountered with underwater sound levels of > 150dBrms.
[4]Individual murrelet flocks may be encountered from one to multiple times throughout the 5-year duration of the Action. Thus, the total individual encounters should not be interpreted as representative of the total number of murrelets exposed.
[5]Total presented is the mean rate over the 5-year duration of the Action.

Summary of Exposure Analysis

Based upon the simulations described above, the FWS does not expect murrelets to be exposed to injurious levels of sonar (for S1-S8, $p < 0.10$). However, murrelets are expected to be encounter potentially behavior-modifying levels from S1 and S5 sonar sources during the winter and summer KTR and DBRC. The FWS predicts that 220 murrelet encounters (100 murrelet encounters for S1 and 120 murrelet encounters for S5) with acoustic waves >150dB$_{rms}$ per year during the winter. During the summer, up to 66 murrelet encounters per year (30 encounters for S1 and 36 encounters for S5) are expected due to sonar use.

Assuming five of the nine potentially injurious countermeasure tests would occur during the winter, 1 flock encounter is expected during each of the four, 30-minute countermeasure tests and 2 flock encounters is expected during the one countermeasure test exceeding 30 minutes. This resulted in 30 total, winter-time-injured murrelets during the 5-year Action. No flock encounters are expected during any summer countermeasure testing.

Additionally, a large number of flock encounters are expected during countermeasure testing that may be of sufficient intensity to cause a behavioral response. From the

simulations, the number of flocks encountering 150dB$_{rms}$ minimum sound levels resulted in 412 flocks during the 5-yr duration of the Action (approximately 83 flock encounters per year or 1,784 total individual encounters; Table 18). The flock encounters were higher during the winter than the summer due to the higher winter density of murrelets in Puget Sound, with an estimated 274 of the 412 flock encounters to 150dB$_{rms}$ minimum sound levels (67 percent) are expected during the winter. With a winter flock size of 5 birds, we predict 1,370 individual murrelet encounters (77 percent of all expected encounters) during the winter (Table 18). Although we expect that some murrelet flocks will have multiple encounters (and therefore will be counted multiple times comprising the totals in Table 18), the actual number of murrelets affected will likely be lower. However, we were unable to develop a reliable means to estimate the number of individual murrelet encountering one or more sound waves.

Response

The FWS was unable to locate scientific literature or reports specific to the effects of sonar or countermeasures on marbled murrelets, seabirds, or waterfowl. Nonetheless, we have assumed that exposure of murrelets to sound waves from sonar use and countermeasure testing may result in behavioral effects, and that it is appropriate to rely on criteria established for impulsive sound (USFWS 2009).

We also expect murrelets to be exposed to potentially injurious SPLs as well as levels that may have behavioral effects from the Navy's countermeasure testing. To address murrelet response to countermeasure testing, we reviewed the best scientific information available concerning the effects of continuous pure-tone sounds on several vertebrate species, primarily birds and marine mammals. This led to adopting the thresholds of 183 dB$_{SEL}$ and 150 dB$_{rms}$ for anticipated physical impacts and potential behavioral effects on murrelets. Though limited in scope, these studies provided sufficient basis to characterize the effects of the high SPLs generated by countermeasure tests.

<u>Murrelet Behavioral Response to Acoustic Waves >150dB$_{rms}$</u>

There is much uncertainty regarding the behavioral response of organisms to underwater sound in general. The majority of the information from controlled experiments on the behavioral effects of underwater sound is from studies using pure tone sounds. Sounds generated by sonar, however, are considered gated sinusoids (US Navy 2009) that can occur as low, mid, or high frequency, making comparisons with existing data from studies using impulsive or pure tones difficult. Additionally, the few data that do exist are focused primarily on the response of humans, marine mammals, and fishes. With the exception of a few preliminary studies and limited observational information, the following draws heavily from the literature on fishes, and out of necessity, extrapolates from these data in order to evaluate potential effects to murrelets.

In general, response behaviors that could indicate disturbance of murrelets in the marine environment include aborted feeding attempts; multiple delayed feeding attempts within a single day, or across multiple days, reduced foraging success (exhibited through more foraging dives or longer foraging bouts), and avoidance of foraging areas. These behaviors could result in an

increased risk of predation and reduced fitness in adults, the outcome of which could affect survival and fecundity at the individual or population scales.

Turnpenny and others (1994) attempted to establish a threshold of underwater sound that would elicit behavioral responses in brown trout, bass, sole, and whiting. With brown trout an avoidance reaction occurred above 150 dB_{rms} and other reactions (e.g., a momentary startle), were noted at 170 to 175 dB_{rms}. The report references Hastings' "safe limit" recommendation of 150 dB_{rms} and concludes that the Hastings' "safe limit" provides a reasonable margin below the lowest levels where fish injury was observed. In an associated literature review, Turnpenny and Nedwell (1994) also state that the Hastings' 150 dB_{rms} limit did not appear overly stringent and that its application seemed justifiable. Additionally, observations by Feist and others (1992) suggest that sound levels in this range may also disrupt normal migratory behavior of juvenile salmon.

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

The response of seabirds, including marbled murrelets, was monitored in an uncontrolled study during impact pile driving associated with the Hood Canal Floating Bridge Replacement project in Washington (Entranco and Hamer Environmental 2005). At the onset of pile driving, observers noted that the response of seabirds was typically to flush. However, this response lessened over time, suggesting habituation may have occurred. In particular, murrelets were observed in close proximity to active pile driving and continued to dive and forage (Entranco and Hamer Environmental 2005).

Clearly, a substantial gap exists in scientific knowledge on this topic. The study by Fewtrell presents the best experimental data on behavioral responses of fishes to impulsive sounds above 158 dB_{rms}. Given the large amount of uncertainty associated with inferring the behavioral response from experimental data to species in situ from a variety of sources (airguns, pile-driving, and non-impulsive pure tones) on a variety of species, the FWS believes it is appropriate to establish a conservative threshold for evaluating behavioral responses. As such, for the purposes of this analysis, the FWS expects that sound pressure levels in excess of 150 dB_{rms} could result in murrelets exhibiting adverse behavioral responses. Whether or not these behavioral responses will lead to significant disruptions in normal murrelet behavior is discussed in the next section.

In general, animals that encounter humans or human activities often exhibit the same behavior as when they encounter predators (Beale and Monaghan 2004; Frid 2003; Frid and Dill 2002; Gill et al. 2001; Harrington and Veitch 1992; Lima 1998; Romero 2004). The level of perceived risk likely results from a combination of disturbance stimuli, including factors related to natural predation risk (e.g., Papouchis et al. 2001).

In response to perceived threats, animals undergo physiological changes that prepare them for flight or fight responses and with chronic exposure, can have more serious consequences (e.g., such as interruptions of essential behavioral or physiological events, alteration of an animal's time budget, or some combinations of these responses; Frid and Dill 2002; Romero 2004; Sapolsky et al. 2000; Walker et al. 2005; Greenberg et al 2002). For example, human disturbance has led to abandonment of nesting and foraging sites (Henson and Grant 1991; Gill et al. 1996; Fowler 1999); increases in activity levels and premature death or reduced reproductive success when their energy expenditures exceed their energy budgets (Daan et al. 1996; Giese 1996, Mullner et al. 2004;); or cause animals to experience higher predation rates when they adopt risk-prone foraging or migratory strategies (Frid and Dill 2002). The FWS did not find any studies where the behavioral response of murrelets (or other alcids) to high underwater SPLs was examined.

High underwater SPLs can cause a variety of behavioral responses that have not been well studied. Although behavioral responses array along a continuum of severity, there is no easily identifiable point at which behavioral responses have a deleterious effect on either the survival or fecundity of individuals or the populations they represent.

Richardson et al. (1995) speculated that a high underwater sound pulse (from underwater explosions) may interrupt foraging dives and cause a return to the surface, or that some might leave the area; however, he also found that available evidence suggested that the latter is unlikely. Stemp (1985) found the number of Northern fulmars (*Fulmarus glacialis*), blacklegged kittiwakes (*Rissa tridactyla*), and thick-billed murres (*Uria lomvia*) within a few hundred meters of repeated underwater explosions originating from seismic vessels did not exhibit consistent differences in behavioral responses during periods with and without explosions.

However, the work of Ross et al. (2001) found that playing recordings of motor boats underwater was an effective deterrent for common eiders (*Somateria molissima*) during underwater foraging bouts at commercial mussel farms. Although the deterrent was only effective after the eiders associated the sound with actual hazing, the results suggest that some diving birds are able to detect sound in the underwater environment and will alter their behavior, even during foraging.

Murrelet Foraging and Energetics

Energy costs may affect foraging behavior both in the type of prey sought and the distance between the foraging and nesting area (Elliot et al. 2009; Hull et al. 2001). Murrelets are expected to adapt their foraging strategy depending upon such factors as their breeding condition, overall fitness, and abundance/availability of prey resources that can determine the energy gain (Schluter 1995; Svanbäck and Eklöv 2003; Svanbäck and Bolnick 2005).

Foraging behavior may be adjusted in response to changing conditions to optimize energy intake (Schoener 1971, Pyke 1977), and is fundamentally linked to fitness, as energy intake has direct effects on survival. We expect murrelets to increase foraging activity in association with increased maintenance energy costs or decreased food availability (Owen et al. 1992, Percival and Evans 1997, McKnight 1998, Webster and Weathers 2000, Cope 2003) as described in other bird species.

Murrelets have been observed leaving their egg unattended for 3-4 hours during the morning, mid-day, and evening (Naslund 1993a, pers. comm.; Nelson and Peck, in press; Simons 1980). Seabirds often leave their eggs unattended to maximize foraging time and accumulate sufficient energy reserves for lengthy incubation shifts (Boersma and Wheelwright 1979, Gaston and Powell 1989, Murray and others 1983). Murray and others (1993) have hypothesized that the benefits of increased foraging time during egg neglect often outweigh the disadvantages of leaving the egg unattended. Disadvantages of egg neglect include predation, heat loss, and exposure to the elements.

Because murrelets can nest at distances around 50 miles inland, the commuting distance to provision young from the foraging location to the nest site undoubtedly affects energy budgets (Drent and Dann 1980; Whitworth and Nelson 2000; Hull et al. 2001; Herbert and Golightly 2008). This emphasizes the importance of energetically rich prey for adults and nestling survival (Elliot and Gaston 2008).

Invertebrate prey have lower energy content than Pacific herring, anchovy, surf smelt and sand lance (Goudie and Ankney 1986, Fischer and Griffin 2000; Table 19). Given that diving is an energetically costly behavior (Lovvorn and Jones 1991), any disturbance that reduces capture success or decreases prey availability can result in reduced fitness.

Table 19. The energy (kcal/g), protein, and lipid content of important food sources of the marbled murrelet.

Prey species	Food energy (kcal/g)	Protein	Lipids
Pacific Herring	2.1700 [1]	45.34 [6]	34.00 [6]
Smelt	1.4698 [7]	43.92 [6]	42.88 [6]
Sand Lance	1.7435 [3]	19.50 [3]	8.90 [3]
Anchovy	1.3088 [4]	20.35 [2]	4.84 [2]
Invertebrates (Euphausiids)	0.8908 [5]	5.65 [3]	9.20 [3]

[1]Biggs and Perez 1985; USFWS 1989, [2]USFS 1995, [3]Montevecchi et al 1984 and Brett and Groves 1979, [4]Oehlenschläger 2009, [5]Tarverdiyeva 1972, [6]Bernard and Ullrey 1989; Sidwell 1981, [7]Witteveen 2003 and Witteveen et al. 2006

For example, Cassin's auklets must consume approximately 67 percent of their body mass daily in order to meet their energy needs when provisioning chicks (Hodum et al. 1998); black guillemots consume 61 percent of their body mass in prey per day (Mehlum et al. 1993); and dovekies need to consume 80 percent of their body mass daily to maintain their field metabolic rate (Gabrielson et al. 1991). If the average weight of a murrelet is 232 g and the average prey item is a 10 g Pacific sand lance (Hull et al. 2001), then an adult murrelet may need to capture as many as 14 fish each day to achieve 60 percent of its body mass.

Summary of Potential Murrelet Behavioral Responses

During the 5-year Action, we estimate that murrelets will encounter 3,214 exposures or "doses" of underwater SPLs in excess of 150 dB_{rms} (1,430 doses from sonar and 1,784 doses from countermeasure testing). We arrived at this estimate in the following manner.

Sonar sources S1 and S5 are expected to result in 286 doses per year (130, S1 doses and 156, S5 doses annually) or a 5-year total of 1,430 doses with sound pressure levels >150dB$_{rms}$. Most (220 per year or 1,100 over 5 years) will occur during the winter when murrelet density is higher in Puget Sound (Table 16).

The Navy's testing of various countermeasures is expected to result in 1,784 total exposures to 150dB$_{rms}$ sound levels or greater during the 5-year Action (Table 18). Again, the FWS estimates most will occur during the winter (an estimated 274 flocks or 1,370 doses comprising 77 percent of all expected exposures). During the summer, comparatively fewer doses are projected, with 36 doses at KTR and 378 doses at DBRC.

As recommended by the FWS, the Navy will not commence conducting countermeasure earlier than two hours after sunrise during the nesting season (April 1 to September 15), to the extent practicable. Because 95 percent of all countermeasure tests are 30 minutes or less, this conservation measure ensures that 95 percent of the countermeasure testing will commence 2 hours after sunrise and most countermeasures will terminate 2 hours before sunset and thus avoid the species' most critical daily foraging periods for breeding adults (during the dawn and dusk periods) during the nesting season. The FWS expects this measure will decrease the number of exposures.

Nonetheless, murrelets forage intermittently throughout day and thus are expected to encounter an acoustic wave from sonar use or countermeasure testing. The expected result may be an intermittent, short-term delay or disruption of murrelet foraging bouts. A response may arise from any of the following scenarios: (1) murrelets perceiving the sound field as threatening, resulting in birds relocating (swimming or flying) in the immediate vicinity where the sound field is less intense, (2) interruption of a pursuit dive, forcing the murrelets to the surface; or (3) experiencing short-term physiological stress responses.

The findings of Ross et al. (2001), as well as observations of murrelets foraging near active pile driving projects (Entranco and Hamer Environmental 2005), suggest that murrelets are unlikely to exhibit a detectable change in foraging behavior due to an encounter with a sound field underwater. While it is true that waterbirds exhibit a wide range in behavioral responses to anthropogenic disturbance (Klein et al. 1995), relying upon murrelet behavioral responses as the sole indicator of the species' vulnerability to underwater sound stressors could lead to errant conclusions about the effects of such stressors on murrelets at the individual or population scales.

For example, overall body condition and foraging success are proximate and synergistic factors that can cause animals to exhibit less behavioral response to disturbance stimuli when food intake is in high demand (Stillman and Goss-Custard 2002). In the scenario where foraging success is high at some location and body condition is low (i.e., during winter and in adult breeding murrelets during the breeding season), a murrelet behavioral response to underwater sound would likely be lower. Thus, adopting the conceptual framework offered by Gill et al. (1996), we considered murrelet response to the underwater acoustic stimuli as a trade-off between food intake and the perceived predation risk.

In this framework, any of the murrelet responses mentioned above will depend upon the tradeoff between the starvation risk of avoiding the sound fields and the perceived risk of predation. When the risk of predation is maximized, we assume that murrelets even in the poorest condition will exhibit a behavioral response. In this scenario, a murrelet behavioral response could lead to changes in survival or fecundity for the species.

Our review of Ross et al. (2001), Stillman and Goss-Custard (2002), and Gill et al. (1996) led to the conclusion that the perceived risk of predation is fundamental to inferring fitness effects on individual murrelets from underwater sound fields >150dB$_{rms}$. When investigators examined the behavioral response of waterbirds to the disturbance stimuli of people approaching birds in boats (Ross et al. 2001) and on foot (Goss-Custard 2002), they observed responses similar to those listed above. However, the stimuli considered in this action lack a clear anthropogenic threat. That is, Navy personnel and support vessels will not be directly pursuing murrelets that may be foraging in the vicinity of the RTD&E activities involving the use of sonar and countermeasures. In the absence of a clear anthropogenic threat during the RTD&E activities, we assume that it is unlikely that murrelets will exhibit any of the aforementioned behaviors that may lead to termination of a foraging bout (i.e., individuals will likely perceive the sound wave as non-threatening and continue to forage).

Therefore, we conclude that murrelets are likely to habituate[12] to sonar and countermeasure sound fields (> 150 dB$_{rms}$) because of the absence of a clear, life-threatening stimulus. As a result, we expect that murrelets will generally continue to forage within these lower intensity sound fields as a learned response to the stimulus (habituation). In fact, habituation may have already occurred in many of the murrelets.

Interspecific resource partitioning between seabirds within tidally influenced marine habitat suggests murrelets likely forage in traditional areas (Irons 1998; Holm and Burger 2002). Murrelets that traditionally forage in the Action Area have likely encountered these sound fields in the past (the Navy has historically used sonar and conducted countermeasure testing in the Action Area generating thousands of underwater acoustic waves in excess of 150 dB$_{rms}$). We thus expect habituation to these lower-intensity sound fields has already occurred in murrelets that traditionally forage within the DBRC and KTR.

On the other hand, some murrelets may have no previous exposure to these sound fields and may have a stronger behavioral response initially, but as reasoned above, they are not likely to abort foraging as a result of encountering a sound field. Therefore, the FWS expects the effects on the normal feeding behavior of murrelets to be insignificant.

[12] Habituation is a simple form of learning, in which an animal, after a period of exposure to a stimulus, stops responding. Habituation can occur at different levels in the nervous system. Sensory systems may stop, after a while, sending signals to the brain in response to a continuously present or often-repeated stimulus (Cohen et al. 1997). Or in other cases, the signals can be received in the brain, but the animal has learned to not respond (Rose and Rankin 2001).

The Physical Impacts[13] of Countermeasure Testing

We introduce here a brief discussion of the potential array of physical effects from underwater acoustic wave. We follow that with an evaluation specific to countermeasures and the types of effects to murrelets we anticipate.

High levels of underwater sound are known to have negative physiological and neurological effects on a wide variety of vertebrate species (Yelverton et al. 1973; Yelverton and Richmond 1981; Gisiner et al. 1998; Cudahy and Ellison 2002; USDD 2002; Hastings and Popper 2005). However, knowledge of the injurious effects of underwater sound specific to seabirds is largely limited to studies involving 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).

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). 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 (Fitch and Young 1948) found that diving cormorants were consistently killed by seismic blasts, and pelicans were frequently killed, but only when their heads were below water.

While these physical effects were associated with impulsive sound and at higher levels than the $183dB_{SEL}$ evaluated for countermeasure testing, our purpose is to introduce the extreme nature of effects associated with high intensity underwater sound pressure levels. The discussion that follows will therefore focus on those effects more directly linked to continuous sound sources.

Decreased auditory function from exposure to elevated SPLs is expected to cause Temporary Threshold Shift (TTS) that can last from hours to days (Gisiner et al. 1998, p. 26). Although TTS is categorized by many as a short-term fatiguing of the auditory system (rather than "injury") (Popper et al. 2006), Ryals et al. (1999) documented hair cell loss in birds that experienced acoustic overexposure from 12-24 hour exposures to continuous sound. Using scanning electron photomicrographs the authors were able to show that hair cell loss and damage on the surface of the papillae (pp. 75, 76, 77, 78, 80, 82). The FWS interprets the loss and/or physical damage of hair cells to be synonymous with injury.

The inner ear is most susceptible to auditory damage from trauma, although intense sound can also damage the middle and outer ear (Gisiner et al. 1998, p. 25). However, 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 a threshold shift depends upon several factors such as the sensitivity of the subject, and the received SPL, frequency, and duration of the sound (Gisiner et al. 1998, p. 25) and duration may have more influence (Ryals et al. 1999; Kastak et al. 2005). Although these effects are not completely understood, there is general agreement that: 1) there is considerable variation in responses within and between species, 2) hearing loss occurs near the exposure

[13] The FWS adopts the definition of the term "impact" as a physiological consequence affecting the general welfare of an individual (Beale 2007, p.113).

frequency (Hz) for narrow-band sound, and 3) hearing loss becomes irreversible under some combination of sound pressure level and exposure time (Saunders and Dooling 1974, p. 1; Gisiner et al. 1998, p. 25).

The majority of studies on auditory damage [with cats and rodents (especially chinchilla)] used relatively long duration stimuli (> 1 hour) and mid to low frequencies (1-4 kHz). These have 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 TTS, without adequate recovery periods, can also induce permanent, acute hearing loss (Gisiner et al. 1998).

To establish a threshold for the onset of TTS in murrelets from underwater sound, we relied largely on data from pinnipeds, particularly harbor seals (*Phoca vitulina*) (Kastak et al. 2005). While there are few morphological similarities between pinnipeds and seabirds, both groups are amphibious, spend a significant amount of time foraging at sea, and dive to pursue prey. Additionally, both pinnipeds (Popper and Ketten 2008, p. 232) and seabirds (Ketten 2007) have evolved ear structures that are specially adapted to hearing in-air and in-water. Further, 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).

The only documented auditory ranges encountered for seabirds were for penguins. Woehler (2002) evaluated six species of penguins and concluded that emperor penguins (*Aptenodytes forsteri*) can detect the highest frequency sounds with an upper range limit of 12.5 kHz (p. 97) and a lower range of 500 Hz. In the absence of direct data, the frequencies of the species' vocalizations and the data from Woehler (2002) led us to assume a hearing range for murrelets of 500 Hz to 12.5 kHz. Greatest sensitivity in pinnipeds is between 700 Hz and 20 kHz (Federal Register 2008), so some overlap in the hearing range also occurs between pinnipeds and seabirds. Based upon life history similarities, morphological similarities in ear structures and hearing needs, and the expected overlap in auditory range, the FWS believes pinnipeds represent an appropriate surrogate for determining the onset of TTS.

Exposure to narrow-band sound at a certain dB level above a species-specific hearing threshold will induce TTS (Ketten 2004). A common way to predict the onset of TTS is to determine a species' range for best hearing sensitivity and then apply criteria at some level above the threshold for that species. However, the hearing sensitivity of marbled murrelets is not known, so this method is not currently possible.

Instead, we utilize the work of Kastak et al. (2005), who examined the interactions of amplitude and duration in inducing TTS from continuous sound exposure based upon the SEL upon three pinnipeds - a Californina sea lion (*Zalophus californianus*), a harbor seal (*Phoca vitulina*), and a northern elephant seal (*Mirounga angustirostris*), all of which are amphibious mammals and presumably experienced similar adaptive forces as seabirds that gave rise to the role and anatomical structure of the ears. Their study exposed pinnipeds to pure tones for durations of up

to 50 minutes and found a significant linear relationship between SEL and magnitude of TTS (p. 3161). The onset of TTS occurred in harbor seals at SPLs of approximately 183 dB_{SEL} (Kastak et al. 2005, p. 3162).

To establish a threshold for the injurious effects of high underwater SPLs from continuous sound, the FWS adopted the findings of Kastak et al. (2005) from their work on harbor seals and established 183 dB SEL to be the threshold for the potential onset of TTS in murrelets. While peak pressure is useful for high-pressure transient waves, it does not correlate well with injury to non-auditory tissues (Hubbs and Reichnitzer 1954). Hastings and Popper (2005) recommend use of an SEL to better account for both the negative and positive pressure excursions.

Injury to marbled murrelets is therefore expected if the accumulated energy received exceeds 183 dB (re: 1 μPa^2-sec). This approach assumes that there will be a break of at least 12 hours between acoustic events allowing for murrelets recovery from exposure to high SPLs.

The Scope and Severity of Murrelet Injury from Countermeasure Testing

The FWS relied largely upon the study by Kastak et al. (2005) to establish the metric and threshold levels for the effects and a second study by Ryals et al. 1999) to describe the effects of continuous sound on murrelets. The research of Ryals et al. (1999), in particular, was aimed at describing whether the variability in susceptibility and recovery to acoustic overstimulation of continuous sound among four bird species was due to species differences or whether the differences were due to methodological, exposure condition, or hearing assays (of hair cell loss).

Hearing Threshold Shift

In humans, exposure to continuous airborne noise 90 to 100 dB above hearing threshold has been documented to cause TTS and permanent threshold shift (PTS) at exposures of 80 dB above hearing threshold and an exposure duration of 8 hours per day for 10 years (Richardson et al. 1995). It is uncertain to what degree these "dB-above threshold criteria" are applicable to other taxa (see Richardson et al. 1995; Wartzok and Ketten 1999), but the work of Ryals et al. (1999) lends insight to the role of sound pressure level, frequency, and duration in inducing TTS in four bird species - Japanese quail (*Coturnix coturnix japonica*) (n=9), budgerigars (*Melopsittacus undulates*) (n=7), canaries (*Serinus canaria*) (n=2), and zebra finches (*Taenopyga guttata*) (n=2).

Studies on several taxa including fish, birds, and terrestrial mammals indicate that the degree of TTS is linearly correlated with the hearing threshold, with a greater magnitude of TTS at frequencies in those species with a high sensitivity compared to species with low sensitivity (Linear-threshold-shift-hypothesis; Smith et al. 2004b). Ryals et al. (1999) exposed all birds to 2.86 kHz continuous tones, the most sensitive frequency in all species, at 112 dB or 118 dB SPL for 12 hours and at 120 dB SPL[14] for 24 hours using a fewer number of birds from each species.

The results showed dramatic differences in the initial amount of threshold shift between species and in the amount and rate of recovery. Quail and budgerigars showed the greatest susceptibility to hair cell loss from the 112 dB and 118 dB SPL exposures with observed -70 dB (quail) and -

[14] Although the metric used in Ryals et al. (1999) was not clear to the FWS, we assume the metric was "peak" SPLs.

40 dB (budgerigars) threshold shifts while canaries and finches showed no measureable responses. While the budgerigars showed a near-full recovery (within 10 dB of pre-exposure sensitivity) in three days, quail never achieved full recovery. One year after exposure the quail still showed a -20 dB threshold shift (PTS). All showed varying amounts of missing hairs cells following a 24-hour exposure to 120 dB SPL at 2.86 kHz. The occurrence and/or duration of threshold shifts is clearly a species-specific response that appears to be dependent on the duration of exposure, sound level, and frequency (Hz).

Countermeasure testing will generate continuous SPLs at approximately 233 dB (at source) for 30 minutes (4 tests) to 24 hours (1 test) within the entire mid-frequency band (1-5 kHz), well above the SPLs evaluated by Ryals et al. (1999). The Navy estimates the SPLs from the five countermeasures will attenuate to 183 dB_{SEL} at a distance of 123 m. With this information, the FWS estimates up to 30 murrelets will be exposed to five countermeasure tests (during the winter period).

Given the anecdotal observations of murrelets and seabirds diving within 75 m of active pile driving sites (and presumably continuing to forage even after encountering sound fields with high SPLs), we expect murrelets will be exposed with a minimum of 183dB_{SEL} throughout the test duration. Based largely upon the studies of Kastak et al. (2005) and Ryals et al. (1999), the FWS expects physical impacts to all 30 murrelets that would result in either a temporary or a permanent reduction in hearing sensitivity (TTS and PTS).

For the purposes of the jeopardy analysis, we assume that 30 murrelets will be injured from the Navy's countermeasure testing. Ten (of the 30) murrelets have an increased likelihood of encountering high SPLs during multiple foraging bouts due to the 24 hour duration of one test, increasing the potential for PTS. Although we do not expect a net exposure of more than 1 or 2 hours because the 10 murrelets (equivalent to two flocks) are likely to forage at various distances from the sound source throughout the 24-hour countermeasure test period, full recovery to pre-exposure hearing sensitivity is not expected. The FWS expects these 10 murrelets to experience a more significant loss of hearing sensitivity.

For the remainder of the 20 murrelets exposed to shorter (less than 30 minutes) countermeasure tests, the FWS assumes TTS will be the most prevalent effect. However, the susceptibility of murrelets to hair cell loss is unknown. Therefore, PTS (as determined by the extent of unrecoverable hair cell loss) cannot be reasonably ruled out as a consequence for these murrelets, although the magnitude of any PTS is expected to be less due to the shorter exposure duration. In general, we expect most of the 20 murrelets to regain all of their hearing sensitivity within 12 to 24 hours following exposure [Kastak et al. 2005 observed recovery within 24 hours in the pinnipeds experiencing TTS from up to 50 minute exposures and the budgerigars with TTS from 12 hour exposures (compared to the 30 minute exposure from countermeasures) examined by Ryals et al. (1999) exhibited recovery within three days, although cell damage to inner ear structures was noted]. Some murrelets may require longer periods to return to pre-exposure hearing sensitivity.

The consequence on individual murrelets from PTS or TTS will be a temporary or permanent reduction in the capability to sense or detect acoustic, air-borne environmental sound. As a result, the FWS concludes the Navy's testing of countermeasures will injure 30 murrelets through cell damage to the inner ear structures that are likely to significantly impair essential behaviors such as feeding or sheltering.

PTS, TTS and Murrelet Fitness

We examined the effects of TTS and PTS upon individual murrelet fitness as influenced by the capability to perform three essential life functions – foraging, reproduction, and predator avoidance. Appreciable reductions in any "outputs" of these three life functions are assumed to reduce the fitness of individuals, or the populations those individuals represent, through changes in survival or reproductive rates that could logically influence murrelet viability in Conservation Zone 1.

It's important to clarify that affected murrelets could exhibit an incremental drop in the capability to reproduce and yet have no change in individual survival. On the other hand, individual survival would logically be affected if the capabilities contributing to successful foraging or predator avoidance are reduced. Yet murrelet population viability can be affected by all three. To address the nuances of each outcome, we attempted to answer three questions central to this risk analysis.

1) Would the occurrence of TTS or PTS reduce a murrelet's ability to forage?
2) Would the occurrence of TTS or PTS reduce a murrelet's ability to reproduce?
3) Would the occurrence of TTS or PTS reduce a murrelet's ability to detect and avoid predators?

Hearing Threshold Shifts

For this analysis, we defined a sound-induced threshold shift as a reduction in an organism's hearing sensitivity within a portion of the organism's hearing range after the work of Kastak et al. (2005) and Ryals et al. (1999). The reduction can be either be minor (less than 24 hr or temporary) or permanent, and vary as a function of duration, SPL, sound frequency (Hz), and an organism's susceptibility. Considering these variables at the levels reported by the Navy for the underwater sound produced by countermeasure testing, it appears that while threshold shifts *reduce* the hearing sensitivity of affected animals, hearing is not *eliminated.* That is, animals seem to retain a portion of their hearing sensitivity within the hearing range affected by TTS.

Murrelets experiencing a threshold shift will have a reduced capability of detecting and responding to acoustic cues from vocalizations play an important role in incubation exchanges, flight, social interactions at sea including feeding and courtship, and prey delivery interactions with nestlings. Non-vocal sounds generated in flight with the species wings may also serve important roles of maintaining pair bonds and communicate aggression as a means to maintain territorial boundaries at nest sites (Nelson 1997).

Murrelets with Temporary Threshold Shift

The obvious characteristic exhibited by organisms with a temporary, noise-induced reduction in hearing sensitivity is that hearing sensitivity recovers to pre-exposure sensitivity. Thus, the question of preeminent importance to address, before the effects of TTS can be assessed, is what duration of reduced hearing would be reasonable to expect in murrelets? To answer this question, we again turn to work of Kastak et al. (2005) on pinnepeds (underwater) and Ryals et al. (1999) on birds (in air).

Both research efforts clearly documented the occurrence of TTS in the subjects exposed to continuous sound as well as a return of the individuals to their pre-exposure hearing sensitivity. However, the recovery from TTS in pinnipeds was within 24 hours and TTS-afflicted birds was 72 hours[15] regardless of the received exposure levels tested. Pinnipeds received doses ranging from 137 dB - 174 dB_{peak} re: 1 μPa SPL (all at 2.5 kHz) and birds received a narrower range of doses from 112 dB – 120 dB re: 1 μPa SPL (all at 2.86 kHz). The exposure duration varied significantly, however. Pinnipeds were exposed for 20, 22, and 50-minute durations and the birds were exposed for 12 hour and 24 hour durations.

An important principle emerges from close examination of both studies: duration of sound exposure had a greater effect on magnitude of the threshold shift in the tested animals than did the received sound exposure level. As a logical extension of this principle, we assume the magnitude of the threshold shift also is positively correlated with the duration of TTS, at least for intra-specific comparisons. We infer these relationships between exposure duration, the magnitude of TTS, and duration of TTS affect all taxa, including murrelets, in a similar manner.

The received SPLs, exposure durations, and corresponding frequencies examined by Kastak et al. (2005) are similar to the received SPLs (183 dB_{SEL}) and duration (20-30 min) associated with countermeasure testing. The exposure duration for the birds in the study by Ryals et al. (1999) were significantly longer, making extrapolation of the results for the three-day TTS recovery period less reliable in this analysis. Therefore, based on the recovery period of pinnipeds, we assumed a maximum 24 hour recovery period for murrelets, although the magnitude and duration could not be established with scientific evidence.

We now consider the fitness consequences for murrelets attempting to cope with TTS for a 24 hour period (i.e., to what extent the capability of murrelets to forage, reproduce, and avoid predators might be diminished). Given that murrelets will encounter these sound fields during the winter period (Table), the acoustic signals associated with prey delivery interactions with nestlings and other non-vocal sounds generated by breeding adults associated with the nesting season (summer period) will not be affected. Nonetheless, we expect up to 20 murrelets will have a temporary reduction in hearing sensitivity important for 1) detecting and responding to acoustic cues from vocalizations associated with flight and social interactions at sea that may be important for feeding and courtship during the winter period and 2) predator detection/avoidance.

[15] Ryals et al. (1999) documented "recovery" from TTS in budgerigars within 10 dB of pre-exposure hearing sensitivity in three days.

With a reduced hearing sensitivity, it would be reasonable to expect TTS to impair the response mechanisms necessary for energetically efficient foraging and early predator detection behaviors for the 24 hour period following exposure, if these behaviors were hearing dominated. However, we don't expect this to be the case with either behavior.

The FWS assumes successful foraging and predator detection by murrelets are sight-dominated behaviors, though hearing clearly is an important sensory mechanism for both foraging and predator detection. Further, murrelets during the winter often occur in congregations on marine waters where survival-dependent behaviors such as foraging and predator detection are enhanced. Thus, we expect murrelets suffering from TTS for a 24 hour period will continue to forage without a significant reduction in foraging success or reduced predator detection. As a result, it is extremely unlikely that individual murrelets with TTS will experience a reduction in their likelihood of survival.

Murrelets with Permanent Threshold Shift

Unlike the murrelets with TTS, the hearing sensitivity of murrelets with PTS is expected to be permanently reduced. This suggests there is a greater potential for the survival or lifetime reproductive success of these murrelets to be diminished during their lifetime. To adequately address the effects of PTS on individual murrelet survival or reproductive potential requires an age class-specific examination.

We previously (from Table 11 in the *Effects* section) estimated that the murrelet population in Conservation Zone 1 is comprised of 95.2 percent adults, 1.8 percent subadults, and 3.0 percent juveniles. Assuming all age classes will be similarly represented in the Action Area, we expect that the estimated 10 murrelets affected with PTS will likely consist of 9 adults and 1 subadult/juvenile.

Based on the assumption that prey capture is largely sight-dependent and that visual cues from conspecifics assist in foraging, we expect the 10 murrelets with PTS will forage throughout their lifetime without a significant reduction in foraging success. However, the consequences of a permanent reduction in hearing sensitivity may be more severe in the reproductive cycle and predator detection/avoidance because acoustic signals are inherently more integral to these behaviors.

Lifetime Reproductive Success

Receiving and transmitting acoustic signals (vocal and non-vocal) is an integral part of the murrelet reproductive cycle. Although not well understood, vocalizations likely play an important role in prey delivery interactions between breeding adults and their nestlings, courtship, pair bonding, and territory defense (Nelson 1997). Thus, we infer that murrelet reproduction (and lifetime reproductive success) is inherently linked to an individual murrelet's ability to successfully transmit and receive acoustic signals to and from conspecifics.

Generally, any loss in this ability could reasonably reduce the lifetime reproductive success of a murrelet. However, reproductive success has also been linked to experience. That is, reproductive success is often higher in older-aged breeding adult seabirds compared to younger-aged breeding adults (Pinaud and Weimerskirch 2002; Mauck et al. 2004; De Forest and Gaston 1996).

The nine adult murrelets with PTS are expected to have accumulated breeding experience from prior nesting seasons. Thus, they will have learned the acoustic signals associated with breeding, making them more adaptable to the potential deleterious effects of a reduction in hearing sensitivity. That is, we expect the adults will still be able to receive, and therefore recognize and associate important acoustic cues sufficiently to maintain their reproductive success. Therefore, it is unlikely that the nine adult murrelets with PTS will have a measureable reduction in their lifetime reproductive success due to PTS.

However, the estimated one subadult/juvenile with PTS that will enter adulthood in later years with a reduced capacity to receive acoustic signals and with no prior breeding experience, is not likely to readily be able to interpret those signals. As a result, there is an increased likelihood that the lifetime reproductive success of one murrelet will be lower than other same-aged murrelets without PTS. Thus, the reproductive potential of murrelets in Conservation Zone 1 is expected to be reduced.

Predator Detection

The importance of hearing is expected to be subordinate to the role of sight when considering the mechanistic triggers for predator detection in murrelets. Most of the documented predators of adult-sized, flight-capable murrelets are avian (Nelson 1997). Over a short period of time reduced hearing sensitivity in the form of TTS was expected to have a negligible effect on the risk of predation as previously discussed. However, reduced hearing sensitivity is a more significant consideration for all age classes when assessing the lifetime risk of murrelets to predation.

Considering that murrelets are long-lived birds (15 to 20 years) with relatively high estimated survival rates (0.83-0.93) (McShane et al. 2004; Beissinger 1995), it is reasonable to assume that murrelets with a reduced hearing sensitivity from PTS, particularly the less experienced, younger murrelets, will have an increased likelihood of predation.

Current estimates of murrelet survival range from 0.83 to 0.93 (midpoint is 0.88; McShane et al. 2004). From these rates, we infer that one to two of the nine murrelets, on average, would die under "natural" conditions annually (i.e., without PTS). Based upon an assumed subadult/juvenile survival rate of 0.6 to 0.7 (McShane et al. 2004), one subadult/juvenile murrelet (without PTS) would more often than not be expected to survive.

To evaluate a PTS-based increase in mortality from predation, we decreased murrelet survivorship by assuming four murrelets (of the 10) would die due to PTS-related impairment of hearing sensitivity for predator detection. To have a higher mortality rate than what would be expected for non-PTS birds, we assessed the population-level effects of PTS-induced mortality

in four murrelets for the purposes of assessing predation solely due to PTS. Mortality in murrelets with PTS may be more likely in younger, less-experienced murrelets, so we included the one subadult/juvenile with PTS along with three of the nine adults[16]. All mortalities would be attributed to avian predators in this risk scenario.

Effects from a Reduction in Prey

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

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

Murrelets are able to shift their diet throughout the year and over the years in response to prey availability (Becker et al. 2007). However, long-term adjustment to less energetically rich prey resources (such as invertebrates) appears to be partly responsible for poor marbled murrelet reproduction in California (Becker and Beissinger 2006). If prey availability is reduced in the Action Area, murrelets may be forced to switch to less energetically rich species, with reproductive consequences similar to those seen in California.

The status of herring stocks, in particular, may have important ramifications for murrelets in the marine environment (see Environmental Baseline). Any continued or further reduction in these stocks could adversely affect murrelets, particularly when they are feeding chicks.

[16] We elected, as a reasonable assumption, to consider four mortalities by selecting the younger portion from an assumed even distribution of ages among the 10 murrelets with PTS. Assigning an age to each of the nine adults (1 adult murrelet, age 3; 1 adult murrelet, age 5; 1adult murrelet, age 7; and so on through age 20) resulted in selecting three adults, with the hypothetical ages of 3, 5, and 7, as the most inexperienced among the nine adults. We assumed murrelets greater than age seven were more experienced and therefore more resilient to the deleterious effects on fitness from PTS. The fourth murrelet was the one of the ten murrelets assumed to be a subadult/junvenile.

A discussion regarding the effects to prey from underwater sound is presented in the effects section for bull trout critical habitat (under PCE 7 (Abundant Prey)). According to our analysis of the effects to herring, some mortality of herring is expected to occur due to the action. Information is currently insufficient, however, to establish that the estimated losses will have significant or measurable effects on herring populations in this Action Area. Therefore, we are unable to describe or infer measurable effects to marbled murrelets from impacts to prey.

CUMULATIVE EFFECTS (Bull Trout Critical Habitat and Marbled Murrelet)

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

There are ongoing activities in the Action Area that may affect marbled murrelets and bull trout critical habitat in the marine environment. These can include:

1) Release of petroleum products/additives created from oil spills.
2) Other contaminants from stormwater and wastewater discharged in the marine environment.
3) Lost fishing nets and discarded material from boats.
4) Disturbance from human activities such as vessel traffic.

Marbled murrelets and their prey species are likely to be negatively impacted by these activities. Direct exposure of marbled murrelets and their prey to degraded water quality is most likely during the late fall, winter, and early spring when rain events occur. Marine pollutants from industrial sources such as pulp mills, farms, wastewater and runoff from impervious surfaces (i.e., highways) could impact marbled murrelet populations. However, the extent of these effects is currently unknown (McShane et al. 2004). The response to these exposures will depend on the amount and concentration of contaminants discharged, which is dependent upon many factors (e.g., existence of stormwater BMPs, maintenance of the stormwater BMPs, time between rain events), and is therefore likely to be more severe in urbanized areas. Continued negative effects to prey abundance is of particular concern.

Abandoned and discarded gillnets are known to entangle seabirds, mammals and fish. Since the development of synthetic nets in the 1960s, lost nets can take decades to decompose. It has been estimated that 1,300 tons of derelict fishing gear is in the Puget Sound (Ith 2004). These nets entangle and kill large numbers of seabirds, particularly cormorants, loons and scoters (Good et al 2009). We expect that marbled murrelets will continue to be negatively impacted by derelict nets, but the impact will lessen over time as net removal projects continue with the objective of near elimination of nets, reductions in fishing and improved reporting of lost nets (Stiffler 2009).

Bull trout critical habitat is also likely to be negatively impacted those activities described above. Urban development will result in increased stormwater and wastewater discharges and degraded

water quality. This will result in adverse effects to PCE 7 (an abundant food base including terrestrial organisms of riparian origin, aquatic macro invertebrates, and forage fish) and PCE 8 (Permanent water of sufficient quantity and quality such that normal reproduction, growth, and survival are not inhibited). Marine critical habitat on the Washington coast and in Puget Sound has already been significantly altered by human development (PSWQAT 2000). Global changes in sea level and climate may be having widespread effects on critical habitat, and on the Puget Sound ecosystem as a whole (Klarin et al. 1990; Thom 1992) and will likely exacerbate the degradation caused by human activities.

INTEGRATION AND SYNTHESIS OF EFFECTS (Marbled Murrelet)

Murrelets foraging in the KRCE Action Area are expected to suffer physical impairment from exposure to underwater acoustic waves (> 183 dB_{SEL}) stemming from the Navy's countermeasure testing. These effects are anticipated to occur during the winter period at either DBRC or KTR from a total of 5 countermeasure tests (1 per year) that will be conducted while murrelets feed in the vicinity of the test location. The combination of high SPLs within the expected hearing range of murrelets during murrelet foraging bouts is expected to cause TTS and PTS in up to 30 murrelets in Conservation Zone 1 and are expected to affect all age classes.

The effects of TTS are not likely to reduce the fitness of murrelets because of the expected short term duration (not to exceed 24 h) of the reduced hearing sensitivity. However, the effects of a permanent reduction in hearing sensitivity (PTS), while not expected to lead to direct mortality, were assumed to appreciably decrease the likelihood of some murrelets detecting and avoiding predators over their lifespan. Based upon professional judgment, we assumed for the following analysis that an estimated three of breeding-aged murrelets with PTS and one subadult with PTS would have a lower likelihood of survival and would be removed from the murrelet population in Conservation Zone 1. As a result, we concluded the Action would lead to the loss of up to four murrelets in Conservation Zone 1.

Approach to the Risk Analysis

In accordance with regulations under section 7 of the Act, the risk posed by the Action will be assessed in terms of whether the effects of PTS and TTS in up to 30 murrelets (up to 10 of which would experience PTS in a reasonable worst case analysis) in Conservation Zone 1 will measurably reduce the likelihood of survival and recovery of murrelets in the affected population (Conservation Zone 1) and within the listed portion of the species range. Just as the continued existence of a species depends upon the fate of the populations that comprise them, so the continued existence of one or more populations is determined by the fate of individuals that comprise them. In other words, the abundance and distribution of murrelets within the listed range of the species (Conservation Zones 1 – 6[17]) depends upon whether or not the individuals within each Conservation Zone increase or decrease in response to the ability of individual murrelets to survive, grow and mature, reproduce, and commute within and between the species' range.

[17] For convenience in this analysis, the murrelets within each Conservation Zone were considered to comprise separate, non-isolated subpopulations such that immigration and emigration are uninhibited.

In the *Effects* section, we identified the consequences of TTS and PTS for the 30 murrelets exposed to continuous sound with a high SPL underwater. These effects may diminish the capability of murrelets to live, grow, mature, reproduce, and move. In this section, we describe the potential change in "fitness" of affected murrelets. Maintaining the fitness[18] (the growth, survival, and lifetime reproductive success) of individuals is a necessary attribute of viable populations. We therefore assess how the possible reduction in fitness of individual murrelets occurring in the vicinity of active countermeasure tests may, in turn, affect the survival and recovery of murrelets in Conservation Zone 1. We then address how these effects would ultimately affect the survival and recovery of the murrelet within the listed range of the species.

Reducing the fitness of individuals in a population is not always sufficient to reduce the viability of a population, nor is reducing the viability of a population always sufficient to reduce the viability of a species. Thus, our final analysis includes the baseline conditions of the population (Conservation Zone 1) and species (listed range) as reference points.

The base conditions used for evaluating the consequence of impacts to individuals at the scale of the affected subpopulation are presented in the *Environmental Baseline* and *Status of the Species in the Action Area* sections of this opinion. In particular, we assess the consequences of the Action by describing the expected changes, if any, in murrelet reproduction, numbers, and distribution in the Action Area. This risk analysis is then carried forward into an analysis of murrelet extinction risk at the Conservation Zone and rangewide scales.

As described in the FWS's 5-year review of the murrelet's status (USFWS 2009), the current breeding success of the species (in all Conservation Zones) is significantly below the level required to insure the long-term survival of the species. Of even greater concern, a statistically significant decline was detected in Conservation Zone 1 for the 2001-2008 period and the decline in Conservation Zone 3 is approaching significance (p=0.0731) for the 2000-2008 period (Falxa et al. 2009, p. 14). The overall population trend from the combined 2000-2008 population estimates (Conservation Zones 1 - 5) indicate a statistically significant, rangewide annual rate of decline in the range of 2.4 to 4.3 percent (Falxa et al. 2009, p. 14), or about 490 birds per year (se = 241, p = 0.0412). This equates to an overall estimated 21.6 percent decline during the 2000-2008 survey period.

Our final determination in this biological opinion, including any identified effects from the *Cumulative Effects* section, is based upon whether or not the murrelet within its listed range is likely to experience a further reduction in viability (survival and recovery) and whether or not a reduction is likely to be appreciable. We use quantitative methods to the extent practicable to inform our inferences.

[18] Fitness is the response of an individual organism or a population of organisms to natural selection and is commonly measured by an individual's reproductive success or, for a population, the number of offspring contributed to the next generation in relation to the number of offspring required to maintain the subject population at its' current size.

The Basics of Population Change

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

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

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

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

To determine the importance of demographic consequences caused by the action, we compare estimates of population parameters (adult survival and fecundity) with and without the action. We begin this analysis with a more detailed investigation of the population status of

Conservation Zone 1, as briefly presented in the *Status of the Species* section of this Opinion. We then consider both the short- and long-term changes in demographic survival rates and fecundity in relation to the survival and recovery of the species, first at the scale of Conservation Zone 1 and then throughout the listed range.

Population-level Consequences

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

Current population estimates indicate four Conservation Zones contain relatively robust numbers of murrelets (Zones 1 - 4). However, the historical frequency of sudden, wide-spread lethal impacts from oil spills (Bentivoglio et al. 2002; Ford et al. 2001) coupled with exceedingly low annual reproduction of murrelets, raises significant uncertainty for the viability and long-term survival of the species (McShane et al. 2004).

The 2007 and 2008 abundance estimates within the species listed range were the lowest recorded since inception of the NWFP Effectiveness Monitoring program (Falxa et al. 2009, p. 9), with the current population size within the listed range of the species estimated at 17,965 birds (95% CI: 14,722 - 21,208; USFWS 2009, p.16). Trend analyses of the change in murrelet abundance within Conservation Zones 1 – 5 did not detect statistically significant trends at the scale of the Conservation Zone for 2000-2008[19], yet the decline in Conservation Zone 3 is approaching significance (p=0.0731) for the 2000-2008 period (Falxa et al. 2009, p. 14). The overall population trend from the combined 2000-2008 population estimates (across all Conservation Zones 1 - 5) indicate a statistically significant, rangewide annual rate of decline from 2.4 to 4.3 percent (Falxa et al. 2009, p. 14), or about 490 birds per year (se = 241, p = 0.0412). This equates to an overall estimated 21.6 percent decline during the 2000-2008 survey period.

Murrelets currently occupy the full spatial extent of their historical distribution, but the area of occupancy within their range may be reduced from historic levels. The species distribution exhibits five areas of discontinuity: a segment of the border region between British Columbia, Canada and Washington; southern Puget Sound, Washington; Destruction Island, Washington to Tillamook Head, Oregon; Humboldt County, California to Half Moon Bay, California; and the entire southern end of the breeding range in the vicinity of Santa Cruz and Monterey Counties, California (McShane et al. 2004, p. 3-70).

The current range of estimates for Ŕ, the juvenile to adult ratio, is below the level necessary to maintain or increase the murrelet population. Whether derived from marine surveys or from population modeling (R = 0.02 to 0.13, Table 2, Appendix A), the available information confirms that the current ratio of hatch-year birds to after-hatch year birds is insufficient to maintain stable numbers of murrelets throughout the listed range. The current estimates for Ŕ

[19] If the 2000 data are excluded, trend analyses detected a highly significant decline in Conservation Zone 1 (p = 0.0099) with an estimated annual rate of decline of 7.9 percent (SE = 183) or 577 birds per year.

also appear to be well below what may have occurred prior to the murrelet population decline (Beissinger and Peery (2007, p. 298). Model predictions forecast an extinction risk of 16 percent, with a 3-state mean population size of 45 individuals in 100 years in the listed portion of the species' range (McShane et al. 2004, p. 3-58). Thus, the breeding success throughout the species' listed range is currently too low to maintain or increase populations (McShane et al. 2004). The prediction for λ, the intrinsic rate of population change (all Conservation Zones) during the current decade (2001-2010), ranges from -3 percent to -6.2 percent (McShane et al. 2004).

The best available science indicates that murrelet populations are currently incapable of reproducing sufficiently to maintain population viability throughout the listed range. Therefore, we agree with Ralph et al. (1995) that the low annual maximum reproductive capability of female murrelets, among the lowest of all alcids, warrants greatest attention in conservation and recovery planning. This inherently low annual reproductive capability coupled with the suite of mortality factors affecting murrelets in Conservation Zone 1, indicates that the species will continue to experience local and rangewide population declines in the foreseeable future. Thus, the survival and recovery of the species appears to be dependent upon the protection/improvement of adult survival and breeding success.

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

Conservation Zone 1

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

To evaluate the consequences of the loss of four murrelets, we assumed the following: 1) that the action-caused mortality will be an additive mortality source; 2) that the future population growth rate for the species will remain negative (for all Conservation Zones) for at least next several years; and 3) all four murrelets are residents of Conservation Zone 1. Thus, the consequence of additional murrelet mortality is straightforward: two female, breeding-aged murrelets "removed" from the murrelet population by the effects of PTS, and any reproduction

later in time from those two females (assuming a 1:1 sex ratio in murrelet populations) is not expected to be replaced through natural reproduction at any time in the foreseeable future.

Evidence suggests that the species is highly constrained by poor fecundity (McShane et al. 2004). The latest population estimate for the listed portion of the murrelets range is 17,965 (95 percent Confidence Interval: 14,722 – 21,208; Falxa et al. 2009).

To determine whether this permanent loss in two breeding-aged female murrelets (and any future reproduction) will appreciably reduce the likelihood of murrelet persistence, we considered the number of females currently present in the rangewide population estimate. With the current rangewide population size of 17,965 murrelets (Falxa et al. 2009), we estimate the population contains approximately 8,983 females and approximately 40 percent of the females (3,593) are expected to occur in Conservation Zone 1.

Considering the estimated -3.40 percent annual rate of population change in Conservation Zone 1 during the next decade (McShane et al. 2004, pg. 3-52), the number of females is expected to decrease by approximately 121 individuals annually (3,593 – 3.40 percent). This Action results in the additional loss of two female murrelets sometime during the implementation period (2010-2015) of the KRCE.

Consistent with the analysis included in the FWS's 2008 Biological Opinion on the Navy's Explosive Ordinance Demolition Training (USFWS 2008), we evaluated the change in murrelet reproductive potential in subsequent generations and determined that up to two additional female offspring can be expected to be removed from Conservation Zone 1 (the hypothetical offspring of the two, breeding-aged females removed) during the next three generations as a result of the action.

We calculated the consequence of four adult-aged murrelet mortalities (two females) on the long-term reproductive potential of the subpopulation using the following assumptions (constants): an adult breeding rate of 0.65, a juvenile ratio of 0.0621, a murrelet abundance of 4,699 (Conservation Zone 1), a murrelet life span of 15 years, a fecundity of 0.096 young/nest attempt[20], a 1:1 sex ratio, and the demographic rates presented in Appendix A. Hypothetically, four adult murrelets would likely produce two juvenile murrelets (arriving at sea) during the period 2010 – 2028 (first generation). These young, on average, would be expected to produce an additional two murrelets during their lifetime in the second and third generations (2024-2045) following implementation of this action (Appendix A). Thus, a total (direct and indirect) loss of eight murrelets would be expected sometime during the 2010-2045 period (four females).

The expected change in the population-level, reproductive potential of murrelets in Conservation Zone 1 as a result of the Action is approximately 0.17 percent, based upon a change in the

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

number of females [100 x (4/2,350)]. Consequently, we conclude that the annual murrelet reproductive output will likely not be measurably reduced in Conservation Zone 1 due to the Action. We base this conclusion largely upon two factors: 1) the small change in number of females compared to the expected high variability in lifetime reproductive success (fitness) between individuals and 2) the expected low annual number of breeding adults. The abundance of female murrelets appears to be sufficiently high that the loss of four female murrelets from Conservation Zone 1 is not likely to be appreciable at either the Conservation Zone or the rangewide scale.

Given these considerations, we do not anticipate the effects from mortality would reduce appreciably the likelihood of survival and recovery of murrelets in Conservation Zone 1. Based upon the magnitude of the change in female abundance, we do not expect murrelet persistence in Conservation Zone 1 to be appreciably reduced due to the Action, nor do we expect an appreciable reduction in persistence at the scale of the listed range of the species.

CONCLUSION

Bull Trout Critical Habitat

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

After reviewing the current status of bull trout critical habitat, the effects of the proposed action, and the cumulative effects, it is the FWS's Biological Opinion that the Keyport RDT&E activities, as proposed, are not likely to destroy or adversely modify designated bull trout critical habitat. Our determination is based on the following rationale:

Potential significant adverse effects to bull trout critical habitat as a result of the proposed action are limited to adverse effects to PCE (7), an abundant food base within the DBRC geographic area. However, we could not establish that these effects would measurably alter the function of designated critical habitat in the Action Area. The anticipated effects of the action, combined with the effects of interrelated and interdependent actions, and cumulative effects, are not expected to alter the ability of critical habitat to serve its intended recovery role for the bull trout within the Action Area, the critical habitat unit, or the coterminous range of the species.

Marbled Murrelet

After reviewing the current status of the murrelet, the environmental baseline for the Action Area, the effects of the proposed Keyport RDT&E activities, and the cumulative effects, it is the FWS's Biological Opinion that the Keyport RDT&E activities, as proposed, is not likely to jeopardize the continued existence of the murrelet.

We base this conclusion on the analysis presented in the Integration and Synthesis section where the overall change in fecundity of the species was biologically insignificant. In other words, we do not expect that the combined effects of the initial loss of four murrelets (two females) in 2010-2015 and the subsequent loss of four more murrelets (2 females) during 2010-2045 will be appreciable at the scale of the Conservation Zone 1 (3,593 females) or at the rangewide scale (8,677 females). Thus, this Action is not expected to appreciably reduce the likelihood of survival and recovery of the species. As a result, we conclude the Project will not jeopardize the continued existence of the murrelet.

INCIDENTAL TAKE STATEMENT

Federal regulation pursuant to section 4(d) and section 9 of the ESA prohibit the take of endangered and threatened species, respectively, without special exemption.

Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct.

Harm is defined by the FWS as an act, which actually kills or injures wildlife. Such 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 FWS as an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering (50 CFR 17.3).

Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the 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 so that they become binding conditions, as appropriate, for the exemption in section 7(o)(2) to apply. The Navy has a continuing duty to regulate the Action covered by this incidental take statement. If the Navy 1) fails to assume and implement the terms and conditions or 2) fails to require the KTRE to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, 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 FWS as specified in the incidental take statement [50 CFR 402.14(i)(3)].

EXTENT OF TAKE

The FWS anticipates up to 30 murrelets could be taken as a result of this proposed action. The incidental take is expected to be in the form of harm due to the effects of TTS and PTS caused by countermeasure testing. This take would occur during the 5 years of implementation of the proposed action.

The FWS will not refer the incidental take of any migratory bird for prosecution under the Migratory Bird Treaty Act of 1918, as amended (16 U.S.C. 703-712), if such take is in compliance with the terms and conditions (including amount and/or number) specified herein.

EFFECT OF THE TAKE

In the accompanying Opinion, the FWS determined that this level of anticipated take is not likely to result in jeopardy to the marbled murrelet.

REASONABLE AND PRUDENT MEASURES

The FWS believes the following reasonable and prudent measures are necessary and appropriate to minimize take of marbled murrelets:

Reasonable and Prudent Measure 1: Conduct testing activities at locations and times to minimize exposure of marbled murrelets to sound from countermeasures.

Reasonable and Prudent Measure 2: Reasonable and Prudent Measure 2: Assure that performance measures described in the Conservation Measures section in the project description, are met to assure that incidental take is not exceeded.

TERMS AND CONDITIONS

In order to be exempt from the prohibitions of section 9 of the Act, the Navy must comply with the following terms and conditions, which implement the reasonable and prudent measures described above and outline required reporting/monitoring requirements. These terms and conditions are non-discretionary.

To Implement Reasonable and Prudent Measure 1:

1) Where practicable (as determined by the Navy) during the summer, conduct long duration (exceeding 30 minutes) countermeasures tests in the KTR instead of DBRC.
2) Where practicable (as determined by the Navy), conduct countermeasure testing activities during the summer rather than the winter.

To Implement Reasonable and Prudent Measure 2:

1) Annual Testing Report - The Navy shall submit an Annual Report for the KTR and DBRC on April 1 of every year (covering data gathered through December 31 of the prior year). These data can be characterized broadly describing frequency level and duration with regard to location and date. These data shall be summarized at the end of the 5-year period in a report as well.

These reports shall contain the exercise information for each countermeasure event:

a) Date and times that event began and ended
b) Location
c) Total hours that sound was generated
d) Frequency/ies and maximum source levels generated during event

2) To the extent practicable, the Navy, in coordination with FWS, shall develop and implement a method of summarizing countermeasure activities geographically and seasonally across the KTR and DBRC. The Navy shall develop this method, in a coordinated Navy-FWS joint report format, 6 months from the date of the issuance of the Record of Decision for this action.

3) The Navy, in coordination with the FWS, shall develop and implement a plan to monitor compliance with the performance measures for countermeasure sound sources described as part of the action. This monitoring plan will be completed within 6 months from date of the Record of Decision for this action and subject to approval by Navy and FWS. The plan and reporting will be in a coordinated Navy-FWS joint report format, ensuring classification requirements are met.

The FWS believes that no more than 30 murrelets will be incidentally taken as a result of the proposed action. The reasonable and prudent measures, with their implementing terms and conditions, are designed to minimize the impact of incidental take that might otherwise result from the proposed action. If, during the course of the action, this level of incidental take is exceeded, such incidental take represents new information requiring reinitiation of consultation and review of the reasonable and prudent measures provided. Exceedance of the incidental take level could occur should the performance measures described not be met or the numbers or duration of activities be exceeded. The Federal agency must immediately provide an explanation

of the causes of the taking and review with the FWS the need for possible modification of the reasonable and prudent measures.

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

CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs the Navy to utilize their authorities to further the purposes of the ESA 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. These recommendations are provided to the Navy, recognizing that these may not be within the scope of the mission of the NUWC, Keyport.

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

Marbled Murrelet

- During the marbled murrelet nesting season (April 1 to September 15) avoid sonar testing, where feasible, during the period from 2 hours before sunrise to 2 hours after sunrise.
- Develop, in coordination with the FWS, and implement a plan to monitor compliance with the performance measures for sonar sound sources described as part of the action.
- The acoustical impacts of underwater sound on diving seabirds, specifically sonar and continuous high-energy sounds, are largely unknown. Our current assumptions are based on research on marine mammals and fish, which indicate there are potential physical effects. Potential research to address this are:

    1. Fund and develop, in coordination with the Washington Fish and Wildlife Office (WFWO), a research project using established two-dimensional computed tomography (CT) scan techniques for Cetacean species and apply it

to the marbled murrelet to ascertain the effects of high-intensity underwater sound on their tissues, auditory receptors, and airspaces. The WFWO is currently prepared to provide a draft research proposal and initial contacts for such an effort.

2. Fund and develop, in coordination with the WFWO, a research project to further our knowledge of the hearing sensitivity of marbled murrelets (using a surrogate such as another alcid) both in-air and in-water. The project could utilize a non-invasive physiological measurement technique such as auditory brainstem response to test hearing sensitivity. This work would constitute an important first step in documenting the peripheral auditory system of alcids and would substantially improve our understanding of the perception of sound by seabirds. The WFWO is currently prepared to provide a draft research proposal and initial contacts for such an effort.
3. In coordination with WFWO, assist in the identification of appropriate analysis methods for the types of continuous sounds generated by countermeasures, and their effect on diving seabirds, including the murrelet.

- Implement marbled murrelet surveys, following established protocols that would develop statistically valid data on murrelet densities and seasonable variability in KTR and DBRC. Data are most deficient in KTR and during the winter in KTR and DBRC.
- In coordination with the WFWO and other entities, develop and implement a seabird monitoring and reporting protocol during KRCE activities that produce sound levels that may be harmful to murrelets. Data collected should include the date and time of activity, the time survey is initiated and terminated, species of diving birds observed, distance of birds from sound sources and behavior and condition of birds. Murrelet and other alcid species identification training should be provided to all observers participating in the seabird monitoring.
- In coordination with WFWO, use an adaptive management approach to consider new data and monitoring information on an annual basis, to evaluate whether monitoring or conservation measures should be modified or added.
- Protect existing murrelet nesting habitat and manage to develop additional murrelet nesting habitat on Navy lands.

Forage Fish (Bull Trout Critical Habitat)

- Apply seasonal restrictions on training activities generating high levels of sound near herring holding and spawning areas and forage fish spawning beaches. Restrictions should be based on WDFW data.
- Conduct surveys on spawning beaches and holding areas located on Naval installations and implement restoration and improvement projects, where applicable, to increase the potential forage base for murrelets and bull trout.

Working Relationships

- Establish a Cooperative Working Group that includes the Services (FWS, National Marine Fisheries Service) and Navy Fleet, Installations, RDT&E Divisions to encourage cooperation between Navy, resource agencies and civilian experts. Early involvement will help identify issues and improve cooperation on developing solutions in order to facilitate consultations and protect listed species and their habitat.

REINITIATION NOTICE

This concludes formal consultation on the action(s) outlined in the request. As provided in 50 CFR 402.16, re-initiation 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 (such as failure to meet the performance measures) 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 NUWC Division, Keyport 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 by NUWC Division, Keyport, any RDT&E activities causing such take must cease pending re-initiation.

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APPENDICES

Appendix A: Status of the Species: Marbled Murrelet
Appendix B: Status of the Species: Bull Trout Critical Habitat

APPENDIX A

STATUS OF THE SPECIES: Marbled Murrelet

Legal Status

The marbled murrelet (murrelet) was listed as a threatened species[1] on September 28, 1992, in Washington, Oregon, and northern California (57 FR 45328 [October 1, 1992]). Since the species' listing, the FWS has completed two 5-yr status reviews of the species: September 1, 2004 (USFWS 2004) and June 12, 2009 (USFWS 2009). The legal status of the murrelet remains unchanged from the original designation.

Threats to Murrelet Survival and Recovery

Murrelets are long-lived seabirds that spend most of their life in the marine environment, with breeding adult birds annually nesting in the forest canopy of mature and old-growth forests from April 1 through September 15. Murrelets have a naturally low reproductive rate. Breeding adults lay just one egg and renesting, in the event of nest failure, is thought to be an extremely rare event.

Several threats to murrelets, present in both the marine and terrestrial environments, have been identified. These threats collectively comprise a suite of environmental stressors that, individually or through interaction, have significantly disrupted or impaired behaviors which are essential to the reproduction or survival of individuals. When combined with the species naturally low reproductive rate, these stressors have led to declines in murrelet abundance, distribution, and reproduction at the population scale within the listed-range.

When the murrelet was listed under the Endangered Species Act (57 FR 45333-45336 [October 1, 1992]) and summarized in the Recovery Plan (USFWS 1997a, pp. 43 -76), several anthropogenic threats were identified as having caused the dramatic decline in the species.

- 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; and
- manmade factors such as mortality from oil spills and entanglement in fishing nets used in gill-net fisheries.

[1] The Act defines a threatened species as a species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

There have been changes in the levels of these threats since the 1992 listing (USFWS 2004, pp.11-12; USFWS 2009, pp. 27-67). The regulatory mechanisms implemented since 1992 that affect land management in Washington, Oregon, and California (for example, the Northwest Forest Plan (NWFP)) and new gill-netting regulations in northern California and Washington have reduced the threats to murrelets (USFWS 2004, pp.11-12). The threat levels for the other threats identified in 1992 listing (57 FR 45333-45336 [October 1, 1992]) including the loss of nesting habitat, predation rates, and mortality risks from oil spills and gill net fisheries (despite the regulatory changes) remained unchanged following the FWS's 2004, 5-year, range-wide status review for the murrelet (USFWS 2004, pp.11-12).

However, new threats were identified in the FWS's 2009, 5-year review for the murrelet (USFWS 2009, pp. 27-67). These new stressors are due to several environmental factors affecting murrelets in the marine environment. These new stressors include:

- Habitat destruction, modification, or curtailment of the marine environmental conditions necessary to support murrelets due to:
    - elevated levels of polychlorinated biphenyls in murrelet prey species;
    - changes in prey abundance and availability;
    - changes in prey quality;
    - harmful algal blooms that produce biotoxins leading to domoic acid and paralytic shellfish poisoning that have caused murrelet mortality; and
    - climate change in the Pacific Northwest.

- Manmade factors that affect the continued existence of the species include:
    - derelict fishing gear leading to mortality from entanglement;
    - energy development projects (wave, tidal, and on-shore wind energy projects) leading to mortality; and
    - disturbance in the marine environment (from exposures to lethal and sub-lethal levels of high underwater sound pressures caused by pile-driving, underwater detonations, and potential disturbance from high vessel traffic).

Detailed discussions of the above-mentioned threats, life-history, biology, and status of the murrelet are presented in the Federal Register, listing the murrelet as a threatened species (57 FR 45328 [October 1, 1992]); the Recovery Plan, Ecology and Conservation of the Marbled Murrelet (Ralph et al. 1995); the final rule designating murrelet critical habitat (61 FR 26256 [May 24, 1996]); the Evaluation Report in the 5-Year Status Review of the Marbled Murrelet in Washington, Oregon, and California (McShane et al. 2004); and the 2004 and 2009, 5-year Reviews for the Marbled Murrelet (USFWS 2004; USFWS 2009).

Nesting Habitat Abundance

The destruction, modification, or curtailment of nesting habitat from logging, urbanization, and land use conversion has generally been regarded as the most influential environmental stressor that led to the 1992 Federal listing of the species under the Act. The FWS estimates that over 80 percent of the historic nesting habitat has been rendered unsuitable for nesting (57 FR 45328 [October 1, 1992]). Because of the important role nesting habitat plays in the survival and recovery of the species, significant attention has been given to describing the quality, quantity, and location of the remaining nesting habitat and planning for the restoration of nesting habitat in California, Oregon, and Washington.

Loss of Nesting Habitat Since 1992

The FWS has determined that the rate of habitat loss has declined since listing, particularly on Federal lands due to implementation of the NWFP (USFWS 2004, pp.11 and 13). Between 1992 and 2003, the estimated loss of suitable murrelet habitat totaled 22,398 acres in Washington, Oregon, and California combined, of which 5,364 acres resulted from timber harvest and 17,034 acres resulted from natural events (McShane et al. 2004, pg. 4-64). Those data primarily represented losses on Federal lands, and did not include data for most private or State lands within the murrelets' range.

More recently, Raphael et al. (2006) used habitat models to estimate losses of potential murrelet habitat for the period from 1994-1996 to 2002-2003 on both Federal and non-Federal lands within the five Conservation Zones in the NWFP area. Results indicate that losses of potential nesting habitat may be greater than previously estimated, with losses ranging from 61,000 to 279,000 acres (depending on the model, see discussion below) in the 5-Conservation Zone area, with 10 to 28 percent of habitat loss occurring on Federal lands and 72 to 90 percent on non-Federal lands.

Current Amount of Nesting Habitat

McShane et al. (2004, p. 4-2), reviewed and summarized habitat estimates from 16 sources and estimated the amount of murrelet nesting habitat at 2,223,048 acres distributed throughout Washington, Oregon, and California (McShane et al. 2004, p. 4-5). Washington State contains almost half of all remaining nesting habitat with an estimated 1,022,695 acres or 48 percent of the total. Approximately 93 percent (2,000,000 acres) are reported to occur on Federal lands (McShane et al. 2004, p. 4-10).

In another effort, Raphael et al (2006) produced two spatial models for the NWFP Effectiveness Monitoring (EM) program to predict the amount, location, and distribution of murrelet nesting habitat. Combining vegetation-based maps derived from satellite imagery and prior estimates of habitat on State and private lands from 1994 to 2003, Raphael et al. (2006, p. 109) used a panel of experts to reclassify 22 old-growth forest classes into four classes of murrelet habitat based upon nesting suitability. Referred to as the Expert Judgment Model, the model classifies existing forest structure, based upon percent conifer cover, canopy structure, quadratic mean diameter, and forest patch size, into four classes of suitability for nesting murrelets. Raphael et al. (2006,

p.116 - 123) found that across the murrelet range, most habitat-capable land (52 percent) is unsuitable nesting habitat (Class 1) and 18 percent is classified as Class 4 habitat (highest suitability), with an estimated 41 percent of the Class 4 habitat (1,620,800 acres) occurring on non-Federal lands.

The second habitat model developed by Raphael et al. (2006) used the Biomapper Ecological Niche-Factor Analysis methodology developed by Hirzel et al. (2002). The resulting murrelet habitat suitability maps are based on both the physical and vegetative attributes adjacent to known murrelet occupied polygons or nest locations for each NWFP province. The maps provide a range of habitat suitability values, each with acreage estimates. In Washington, 2.1 million acres of habitat were rated with a habitat suitability (HS) greater than 60 and captured 82 percent of the stands documented as occupied, while 440,700 acres of habitat were rated as HS >80 habitat and captured 36 percent of the known occupied stands.

The FWS believes the Expert Judgment and Ecological Niche Factor Analysis models, which relate known (occupied) murrelet nest stands to habitat abundance, distribution, and quality, represent the best available information on the subject. While not necessarily the best means to describe suitable habitat at the site scale, the FWS expects these models have higher reliability for provincial-scale analysis compared to previous efforts.

Population Status

The initial at-sea surveys for murrelets that began during the 1990s in the marine waters of Washington, Oregon, and California were generally independent and sporadic efforts to assess murrelet population status (abundance, trends, distribution, and fecundity). Through a more coordinated effort, researchers developed the EM Program for the NWFP (Bentivoglio et al. 2002) in 2000 that unified the various at-sea monitoring efforts within terrestrial portions of the five Conservation Zones contained within the planning area of the NWFP. At-sea surveys in Conservation Zone 6, though independent of the EM Program, are modeled after the EM Program survey methods. The at-sea survey data collected prior to the EM Program are generally not suitable for statistical comparisons or trend analyses due to differences in survey methods, (McShane et al. 2004).

<u>Abundance and Distribution</u>

Murrelet abundance during the early 1990s in Washington, Oregon, and California was estimated at 18,550 to 32,000 birds (Ralph et al. 1995). Through the efforts of the EM program, the 2008 murrelet abundance in the listed range of the species (Table 1) is estimated at 17,965 birds (14,722 – 21,208, 95 percent confidence interval (CI); USFWS 2009, p.16). Conservation Zones 3 and 4 support approximately 61 percent (11,036/17,965) of the murrelet population within the U.S., have the highest reported densities and the lowest within-zone statistical variation in population size (Falxa et al. 2009, p. 9). Murrelets occur in the lowest abundance in Conservation Zones 5 and 6 where just 1.6 percent of all murrelets were recorded during the 2008 surveys.

At the time of listing, the distribution of active nests in nesting habitat was described as non-continuous (USFWS 1997a, p 14). The at-sea extent of the species currently encompasses an area similar in size to the species historic distribution, but with the extremely low density of murrelets in Conservation Zones 5 and 6, the southern end of the murrelet distribution is sparsely populated compared to Conservation Zones 1-4.

Table 1. Estimates of murrelet density and population size (95 percent confidence interval (CI)) in Conservation Zones 1 through 6 during the 2008 breeding season (USFWS 2009, p. 16).

Conservation Zone	**Density** (birds/km^2)	**Coefficient of Variation** (% Density)	**Population Size Estimates with 95% CI**			**Survey Area** (km^2)
			Number of Birds	Lower	Upper	
1	1.34	17.0	4,699	3,132	6,201	3,497
2	1.18	21.1	1,944	1,187	2,843	1,650
3	3.87	15.4	6,176	4,175	7,903	1,595
4	4.18	19.4	4,850	3,688	7,325	1,159
5	0.14	50.5	121	-	242	883
6	-	-	174	91	256	-
Zones 1-6	-	-	17,965	14,722	21,208	-

The at-sea distribution also exhibits discontinuity within Conservation Zones 1, 2, 5, and 6, where five areas of discontinuity are noted: a segment of the border region between British Columbia, Canada and Washington, southern Puget Sound, WA, Destruction Island, WA to Tillamook Head, OR, Humboldt County, CA to Half Moon Bay, CA, and the entire southern end of the breeding range in the vicinity of Santa Cruz and Monterey Counties, CA (McShane et al. 2004, p. 3-70).

Trend

There are two general approaches that researchers use to assess murrelet population trend: at-sea surveys and population modeling based on demographic data. In general, the FWS assigns greater weight to population trend and status information derived from at-sea surveys than estimates derived from population models because survey information generally provides more reliable estimates of trend and abundance.

Marine Surveys

Researchers from the EM Program detected a statistically significant decline ($p \leq 0.05$) in the abundance of the surveyed populations in Conservation Zones 1 through 5 for the 2000-2008 sample period (Falxa et al. 2009, p. 14). The decline, estimated at 490 birds per year (Standard Error (se) = 241, $p = 0.0412$), or about 3,900 birds over the 9-year period (95% CI = ±4,553 birds), represents a 2.4 percent annual rate of decline (21.6 percent decline during the 2000 - 2008 survey period).

Because of a concern about possible departures from the survey protocol in 2000, Falxa et al. (2009) also report results from the 2001-2008 period without the 2000 data. In the absence of 2000 data, the estimated decline increases to 870 birds per year (standard error (se) = 129), or about 6,900 birds over the 8-year period (95% CI = ±2,533 birds), representing an annual decline of 4.3 percent (34.4 percent decline during the 2001-2008 survey period).

The 2008 population estimate for Conservation Zone 6 represents a decline of about 55 percent from the 2007 estimate and a 75 percent decline from the 2003 estimate (Peery et al. 2008), or an average decline of about 15 percent per year between 2003 and 2008. The 2007 and 2008 population estimates in Conservation Zone 6 are the lowest since the surveys began in 1999. The authors conclude that the murrelet population in central California has exhibited a significant and rapid decline from 2003 to 2008 (Peery et al. 2008).

Trend analyses detected no statistically significant trends in murrelet abundance at the scale of the Conservation Zone for 2000-2008.[2] However, using 9 years of survey data, the statistical power to detect decline rates of 2 to 4 percent per year was generally not high (Miller et al. 2006; pg. 57).[3] With a *p value* estimate of 0.07, it appears the change in murrelet abundance during the 2000-2008 sample period is approaching significance in Conservation Zone 3.

Population Models

Prior to the use of survey data to estimate trend, demographic models were more heavily relied upon to generate predictions of trends and extinction probabilities for the murrelet populaition (Beissinger 1995; USFWS 1997b; Cam et al. 2003; and McShane et al. 2004). However, murrelet population models remain useful because they provide insights into the demographic parameters and environmental factors that govern population stability and future extinction risk, including stochastic factors that may alter survival, reproductive, and immigration/emigration rates.

In a report developed for the 5-year Status Review of the Marbled Murrelet in Washington, Oregon, and California (McShane et al. 2004, p. 3-27 to 3-60), computer models were used to forecast 40-year murrelet population trends. A series of female-only, multi-aged, discrete-time stochastic Leslie Matrix population models were developed for each conservation zone to forecast decadal population trends over a 40-year period with extinction probabilities beyond 40 years (to 2100). The authors incorporated available demographic parameters (Table 2) for each conservation zone to describe population trends and evaluate extinction probabilities (McShane et al. 2004, p. 3-49).

McShane et al. (2004) used mark-recapture studies conducted in British Columbia by Cam et al. (2003) and Bradley et al. (2004) to estimate annual adult survival and telemetry studies or at-sea survey data to estimate fecundity. Model outputs predicted -3.1 to -4.6 percent mean annual rates of population change (decline) per decade the first 20 years of model simulations in

[2] If the 2000 data are excluded, trend analyses detected a highly significant decline in Conservation Zone 1 (p = 0.0099) with an estimated annual rate of decline of 7.9 percent (s.e. = 183) or 577 birds per year.
[3] The FWS does not consider the absence of a statistically detectable trend to be conclusive evidence of population stability.

murrelet Conservation Zones 1 through 5 (McShane et al. 2004, p. 3-52). Simulations for all zone populations predicted declines during the 20 to 40-year forecast, with mean annual rates of -2.1 to -6.2 percent per decade (McShane et al. 2004:p. 3-52). These reported rates of decline are similar to the estimates of -4 to -7 percent per year reported in the Recovery Plan (USFWS 1997b, p. 5).

Table 2. Rangewide murrelet demographic parameter values based on four studies all using Leslie Matrix models.

Demographic Parameter	Beissinger 1995	Beissinger and Nur 1997*	Beissinger and Peery (2007)	McShane et al. 2004
Juvenile Ratio (Ŕ)	0.10367	0.124 or 0.131	0.089	0.02 - 0.09
Annual Fecundity	0.11848	0.124 or 0.131	0.06-0.12	-
Nest Success	-	-	0.16-0.43	0.38 - 0.54
Maturation	3	3	3	2 - 5
Estimated Adult Survivorship	85 % – 90%	85 % – 88 %	82 % - 90 %	83 % – 92 %

*In U.S. Fish and Wildlife FWS (1997b).

McShane et al. (2004, pp. 3-54 to 3-60) modeled population extinction probabilities beyond 40 years under different scenarios for immigration and mortality risk from oil spills and gill nets. Modeled results forecast different times and probabilities for local extirpations, with an extinction risk[4] of 16 percent and mean population size of 45 individuals in 100 years in the listed range of the species (McShane et al. 2004, p. 3-58).

Reproduction

Generally, estimates of murrelet fecundity are directed at measures of breeding success, either from direct assessments of nest success in the terrestrial environment, marine counts of hatch-year birds, or computer models. Telemetry estimates are typically preferred over marine counts for estimating breeding success due to fewer biases (McShane et al. 2004, p. 3-2). However, because of the challenges of conducting telemetry studies, estimating murrelet reproductive rates with an index of reproduction, referred to as the juvenile ratio (Ŕ),[5] continues to be important, despite the debate over use of this index (see discussion in Beissinger and Peery 2007, p. 296).

Although difficult to obtain, nest success rates[6] are available from telemetry studies conducted in California (Hebert and Golightly, 2006; Peery et al. 2004) and Washington (Bloxton and Raphael 2006). In northwest Washington, Bloxton and Raphael (2005, p.5) documented a nest success rate of 0.20 (2 chicks fledging from 10 nest starts). In central California, murrelet nest

[4] Extinction was defined by McShane et al. (2004, p. 3-58) as any murrelet conservation zone containing less than 30 birds.

[5] The juvenile ratio (**Ŕ**) for murrelets is derived from the relative abundance of hatch-year (HY; 0-1 yr-old) to after-hatch-year (AHY; 1+ yr-old) birds (Beissinger and Peery 2007, pp. 297) and is calculated from marine survey data.

[6] Nest success here is defined by the annual number of known hatchlings departing from the nest (fledging) divided by the number of nest starts.

success is 0.16 (Peery et al. 2004, p.1098) and in northern California it is 0.31 to 0.56 (Hebert and Golightly 2006, p.95). No studies or published reports from Oregon are available.

Unadjusted and adjusted values for estimates of murrelet juvenile ratios suggest extremely low breeding success in northern California (0.003 to 0.008; Long et al. 2008, pp.18-19), central California (0.035 and 0.032; Beissinger and Peery 2007, pp. 299, 302), and in Oregon (0.0254 – 0.0598; Crescent Coastal Research, 2008, p.13). Estimates for **Ŕ** (adjusted) in the San Juan Islands in Washington have been below 0.15 every year since surveys began in 1995, with three of those years below 0.05 (Raphael et al. 2007, p.16).

These current estimates of **Ŕ** are assumed to be below the level necessary to maintain or increase the murrelet population. Demographic modeling suggests murrelet population stability requires a minimum reproductive rate of 0.18 to 0.28 (95 % CI) chicks per pair per year (USFWS 1997b and Beissinger and Peery 2007, p. 302). Even the lower level of the 95 percent confidence interval from USFWS (1997b) and Beissinger and Peery (2007, p. 302) is greater than the current range of estimates for Ŕ (0.02 to 0.13 chicks per pair) for any of the Conservation Zones (Table 2).

The current estimates for **Ŕ** also appear to be well below what may have occurred prior to the murrelet population decline. Beissinger and Peery (2007, p. 298) performed a comparative analysis using historic data from 29 bird species to predict the historic **Ŕ** for murrelets in central California, resulting in an estimate of 0.27 (95% CI: 0.15 - 0.65). Therefore, the best available scientific information of murrelet fecundity from model predictions and trend analyses of survey-derived population data appear to align well. Both indicate that the murrelet reproductive rate is generally insufficient to maintain stable population numbers throughout all or portions of the species' listed range.

Summary: Murrelet Abundance, Distribution, Trend, and Reproduction

The 2007 and 2008 estimated abundance for murrelets within the species listed range were the lowest recorded levels since inception of the EM program (Falxa et al. 2009, p. 9), with the current population size within the listed range of the species estimated at 17,965 birds (95% CI: 14,722 - 21,208; USFWS 2009, p.16). Although murrelets are distributed throughout their historical range, the area of occupancy within their historic range appears to be reduced from historic levels. The distribution of the species also exhibits five areas of discontinuity: a segment of the border region between British Columbia, Canada and Washington; southern Puget Sound, WA; Destruction Island, WA to Tillamook Head, OR; Humboldt County, CA to Half Moon Bay, CA; and the entire southern end of the breeding range in the vicinity of Santa Cruz and Monterey Counties, CA (McShane et al. 2004, p. 3-70).

A statistically significant decline was detected in Conservation Zone 1 for the 2001-2008 period and the decline in Conservation Zone 3 is approaching significance ($p = 0.0731$) for the 2000-2008 period (Falxa et al. 2009, p. 14). The overall population trend from the combined 2000-2008 population estimates (Conservation Zones 1 - 5) indicate a statistically significant, rangewide annual rate of decline in the range of 2.4 to 4.3 percent (Falxa et al. 2009, p. 14), or

about 490 birds per year (S.E. = 241, ***p*** = 0.0412). This equates to an overall estimated 21.6 percent decline during the 2000-2008 survey period.

The current range of estimates for **Ŕ**, the juvenile to adult ratio, is assumed to be below the level necessary to maintain or increase the murrelet population. Whether derived from marine surveys or from population modeling (**Ŕ** = 0.02 to 0.13, Table 2), the available information is in general agreement that the current ratio of hatch year birds to after-hatch year birds is insufficient to maintain stable numbers of murrelets throughout the listed range. The current estimates for **Ŕ** also appear to be well below what may have occurred prior to the murrelet population decline (Beissinger and Peery (2007, p. 298) and model predictions forecast an extinction risk of 16 percent, with a 3-state mean population size of 45 individuals in 100 years in the listed portion of the species' range (McShane et al. 2004, p. 3-58).

Thus, considering the best available data on abundance, distribution, population trend, and the low reproductive success of the species, the FWS concludes the murrelet population within the portion of its listed range currently has little or no capability to self-regulate, as indicated by the significant, annual decline in abundance the species is currently undergoing throughout the listed range. The FWS expects the species to continue to exhibit further reductions in the distribution and abundance into the foreseeable future, due largely to the expectation that the variety of environmental stressors present in the marine and terrestrial environments (discussed in the *Threats to Murrelet Survival and Recovery* section) will continue into the foreseeable future.

Recovery Plan

The Marbled Murrelet Recovery Plan outlines the conservation strategy with both short- and long-term objectives. The Plan places special emphasis on the terrestrial environment for habitat-based recovery actions due to nesting occurring in inland forests.

In the short-term, specific actions identified as necessary to stabilize the population include protecting occupied habitat and minimizing the loss of unoccupied but suitable habitat (USFWS 1997b, p. 119). Specific actions include maintaining large blocks of suitable habitat, maintaining and enhancing buffer habitat, decreasing risks of nesting habitat loss due to fire and windthrow, reducing predation, and minimizing disturbance. The designation of critical habitat also contributes towards the initial objective of stabilizing the population size through the maintenance and protection of occupied habitat and minimizing the loss of unoccupied but suitable habitat.

Long-term conservation needs identified in the Plan include:

- increasing productivity (abundance, the ratio of juveniles to adults, and nest success) and population size;
- increasing the amount (stand size and number of stands), quality, and distribution of suitable nesting habitat;
- protecting and improving the quality of the marine environment; and

- reducing or eliminating threats to survivorship by reducing predation in the terrestrial environment and anthropogenic sources of mortality at sea.

Recovery Zones

The Plan identified six Conservation Zones (Figure 1) throughout the listed range of the species: Puget Sound (Conservation Zone 1), Western Washington Coast Range (Conservation Zone 2), Oregon Coast Range (Conservation Zone 3), Siskiyou Coast Range (Conservation Zone 4), Mendocino (Conservation Zone 5), and Santa Cruz Mountains (Conservation Zone 6). Recovery zones are the functional equivalent of recovery units as defined by FWS policy (USFWS 1997b, p. 115).

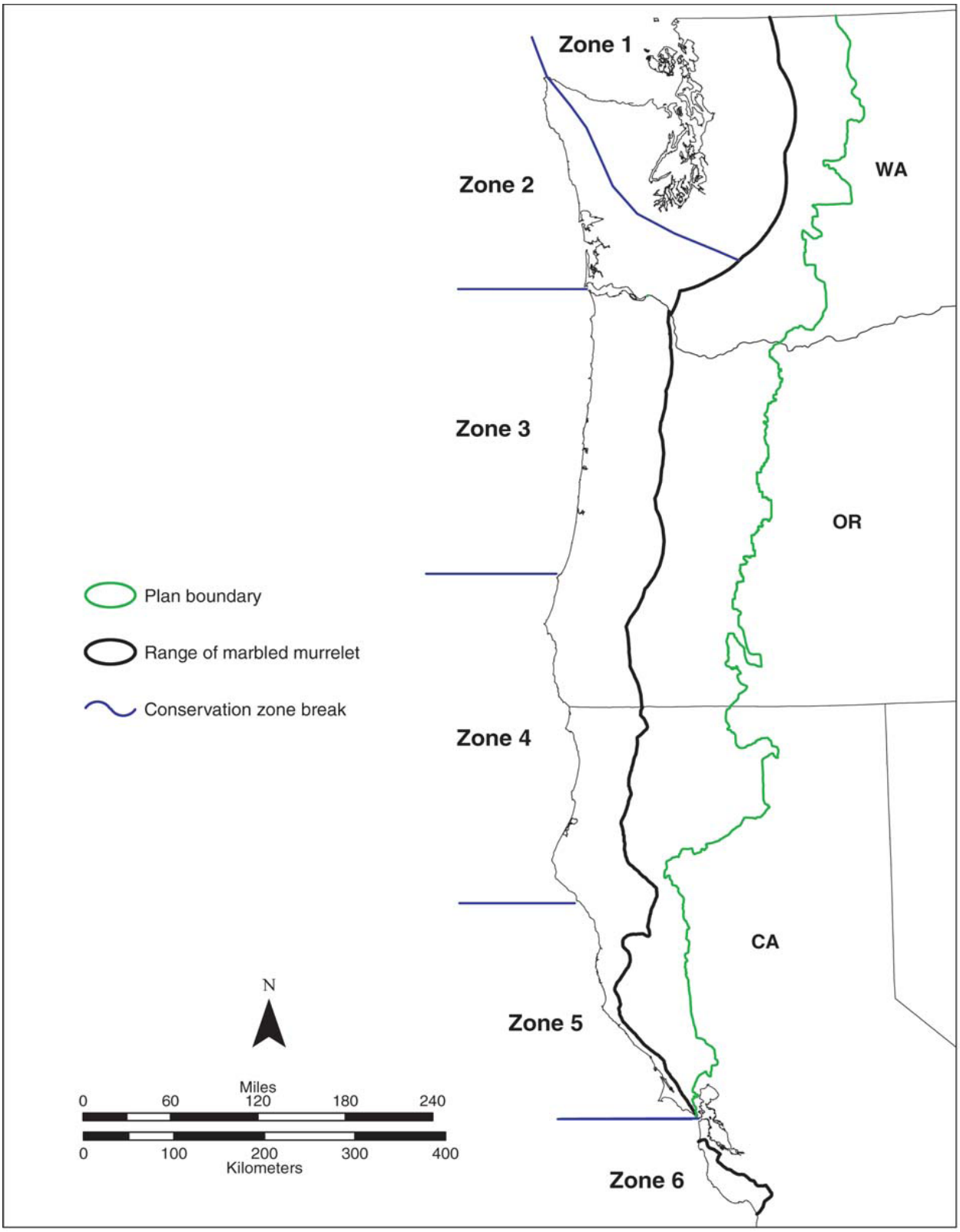

Figure 1. The six geographic areas identified as Conservation Zones in the recovery plan for the marbled murrelet (USFWS 1997b). Note: "Plan boundary" refers to the Northwest Forest Plan. Figure adapted from Huff et al. (2006, p.6).

Recovery Zones in Washington

Conservation Zones 1 and 2 extend inland 50 miles from marine waters. Conservation Zone 1 includes all the waters of Puget Sound and most waters of the Strait of Juan de Fuca south of the U.S.-Canadian border and the Puget Sound, including the north Cascade Mountains and the northern and eastern sections of the Olympic Peninsula. Conservation Zone 2 includes marine waters within 1.2 miles(2 km) off the Pacific Ocean shoreline, with the northern terminus immediately south of the U.S.-Canadian border near Cape Flattery along the midpoint of the Olympic Peninsula and extending to the southern border of Washington (the Columbia River) (USFWS 1997b, pg. 126).

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

Conservation Needs of the Species

Reestablishing an abundant supply of high quality murrelet nesting habitat is a vital conservation need given the extensive removal during the 20th century. However, there are other conservation imperatives. Foremost among the conservation needs are those in the marine and terrestrial environments to increase murrelet 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 that reduce individual fitness[7] or lead to mortality.

The overall reproductive success (fecundity) of murrelets is directly influenced by nest predation rates (reducing nestling survival rates) in the terrestrial environment and an abundant supply of high quality prey in the marine environment during the breeding season (improving potential nestling survival and fledging rates). Anthropogenic stressors affecting murrelet fitness and survival in the marine environment are associated with commercial and tribal gillnets, derelict fishing gear, oil spills, and high underwater sound pressure (energy) levels generated by pile-driving and underwater detonations (that can be lethal or reduce individual fitness).

General criteria for murrelet recovery (delisting) were established at the inception of the Plan and they have not been met. More specific delisting criteria are expected 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

[7] Fitness is measure of the relative capability of individuals within a species to reproduce and pass its' genotype to the next generation.

- 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 FWS estimates recovery of the murrelet will require at least 50 years (USFWS 1997b).

Summary

The level of risk posed by some threats to the murrelet population may have been reduced as a result of the species' listing under the Act, such as the passage of the Oil Pollution Act and implementation of the NWFP. However, the FWS is not aware that any threats have been removed since listing and in some portions of the listed range, new threats (identified above) have been identified which affect the species at the local population or listed-entity scales. Currently, the FWS expects these threats to continue into the foreseeable future and those that cause direct mortality or reduce individual fitness are likely to contribute to murrelet population declines.

Considering the life history characteristics of the murrelet, the species' capability to recover from the mortality or reduced-fitness stressors is extremely low. The low observed reproductive rate causes the murrelet population to be highly sensitive to mortality and fitness-reducing stressors, particularly when they occur at a frequency which exceeds the species' loss-replacement rate. Despite the relatively long life span of murrelets and a reasonably high adult survival rate, the annual replacement rates needed for long-term population maintenance and stability is currently well below the annual rate of individuals being removed from each Conservation Zone.

Therefore, given the interactive effect of an extremely low fecundity and the current threats facing the species, it is reasonable to predict that the murrelet populations (in each Conservation Zone) throughout the listed range are likely to continue to decline. The decline is expected to continue until murrelet fecundity is significantly improved and the anthropogenic stressors affecting fitness, survivorship, and nest success are eliminated or sufficiently reduced.

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APPENDIX B

Status of the Bull Trout Critical Habitat

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

Legal Status

The Service published a final critical habitat designation for the coterminous United States population of the bull trout on September 26, 2005 (70 FR 56212); the rule became effective on October 26, 2005. The scope of the designation involved the Klamath River, Columbia River, Coastal-Puget Sound, and Saint Mary-Belly River population segments (also considered as interim recovery units). Rangewide, the Service designated 143,218 acres of reservoirs or lakes and 4,813 stream or shoreline miles as bull trout critical habitat (Table 1).

Table 1. Stream/shoreline distance and acres of reservoir or lakes designated as bull trout critical habitat by state.

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

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

Conservation Role and Description of Critical Habitat

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

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

The primary function of individual critical habitat units is to maintain and support core areas which 1) contain bull trout populations with the demographic characteristics needed to ensure their persistence and contain the habitat needed to sustain those characteristics (Rieman and McIntyre 1993, p. 19); 2) provide for persistence of strong local populations, in part, by providing habitat conditions that encourage movement of migratory fish (Rieman and McIntyre 1993, p. 22-23); 3) are large enough to incorporate genetic and phenotypic diversity, but small enough to ensure connectivity between populations (Rieman and McIntyre 1993, p. 22-23; Hard 1995, p. 314-15; Healey and Prince 1995, p. 182); and 4) are distributed throughout the historic range of the species to preserve both genetic and phenotypic adaptations (Rieman and McIntyre 1993, p. 23; Hard 1995, p. 321-22; Rieman and Allendorf 2001, p. 763).

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

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

The PCEs are as follows:

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

groundwater influence. Stream reaches with temperatures that preclude bull trout use are specifically excluded from designation.

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

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

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

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

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

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

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

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

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

In marine habitat, critical habitat includes the inshore extent of marine nearshore areas between mean lower low-water (MLLW) and minus 10 meters (m) mean higher high-water (MHHW), including tidally influenced freshwater heads of estuaries. This refers to the area between the

average of all lower low-water heights and all the higher high-water heights of the two daily tidal levels. The offshore extent of critical habitat for marine nearshore areas is based on the extent of the photic zone, which is the layer of water in which organisms are exposed to light. Critical habitat extends offshore to the depth of 33 ft (10 m) relative to the MLLW.

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

Activities that cause adverse effects to critical habitat are evaluated to determine if they are likely to "destroy or adversely modify" critical habitat by altering the PCEs to such an extent that critical habitat would not remain functional to serve the intended conservation role for the species (70 FR 56212 [September 26, 2005], p. 56239, USFWS 2004, Vol. 1 pp. 140-193, Vol. 2 pp. 69-114). The Service's evaluation must be conducted at the scale of the entire critical habitat area designated, unless otherwise stated in the final critical habitat rule (USFWS and NMFS 1998, p. 4-20). Therefore, adverse modification of bull trout critical habitat is evaluated at the scale of the final designation, which includes the critical habitat designated for the Klamath River, Columbia River, Coastal-Puget Sound, and Saint Mary-Belly River population segments.

Current Condition Rangewide

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

There is widespread agreement in the scientific literature that many factors related to human activities have impacted bull trout and their habitat, and continue to do so. Among the many factors that contribute to degraded PCEs, those which appear to be particularly significant and have resulted in a legacy of degraded habitat conditions are as follows: 1) fragmentation and isolation of local populations due to the proliferation of dams and water diversions that have eliminated habitat, altered water flow and temperature regimes, and impeded migratory movements (Rieman and McIntyre 1993, p. 7; Dunham and Rieman 1999, p. 652); 2) degradation of spawning and rearing habitat and upper watershed areas, particularly alterations in sedimentation rates and water temperature, resulting from forest and rangeland practices and intensive development of roads (Fraley and Shepard 1989, p. 141; MBTSG 1998, pp. ii - v, 20-45); 3) the introduction and spread of nonnative fish species, particularly brook trout and lake trout, as a result of fish stocking and degraded habitat conditions, which compete with bull trout for limited resources and, in the case of brook trout, hybridize with bull trout (Leary et al. 1993, p. 857; Rieman et al. 2006, pp. 73-76); 4) in the Coastal-Puget Sound region where amphidromous bull trout occur, degradation of mainstem river FMO habitat, and the degradation and loss of marine nearshore foraging and migration habitat due to urban and residential development; and 5) degradation of FMO habitat resulting from reduced prey base, roads, agriculture, development, and dams.

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