HAWAII RANGE COMPLEX

UPDATE TO THE

REQUEST FOR LETTER OF AUTHORIZATION FOR THE INCIDENTAL HARASSMENT OF MARINE MAMMALS RESULTING FROM NAVY TRAINING OPERATIONS CONDUCTED WITHIN THE HAWAII RANGE COMPLEX

SUBMITTED TO

Office of Protected Resources

National Marine Fisheries Service

National Oceanic and Atmospheric Administration

PREPARED BY

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Update

REQUEST FOR LETTER OF AUTHORIZATION FOR THE INCIDENTAL HARASSMENT OF MARINE MAMMALS RESULTING FROM NAVY TRAINING OPERATIONS CONDUCTED WITHIN THE HAWAII RANGE COMPLEX

Submitted to:

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1.1 Introduction

In July 2007, the U.S. Department of the Navy (Navy) published the Hawaii Range Complex (HRC) Draft Environmental Impact Statement/Overseas Environmental Impact Statement (DEIS/OEIS) which identified and addressed potential environmental impacts associated with sustainable range usage and enhancements within the Navy's HRC (United States Department of the Navy, 2007b). In addition, in July 2007, the Navy requested a five-year Letter of Authorization (LOA) for the incidental harassment of marine mammals incidental to the training events within the HRC for the period July 2008 to July 2013, as permitted by the Marine Mammal Protection Act (MMPA) of 1972, as amended.

The HRC DEIS/OEIS analyzed potential impacts to marine mammals from Navy actions that involve the use of acoustic sources. Since the publication of the DEIS/OEIS and request for LOA, the Navy, in coordination with the National Marine Fisheries Service (NMFS), conducted a re-evaluation of this analysis. This re-evaluation and consequent proposed changes to the DEIS/OEIS led the Navy to determine that the preparation of a Supplement to the DEIS/OEIS and an update to the LOA is appropriate.

Accordingly, this update has been prepared to supplement the analysis contained in the LOA and narrowly focuses on the following three areas:

- Modifications to the analytical methodology used to evaluate the effects of mid-frequency active (MFA) sonar on marine mammals;
- Changes to the amount and types of sonar allocated to each of the alternatives; and,
- Development of a new alternative.

Like the DEIS/OEIS, the primary acoustic concern of this update to the LOA is on the potential effects of the use of MFA sonar. Effects from high-frequency active (HFA) sonar as analyzed in this update pertains to the use of the MK-48 torpedo and remains unchanged from the previous assessment that is presented in the July 2007 LOA.

The first difference from the July 2007 LOA concern modifications to the analytical methodology used to evaluate marine mammal behavior responses to MFA sonar in the HRC. These modifications are two-fold: (1) a change in the mathematical function used to quantify behavioral harassment; and (2) the addition of post acoustic model analysis.

1.2 Modification to the Analytical Methodology

The HRC DEIS/OEIS relies on the use of a dose function analytical approach in this regard. Following publication of the DEIS/OEIS, the Navy continued working with the NMFS to define a mathematical representative curve and applicable input parameters. In this effort to define the mathematical function and applicable input parameters that best quantify behavioral harassment from military readiness activities the Navy and NMFS considered several different methodologies. This development process resulted in the identification of two possible methodologies that could relate acoustic "doses" (i.e., MFA sonar exposures) to the probability of significant behavioral responses. As the regulating agency, NMFS presented the two methodologies to six scientists (marine mammalogists and an acoustician) (both within and outside the federal government) for an independent review. Two scientists, including one from the NMFS Office of Science and Technology, synthesized the reviews from the six scientists and made a recommendation to the NMFS Office of Protected Resources.

Based on this recommendation, while recognizing the limitations of the underlying data as well as past NMFS rulings (Surveillance Towed Array Sensor System Low Frequency Active Low Frequency Active [SURTASS LFA] Sonar Final EIS, and at the same time acknowledging the Supplemental SURTASS LFA Sonar EIS), the NMFS Office of Protected Resources selected for Navy use a mathematical function adapted from a solution in Feller (1968) for use in the HRC Supplemental DEIS (U.S. Department of the Navy, 2008). This function is considered to be appropriate for application to instances with limited data (Feller, 1968), which is the situation with respect to the state of the science for assessing the effects on MFA and HFA sonar on the behavior of marine mammals. Moreover, this same mathematical function was used by the Navy in its Final OEIS/EIS for the SURTASS LFA Sonar (U.S. Department of the Navy, 2001) and relied on in the analysis performed in the Supplemental SURTASS LFA Sonar EIS (U.S. Department of the Navy, 2007a). Accordingly, the Navy is applying the risk function (no longer referred to as the dose function) to estimate the number of species that would experience harassment when exposed to specific received levels of MFA/HFA sonar in the Supplement to the DEIS/OEIS and this update to the LOA. Furthermore, NMFS has modified the model input parameters for MFA sonar effects on mysticetes, odontocetes, and pinnipeds.

1.3 Navy Post Acoustic Modeling Analysis

Following application of the risk function, the Supplement to the DEIS/OEIS includes further analysis of the results of the acoustic model to reduce the potential for the overestimation of MFA sonar hours and provide a more accurate assessment of potential effects. These corrections were necessary because the original DEIS/OEIS modeling resulted in an overestimation for the following reasons:

- Acoustic footprints for sonar sources did not account for land masses.
- Acoustic footprints for sonar sources were added independently and, therefore, did not account for overlap with other sonar systems used during the same time period. As a consequence, the area of the total acoustic footprint was larger than the actual acoustic footprint associated with multiple ships operating together.
- Acoustic modeling did not account for the NMFS defined refresh rate of 24 hours. This time period represents the amount of time in which individual marine mammals can be harassed no more than once.

1.4 Changes to the Amount and Types of Sonar

The second difference between the DEIS/OEIS and the Supplement to the DEIS/OEIS concerns the amount and type of sonar that is analyzed. Sonar hours from the Supplement to the

DEIS/OEIS were based on data available from the Sonar Positional Reporting System (SPORTS). SPORTS is a database tool that was established by Commander, U.S. Fleet Forces Command in March 2006 to determine geographic locations of sonar use. All commands employing MFA sonar and sonobuoys have been required to populate the SPORTS database by reporting MFA sonar use on a daily basis. After publication of the DEIS/OEIS, the Navy determined that SPORTS could also be a useful tool in refining the estimated sonar quantification originally collected and analyzed for the DEIS/OEIS. Accordingly, SPORTS data is used in the Supplement to the DEIS/OEIS and this update to the LOA to assist in determining the amount of MFA sonar use hours for each alternative for purposes of modeling potential effects to marine mammals. Estimates of HFA sonar use (MK-48 torpedo) remain unchanged from the DEIS/OEIS. The resultant changes in sonar hours and events for modeling are presented below (Table 1-1).

1.5 Development of a New Alternative 3 (Preferred Alternative)

The third difference between the DEIS/OEIS and the Supplement to the DEIS/OEIS is the Navy's proposal to add an alternative. Alternative 3 consists of all Alternative 2 activities as described under the DEIS/OEIS with reduced MFA sonar hours. The MFA sonar hours and events analyzed under Alternative 3 are presented in Table 1-1. All non-antisubmarine warfare (ASW) training and RDT&E activities identified for Alternative 2 of the DEIS/OEIS would be implemented under Alternative 3. The Navy has selected Alternative 3 as its preferred alternative. This alternative would allow the Navy to meet its future non-antisubmarine training and RDT&E mission objectives and avoid increases in potential effects to marine mammals above historic levels of antisubmarine warfare (ASW) training in the HRC. Accordingly, the Navy requests that NMFS consider this new preferred alternative for the purpose of this updated request for LOA.

Table 1-1. Sonar Hour Changes

DEIS/OEIS Hours/Events Modeled			Supplement to the DEIS/OEIS Hours/Events Modeled		
TRACKEX					
	Source	**Modeled**			
	53	1,440 hours	**Other ASW (TRACKEX/TORPEX)**		
	Dipping	NA		**Source**	**Modeled**
	Sonobuoy	962 buoys		53	360 hours[1]
				56	75 hours
TORPEX				Dipping	110 dips
	Source	**Modeled**		Sonobuoy	1,278 buoys
	53	356 hours		MK-48	309 runs
	Dipping	NA		Submarine	200 hours
	Sonobuoy	330 buoys			
	MK-48	309 runs			
RIMPAC			**RIMPAC**		
	Source	**Modeled**		**Source**	**Modeled**
	53	532 hours		53	399 hours
				56	133 hours
	Dipping	336 dips		Dipping	400 dips
	Sonobuoy	480 buoys		Sonobuoy	497 buoys
	MK-48	4 runs		MK-48	4 runs
USWEX (6 Exercises)			**USWEX (5 Exercises)**		
	Source	**Modeled**		**Source**	**Modeled**
	53	1,167 hours		53	525 hours
				56	175 hours
	Dipping	576 dips		Dipping	500 dips
	Sonobuoy	768 buoys		Sonobuoy	648 buoys
DEIS/OEIS Totals			**Supplement to the DEIS/OEIS Totals**		
	Source	**Modeled**		**Source**	**Modeled**
	53	3,495 hours		53	1,284 hours
				56	383 hours
	Dipping	912 dips		Dipping	1,010 dips
	Sonobuoy	2,540 buoys		Sonobuoy	2,423 buoys
	MK-48	313 runs		MK-48	313 runs
				Submarine	200 hours

Notes: [1] Includes 27 hours for Kingfisher

2. DURATION AND LOCATION OF ACTIVITIES

There are no changes to Chapter 2 as described under the July 2007 Request for Letter of Authorization.

3. MARINE MAMMAL SPECIES AND NUMBERS

There are no changes to Chapter 3 as described under the July 2007 Request for Letter of Authorization.

4. AFFECTED SPECIES STATUS AND DISTRIBUTION

There are no changes to the affected species status and distribution as described under the July 2007 Request for Letter of Authorization.

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5. HARASSMENT AUTHORIZATION REQUESTED

The Navy maintains its request for a Letter of Authorization (LOA) for the incidental harassment of marine mammals pursuant to Section 101 (a)(5)(A) of the Marine Mammal Protection Act (MMPA) as submitted in July 2007. The authorization requested was for the incidental harassment of marine mammals by behavioral disruption. However, it is understood that a LOA is applicable for up to 5 years, and is appropriate where authorization for serious injury or mortality of marine mammals is requested. The request is for exercises and training events conducted within the Hawaii Range Complex (HRC). These include operations that use mid-frequency and high frequency active sonar or involve underwater detonations. The update request is for a 5-year period commencing from the time the permit is issued.

The acoustic modeling approach taken in the HRC Supplement to the EIS/OEIS and this update to the LOA request attempts to quantify potential behavioral responses to marine mammals resulting from operation of mid-frequency and high frequency active sonar.

Modeling results from the analysis does not predict any marine mammal mortalities. Neither NMFS nor the Navy anticipates that marine mammal strandings or mortality will result from the operation of mid-frequency active sonar during Navy exercises within the HRC. For further information, refer to Chapter 5 of the July 2007 LOA.

Based on modeling results and analysis, it is estimated that 40,457 marine mammals will exhibit behavioral responses NMFS will classify as harassment (Level B) (Table 5-1). No marine mammals will be exposed to sonar in excess of permanent threshold shift (PTS) threshold indicative of Level A injury (Table 5-1).

Table 5-1. Sonar Exposures by Exercise Type and Sonar Source

Source	Modeled		PTS	TTS	Risk Function
53	1,257 hours		0	502	28,049
Kingfisher	27 hours		0	1	22
56	383 hours		0	72	2,369
Dipping	1,010 dips		0	0	164
Sonobuoy	2,423 buoys		0	0	728
MK-48	313 runs		0	19	521
Submarine	200 hours		0	0	8,010
		Total	0	594	39,863

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6. NUMBER AND SPECIES EXPOSED

6.1 Background

Based on available evidence, marine animals are likely to exhibit any of a suite of potential behavioral responses or combinations of behavioral responses upon exposure to sonar transmissions. Potential behavioral responses include, but are not limited to: avoiding exposure or continued exposure; behavioral disturbance (including distress or disruption of social or foraging activity); habituation to the sound; becoming sensitized to the sound; or not responding to the sound.

Existing studies of behavioral effects of human-made sounds in marine environments remain inconclusive, partly because many of those studies have lacked adequate controls, applied only to certain kinds of exposures (which are often different from the exposures being analyzed in the study), and had limited ability to detect behavioral changes that may be significant to the biology of the animals that were being observed. These studies are further complicated by the wide variety of behavioral responses marine mammals' exhibit and the fact that those responses can vary significantly by species, individuals, and the context of an exposure. In some circumstances, some individuals will continue normal behavioral activities in the presence of high levels of human-made noise. In other circumstances, the same individual or other individuals may avoid an acoustic source at much lower received levels (Richardson et al., 1995; Wartzok et al., 2003). These differences within and between individuals appear to result from a complex interaction of experience, motivation, and learning that are difficult to quantify and predict.

It is possible that some marine mammal behavioral reactions to anthropogenic sound may result in strandings. Several "mass stranding" events—strandings that involve two or more individuals of the same species (excluding a single cow-calf pair)—that have occurred over the past two decades have been associated with naval operations, seismic surveys, and other anthropogenic activities that introduced sound into the marine environment. Sonar exposure has been identified as a contributing cause or factor in five specific mass stranding events: Greece in 1996; the Bahamas in March 2000; Madeira, Portugal in 2000; the Canary Islands in 2002, and Spain in 2006 (Advisory Committee Report on Acoustic Impacts on Marine Mammals, 2006).

In these circumstances, exposure to acoustic energy has been considered an indirect cause of the death of marine mammals (Cox et al., 2006). Based on studies of lesions in beaked whales that have stranded in the Canary Islands and Bahamas associated with exposure to naval exercises that involved sonar, several investigators have hypothesized that there are two potential physiological mechanisms that might explain why marine mammals stranded: tissue damage resulting from resonance effects (Ketten, 2005) and tissue damage resulting from "gas and fat embolic syndrome" (Fernandez et al., 2005; Jepson et al., 2003; 2005). It is also likely that stranding is a behavioral response to a sound under certain contextual conditions and that the subsequently observed physiological effects of the strandings (e.g., overheating, decomposition, or internal hemorrhaging from being on shore) were the result of the stranding versus exposure to sonar (Cox et al., 2006). Please refer to the DEIS/OEIS for a detailed discussion on Marine Mammal Protection Act (MMPA) Level B harassment.

6.2 Development of the Risk Function

In Section 4.1.2.4.9 of the DEIS/OEIS, the Navy presented a dose methodology to assess the probability of Level B behavioral harassment from the effects of mid-frequency active (MFA) and high-frequency active (HFA) sonar on marine mammals. Following publication of the DEIS/OEIS the Navy continued working with the National Marine Fisheries Service (NMFS) to refine the mathematically representative curve previously used, along with applicable input parameters with the purpose of increasing the accuracy of the Navy's assessment. As the regulating and cooperating agency, NMFS presented two methodologies to six scientists (marine mammalogists and acousticians from within and outside the federal government) for an independent review (National Marine Fisheries Service, 2008). Two scientists, including one from the NMFS Office of Science and Technology, then synthesized the reviews from the six scientists and developed a recommendation.

One of the methodologies was a normal curve fit to a "mean of means" calculated from the mean of: (1) the mean of the lowest received levels from the 3 kilohertz (kHz) data that the SPAWAR Systems Center (SSC) classified as altered behavior from Finneran and Schlundt (2004); (2) the estimated mean received level produced by the reconstruction of the USS SHOUP event of May 2003 in which killer whales were exposed to MFA sonar (U.S. Department of the Navy, 2004); and (3) the mean of the five maximum received levels at which Nowacek et al. (2004) observed significantly different responses of right whales to an alert stimuli.

The second methodology was a derivation of a mathematical function used for assessing the percentage of a marine mammal population experiencing the risk of harassment under the MMPA associated with the Navy's use of the Surveillance Towed Array Sensor System Low-Frequency Active (SURTASS LFA) sonar (U.S. Department of the Navy, 2001). This function is appropriate for application to instances with limited data (Feller, 1968), and this methodology is subsequently identified as "the risk function" in this document.

The NMFS Office of Protected Resources made the decision to use the risk function and applicable input parameters to estimate the risk of behavioral harassment associated with exposure to MFA sonar. This determination was based on the recommendation of the two NMFS scientists; consideration of the independent reviews from six scientists; the fact the underlying data; and NMFS MMPA regulations affecting the Navy's use of SURTASS LFA sonar (Federal Register [FR] 67:48145-48154, 2002; FR 72: 46846-46893, 2007).

6.3 Methodology for Applying Risk Function

To assess the potential effects on marine mammals associated with active sonar used during training activities, the Navy together with NMFS, as a first step, investigated a series of mathematical models and methodologies that estimate the number of times individuals of the different species of marine mammals might be exposed to MFA sonar at different received levels. The Navy effects analyses assumed that the potential consequences of exposure to MFA sonar on individual animals would be a function of the received sound pressure level (decibels re 1 micropascal [dB re 1 μPa]). These analyses assume that MFA sonar poses no risk, that is, does not constitute harassment to marine mammals if they are exposed to sound pressure levels from the MFA sonar below a certain basement value.

The second step of the assessment procedure requires the Navy and NMFS to identify how marine mammals are likely to respond when they are exposed to active sonar. Marine mammals can experience a variety of responses to sound including sensory impairment (permanent and temporary threshold shifts and acoustic masking), physiological responses (particular stress responses), behavioral responses, social responses that might result in reducing the fitness of individual marine mammals and social responses that would not result in reducing the fitness of individual marine mammals.

Previously, the Navy and NMFS have used acoustic thresholds to identify the number of marine mammals that might experience hearing losses (temporary or permanent) or behavioral harassment upon being exposed to MFA sonar (see Figure 6-1 left panel). These acoustic thresholds have been represented by either sound exposure level (related to sound energy, abbreviated as SEL), sound pressure level (abbreviated as SPL), or other metrics such as peak pressure level and acoustic impulse (not considered for sonar in this Supplement to the DEIS/OEIS). The general approach has been to apply these threshold functions so that a marine mammal is counted as behaviorally harassed or experiencing hearing loss when exposed to received sound levels above a certain threshold and not counted as behaviorally harassed or experiencing hearing loss when exposed to received levels below that threshold. For example, previous Navy EISs, environmental assessments, MMPA take authorization requests, and the MMPA incidental harassment authorization (IHA) for the Navy's 2006 Rim-of-the Pacific (RIMPAC) Major Exercise (FR 71.38710-38712, 2006) used 173 decibel re 1 micropascal squared-second (dB re 1 μPa^2-s) as the energy threshold level (i.e., SEL) for Level B behavioral harassment for cetaceans. If the transmitted sonar accumulated energy received by a whale was above 195 dB re 1 μPa^2-s, then the animal was considered to have experienced a temporary loss in the sensitivity of its hearing. If the received accumulated energy level was below 195 dB re 1 μPa^2-s, then the animal was not treated as having experienced a temporary loss in the sensitivity of its hearing.

The left panel in Figure 6-1 illustrates a typical step-function or threshold that might also relate a sonar exposure to the probability of a response. As this figure illustrates, past Navy/NMFS acoustic thresholds assumed that every marine mammal above a particular received level (for example, to the right of the red vertical line in the figure) would exhibit identical responses to a sonar exposure. This assumed that the responses of marine mammals would not be affected by differences in acoustic conditions; differences between species and populations, differences in gender, age, reproductive status, or social behavior; or the prior experience of the individuals.

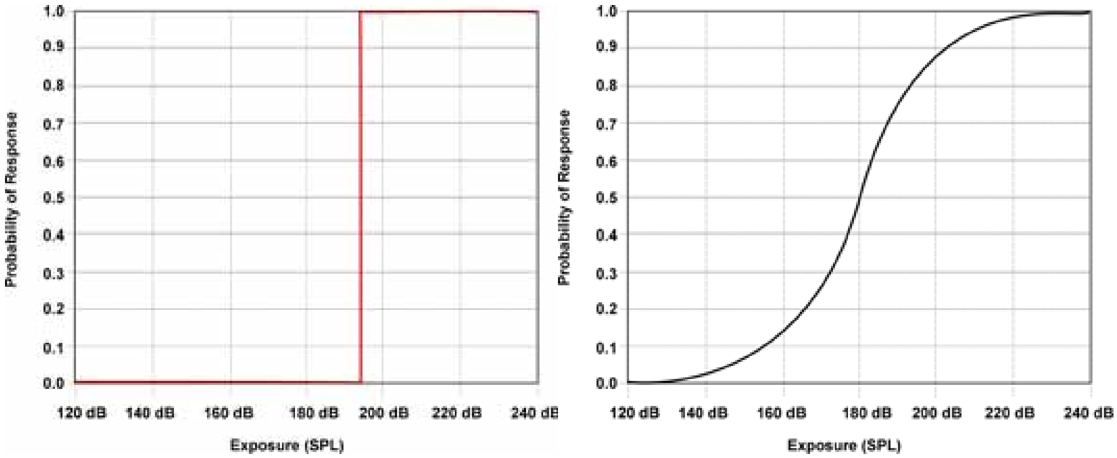

Figure 6-1. The left panel illustrates a typical step function with the probability of a response on the y-axis and received exposure on the x-axis. The right panel illustrates a typical risk continuum-function using the same axes. SPL is "Sound Pressure Level" in decibels referenced to 1 micropascal root mean square (1 μPa rms).

Both the Navy and NMFS agree that the studies of marine mammals in the wild and in experimental settings do not support these assumptions—different species of marine mammals and different individuals of the same species respond differently to sonar exposure. Additionally, there are specific geographic/bathymetric conditions that dictate the response of marine mammals to sonar that suggest that different populations may respond differently to sonar exposure. Further, studies of animal physiology suggest that gender, age, reproductive status, and social behavior, among other variables, probably affect how marine mammals respond to sonar exposures (Wartzok et al., 2003; Southall et al., 2007).

Over the past several years, the Navy and NMFS have worked on developing an MFA sonar acoustic risk function to replace the acoustic thresholds used in the past to estimate the probability of marine mammals being behaviorally harassed by received levels of MFA sonar. The Navy and NMFS will continue to use acoustic thresholds to estimate temporary or permanent threshold shifts using SEL as the appropriate metric. Unlike acoustic thresholds, acoustic risk continuum functions (which are also called "exposure-response functions," "dose-response functions," or "stress-response functions" in other risk assessment contexts) assume that the probability of a response depends first on the "dose" (in this case, the received level of sound) and that the probability of a response increases as the "dose" increases. It is important to note that the probabilities associated with acoustic risk functions do not represent an individual's probability of responding. Rather, the probabilities identify the proportion of an exposed population that is likely to respond to an exposure.

The right panel in Figure 6-1 illustrates a typical acoustic risk function that might relate an exposure, as received sound pressure level in decibels referenced to 1 micropascal (1 μPa), to the probability of a response. As the exposure receive level increases in this figure, the probability of a response increases as well but the relationship between an exposure and a response is "linear" only in the center of the curve (that is, unit increases in exposure would produce unit increases in the probability of a response only in the center of a risk function curve). In the "tails" of an acoustic risk function curve, unit increases in exposure produce smaller increases in the probability of a response. Based on observations of various animals, including humans, the relationship represented by an acoustic risk function is a more robust predictor of the probable behavioral responses of marine mammals to sonar and other acoustic sources.

The Navy and NMFS have previously used the acoustic risk function to estimate the probable responses of marine mammals to acoustic exposures for other training and research programs. Examples of previous application include the Navy Final EISs on the SURTASS LFA sonar (U.S. Department of the Navy, 2001); the North Pacific Acoustic Laboratory experiments conducted off the Island of Kauai (Office of Naval Research, 2001), and the Supplemental EIS for SURTASS LFA sonar (U.S. Department of the Navy, 2007a).

The Navy and NMFS used two metrics to estimate the number of marine mammals that could be subject to Level B harassment (behavioral harassment and temporary threshold shift [TTS]) as defined by the MMPA, during training exercises. The agencies used acoustic risk functions with the metric of received sound pressure level (dB re 1 µPa) to estimate the number of marine mammals that might be at risk for MMPA Level B behavioral harassment as a result of being exposed to MFA sonar. The agencies will continue to use acoustic thresholds ("step-functions") with the metric of sound exposure level (dB re 1 μPa^2-s) to estimate the number of marine mammals that might be "taken" through sensory impairment (i.e., Level A – permanent threshold shift [PTS] and Level B – TTS) as a result of being exposed to MFA sonar.

Although the Navy has not used acoustic risk functions in previous MFA sonar assessments of the potential effects of MFA sonar on marine mammals, risk functions are not new concepts for risk assessments. Common elements are contained in the process used for developing criteria for air, water, radiation, and ambient noise and for assessing the effects of sources of air, water, and noise pollution. The Environmental Protection Agency uses dose-functions to develop water quality criteria and to regulate pesticide applications (U.S. Environmental Protection Agency, 1998); the Nuclear Regulatory Commission uses dose-functions to estimate the consequences of radiation exposures (see Nuclear Regulatory Commission, 1997 and 10 Code of Federal Regulations 20.1201); the Centers for Disease Control and Prevention and the Food and Drug Administration use dose-functions as part of their assessment methods (for example, see Centers for Disease Control and Prevention, 2003, U.S. Food and Drug Administration and others, 2001); and the Occupational Safety and Health Administration uses dose-functions to assess the potential effects of noise and chemicals in occupational environments on the health of people working in those environments (for examples, see FR 61:56746-56856, 1996; FR 71:10099-10385, 2006).

6.3.1 Risk Function Adapted from Feller (1968)

The particular acoustic risk function developed by the Navy and NMFS estimates the probability of behavioral responses that NMFS would classify as harassment for the purposes of the MMPA given exposure to specific received levels of MFA sonar. The mathematical function is derived from a solution in Feller (1968) as defined in the SURTASS LFA Sonar Final OEIS/EIS (U.S. Department of the Navy, 2001), and relied on in the Supplemental SURTASS LFA Sonar EIS

(U.S. Department of the Navy, 2007a) for the probability of MFA sonar risk for MMPA Level B behavioral harassment with input parameters modified by NMFS for MFA sonar for mysticetes, odontocetes, and pinnipeds.

In order to represent a probability of risk, the function should have a value near zero at very low exposures, and a value near one for very high exposures. One class of functions that satisfies this criterion is cumulative probability distributions, a type of cumulative distribution function. In selecting a particular functional expression for risk, several criteria were identified:

- The function must use parameters to focus discussion on areas of uncertainty;
- The function should contain a limited number of parameters;
- The function should be capable of accurately fitting experimental data; and
- The function should be reasonably convenient for algebraic manipulations.

As described in U.S. Department of the Navy (2001), the mathematical function below is adapted from a solution in Feller (1968).

$$R = \frac{1 - \left(\frac{L-B}{K}\right)^{-A}}{1 - \left(\frac{L-B}{K}\right)^{-2A}}$$

Where: R = risk (0 – 1.0);

L = Received Level (RL) in dB;

B = basement RL in dB; (120 dB);

K = the RL increment above basement in dB at which there is 50 percent risk;

A = risk transition sharpness parameter (10) (explained in 3.1.5.3).

In order to use this function, the values of the three parameters (B, K, and A) need to be established. As further explained in Section 3.1.4, the values used in this Supplement to the DEIS/OEIS analysis are based on three sources of data: TTS experiments conducted at SSC and documented in Finneran, et al. (2001, 2003, and 2005; Finneran and Schlundt, 2004); reconstruction of sound fields produced by the USS SHOUP associated with the behavioral responses of killer whales observed in Haro Strait and documented in Department of Commerce (National Marine Fisheries Service, 2005); U.S. Department of the Navy (2004); and Fromm (2004a, 2004b); and observations of the behavioral response of North Atlantic right whales exposed to alert stimuli containing mid-frequency components documented in Nowacek et al. (2004). The input parameters, as defined by NMFS, are based on very limited data that represent the best available science at this time.

6.4 Data Sources Used for Risk Function

There is widespread consensus that cetacean response to MFA sound signals needs to be better defined using controlled experiments. Navy is contributing to an ongoing behavioral response study in the Bahamas that is anticipated to provide some initial information on beaked whales, the species identified as the most sensitive to MFA sonar. NMFS is leading this international effort with scientists from various academic institutions and research organizations to conduct studies on how marine mammals respond to underwater sound exposures.

Until additional data is available, NMFS and the Navy have determined that the following three data sets are most applicable for the direct use in developing risk function parameters for MFA/HFA sonar. These data sets represent the only known data that specifically relate altered behavioral responses to exposure to MFA sound sources.

<u>Data from SSC's Controlled Experiments</u>: Most of the observations of the behavioral responses of toothed whales resulted from a series of controlled experiments on bottlenose dolphins and beluga whales conducted by researchers at SSC's facility in San Diego, California (Finneran et al., 2001, 2003, 2005; Finneran and Schlundt 2004; Schlundt et al., 2000). In experimental trials with marine mammals trained to perform tasks when prompted, scientists evaluated whether the marine mammals performed these tasks when exposed to mid-frequency tones. Altered behavior during experimental trials usually involved refusal of animals to return to the site of the sound stimulus. This refusal included what appeared to be deliberate attempts to avoid a sound exposure or to avoid the location of the exposure site during subsequent tests (Schlundt et al., 2000, Finneran et al., 2002). Bottlenose dolphins exposed to 1-sec intense tones exhibited short-term changes in behavior above received sound levels of 178 to 193 dB re 1 micropascal (μPa) root mean square (rms), and beluga whales did so at received levels of 180 to 196 dB and above. Test animals sometimes vocalized after an exposure to impulsive sound from a seismic watergun (Finneran et al., 2002). In some instances, animals exhibited aggressive behavior toward the test apparatus (Ridgway et al., 1997; Schlundt et al., 2000).

1. Finneran and Schlundt (2004) examined behavioral observations recorded by the trainers or test coordinators during the Schlundt et al. (2000) and Finneran et al. (2001, 2003, 2005) experiments featuring 1-second (sec) tones. These included observations from 193 exposure sessions (fatiguing stimulus level > 141 dB re 1μPa) conducted by Schlundt et al. (2000) and 21 exposure sessions conducted by Finneran et al. (2001, 2003, 2005). The observations were made during exposures to sound sources at 0.4 kHz, 3 kHz, 10 kHz, 20 kHz, and 75 kHz. The TTS experiments that supported Finneran and Schlundt (2004) are further explained below:

    a. Schlundt et al. (2000) provided a detailed summary of the behavioral responses of trained marine mammals during TTS tests conducted at SSC San Diego with 1-sec tones. Schlundt et al. (2000) reported eight individual TTS experiments. Fatiguing stimuli durations were 1-sec; exposure frequencies were 0.4 kHz, 3 kHz, 10 kHz, 20 kHz and 75 kHz. The experiments were conducted in San Diego Bay. Because of the variable ambient noise in the bay, low-level broadband masking noise was used to keep hearing thresholds consistent despite fluctuations in the ambient noise. Schlundt et al. (2000) reported that "behavioral alterations," or deviations from the behaviors the animals being tested had been trained to exhibit, occurred as the animals were exposed to increasing fatiguing stimulus levels.

b. Finneran et al. (2001, 2003, 2005) conducted TTS experiments using tones at 3 kHz. The test method was similar to that of Schlundt et al. (2000) except the tests were conducted in a pool with very low ambient noise level (below 50 dB re 1 µPa/hertz [Hz]), and no masking noise was used. Two separate experiments were conducted using 1-sec tones. In the first, fatiguing sound levels were increased from 160 to 201 dB SPL. In the second experiment, fatiguing sound levels between 180 and 200 dB re 1 µPa were randomly presented.

<u>Data from Studies of Baleen (Mysticetes) Whale Responses</u>: The only mysticete data available resulted from a field experiments in which baleen whales (mysticetes) were exposed to a range frequency sound sources from 120 Hz to 4500 Hz (Nowacek et al. 2004). An alert stimulus, with a mid-frequency component, was the only portion of the study used to support the risk function input parameters.

2. Nowacek et al. (2004) documented observations of the behavioral response of North Atlantic right whales exposed to alert stimuli containing mid-frequency components. To assess risk factors involved in ship strikes, a multi-sensor acoustic tag was used to measure the responses of whales to passing ships and experimentally tested their responses to controlled sound exposures, which included recordings of ship noise, the social sounds of conspecifics and a signal designed to alert the whales. The alert signal was 18-minutes of exposure consisting of three 2-minute signals played sequentially three times over. The three signals had a 60 percent duty cycle and consisted of: (1) alternating 1-sec pure tones at 500 Hz and 850 Hz; (2) a 2-sec logarithmic down-sweep from 4,500 Hz to 500 Hz; and (3) a pair of low (1,500 Hz)-high (2,000 Hz) sine wave tones amplitude modulated at 120 Hz and each 1-sec long. The purposes of the alert signal were (a) to provoke an action from the whales via the auditory system with disharmonic signals that cover the whales estimated hearing range; (b) to maximize the signal to noise ratio (obtain the largest difference between background noise) and c) to provide localization cues for the whale. Five out of six whales reacted to the signal designed to elicit such behavior. Maximum received levels ranged from 133 to 148 dB re 1µPa/√(Hz) (Sound Pressure Density Spectrum Level).

<u>Observations of Killer Whales in Haro Strait in the Wild</u>: In May 2003, killer whales (*Orcinus orca*) were observed exhibiting behavioral responses while the USS SHOUP was engaged in MFA sonar operations in the Haro Strait in the vicinity of Puget Sound, Washington. Although these observations were made in an uncontrolled environment, the sound field that may have been associated with the sonar operations had to be estimated, and the behavioral observations were reported for groups of whales, not individual whales, the observations associated with the USS SHOUP provide the only data set available of the behavioral responses of wild, non-captive animal upon exposure to the AN/SQS-53 MFA sonar.

3. U.S. Department of Commerce (National Marine Fisheries, 2005); U.S. Department of the Navy (2004); Fromm (2004a, 2004b) documented reconstruction of sound fields produced by the USS SHOUP associated with the behavioral response of killer whales observed in Haro Strait. Observations from this reconstruction included an approximate closest approach time which was correlated to a reconstructed estimate of received level at an approximate whale location (which ranged from 150 to 180 dB SPL at that location), with a mean value of 169.3 dB SPL.

6.4.1 Limitations of the Risk Function Data Sources

There are significant limitations and challenges to any risk function derived to estimate the probability of marine mammal behavioral responses; these are largely attributable to sparse data. Ultimately there should be multiple functions for different marine mammal taxonomic groups, but the current data are insufficient to support them. The goal is unquestionably that risk functions be based on empirical measurement.

The risk function presented here is based on three data sets that NMFS and Navy have determined are the best available science at this time. The Navy and NMFS acknowledge each of these data sets has limitations. However, this risk function, if informed by the limited available data relevant to the MFA sonar application, has the advantages of simplicity and the fact that there is precedent for its application and foundation in marine mammal research.

While NMFS considers all data sets as being weighted equally in the development of the risk function, the Navy believes the SSC San Diego data is the most rigorous and applicable for the following reasons:

- The data represents the only source of information where the researchers had complete control over and ability to quantify the noise exposure conditions.
- The altered behaviors were identifiable due to long term observations of the animals.
- The fatiguing noise consisted of tonal exposures with limited frequencies contained in the MFA sonar bandwidth.

However, the Navy and NMFS do agree that the following are limitations associated with the three data sets used as the basis of the risk function:

- The three data sets represent the responses of only four species: trained bottlenose dolphins and beluga whales, North Atlantic right whales in the wild and killer whales in the wild.
- None of the three data sets represent experiments designed for behavioral observations of animals exposed to MFA sonar.
- The behavioral responses of marine mammals that were observed in the wild are based solely on an estimated received level of sound exposure; they do not take into consideration (due to minimal or no supporting data):
    - Potential relationships between acoustic exposures and specific behavioral activities (e.g., feeding, reproduction, changes in diving behavior, etc.), variables such as bathymetry, or acoustic waveguides; or
    - Differences in individuals, populations, or species, or the prior experiences, reproductive state, hearing sensitivity, or age of the marine mammal.

SSC San Diego Trained Bottlenose Dolphins and Beluga Data Set:

- The animals were trained animals in captivity; therefore, they may be more or less sensitive than cetaceans found in the wild (Domjan, 1998).
- The tests were designed to measure TTS, not behavior.
- Because the tests were designed to measure TTS, the animals were exposed to much higher levels of sound than the baseline risk function (only two of the total 193 observations were at levels below 160 dB re 1 μPa^2-s).
- The animals were not exposed in the open ocean but in a shallow bay or pool.

North Atlantic Right Whales in the Wild Data Set:

- The observations of behavioral response were from exposure to alert stimuli that contained mid-frequency components, but was not similar to a MFA sonar ping. The alert signal was 18 minutes of exposure consisting of three 2-minute signals played sequentially three times over. The three signals had a 60 percent duty cycle and consisted of: (1) alternating 1-sec pure tones at 500 Hz and 850 Hz; (2) a 2-sec logarithmic down-sweep from 4,500 Hz to 500 Hz; and (3) a pair of low (1,500 Hz)-high (2,000 Hz) sine wave tones amplitude modulated at 120 Hz and each 1-sec long. This 18-minute alert stimuli is in contrast to the average 1-sec ping every 30 sec in a comparatively very narrow frequency band used by military sonar.
- The purpose of the alert signal was, in part, to provoke an action from the whales through an auditory stimulus.

Killer Whales in the Wild Data Set:

- The observations of behavioral harassment were complicated by the fact that there were other sources of harassment in the vicinity (other vessels and their interaction with the animals during the observation).
- The observations were anecdotal and inconsistent. There were no controls during the observation period, with no way to assess the relative magnitude of the any observed response as opposed to baseline conditions.

6.5 Input Parameters for the Risk Function

The values of B, K, and A need to be specified in order to utilize the risk function defined in Section 3.1.1. The risk continuum function approximates the dose-response function in a manner analogous to pharmacological risk assessment (U.S. Department of the Navy, 2001, Appendix A). In this case, the risk function is combined with the distribution of sound exposure levels to estimate aggregate impact on an exposed population.

6.5.1 Basement Value for Risk—The B Parameter

The B parameter defines the basement value for risk, below which the risk is so low that calculations are impractical. This 120 dB level is taken as the estimate received level (RL) below which the risk of significant change in a biologically important behavior approaches zero for the MFA sonar risk assessment. This level is based on a broad overview of the levels at which multiple species have been reported responding to a variety of sound sources, both mid-frequency and other, was recommended by the scientists, and has been used in other publications. The Navy recognizes that for actual risk of changes in behavior to be zero, the signal-to-noise ratio of the animal must also be zero. However, the present convention of ending the risk calculation at 120 dB for MFA sonar has a negligible impact on the subsequent calculations, because the risk function does not attain appreciable values at received levels that low.

6.5.2 The K Parameter

NMFS and the Navy used the mean of the following values to define the midpoint of the function: (1) the mean of the lowest received levels (185.3 dB) at which individuals responded with altered behavior to 3 kHz tones in the SSC data set; (2) the estimated mean received level value of 169.3 dB produced by the reconstruction of the USS SHOUP incident in which killer whales exposed to MFA sonar (range modeled possible received levels: 150 to 180 dB); and (3) the mean of the 5 maximum received levels at which Nowacek et al. (2004) observed significantly altered responses of right whales to the alert stimuli than to the control (no input signal) is 139.2 dB SPL. The arithmetic mean of these three mean values is 165 dB SPL. The value of K is the difference between the value of B (120 dB SPL) and the 50 percent value of 165 dB SPL; therefore, K=45.

6.5.3 Risk Transition—The A Parameter

The A parameter controls how rapidly risk transitions from low to high values with increasing receive level. As A increases, the slope of the risk function increases. For very large values of A, the risk function can approximate a threshold response or step function. NMFS has recommended that Navy use A=10 as the value for odontocetes, and pinnipeds (Figure 6-2) (National Marine Fisheries Service, 2008). This is the same value of A that was used for the SURTASS LFA sonar analysis. As stated in the SURTASS LFA Sonar Final OEIS/EIS (U.S. Department of the Navy, 2001), the value of A=10 produces a curve that has a more gradual transition than the curves developed by the analyses of migratory gray whale studies (Malme et al., 1984). The choice of a more gradual slope than the empirical data was consistent with other decisions for the SURTASS LFA Sonar Final OEIS/EIS to make conservative assumptions when extrapolating from other data sets (see Subchapter 1.43 and Appendix D of the SURTASS LFA Sonar EIS). (National Marine Fisheries Service, 2008)

Based on NMFS' direction, the Navy will use a value of A=8 for mysticetes to allow for greater consideration of potential harassment at the lower received levels based on Nowacek et al., 2004 (Figure 6-3). (National Marine Fisheries Service, 2008)

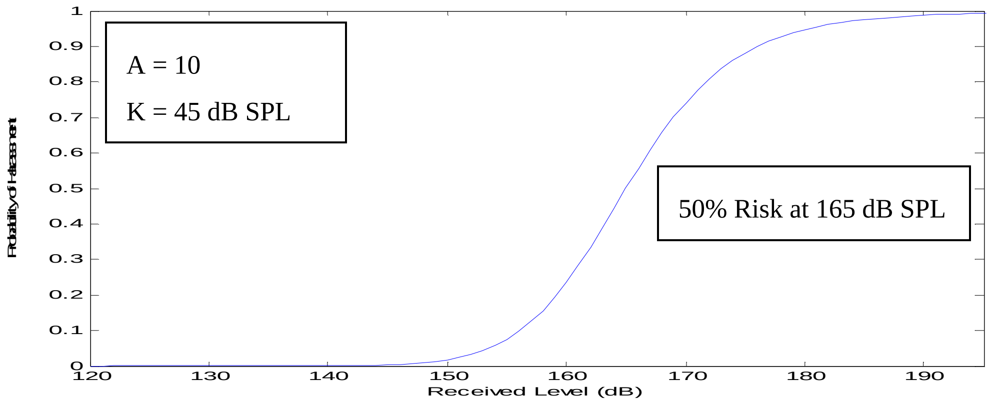

Figure 6-2. Risk Function Curve for Odontocetes (toothed whales) and Pinnipeds

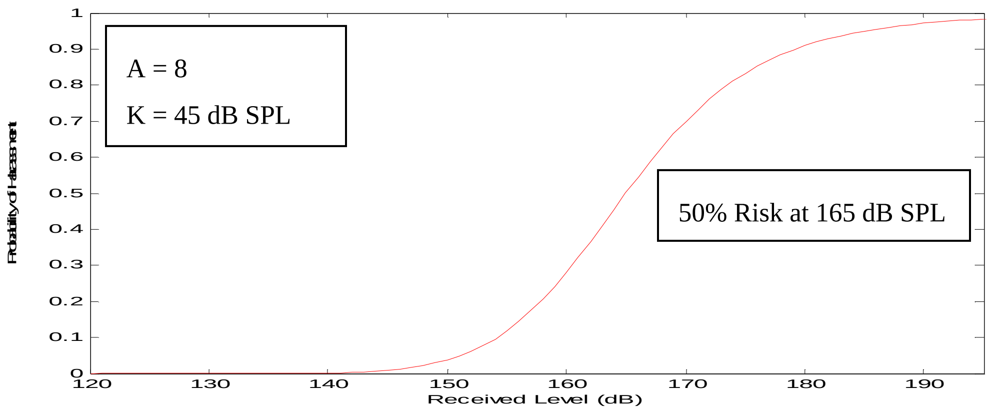

Figure 6 -3. Risk Function Curve for Mysticetes (Baleen Whales)

6.6 Basic Application of the Risk Function

6.6.1 Relation of the Risk Function to the Current Regulatory Scheme

The risk function is used to estimate the percentage of an exposed population that is likely to exhibit behaviors that would qualify as harassment (as that term is defined by the MMPA applicable to military readiness activities, such as the Navy's testing and training with MFA sonar) at a given received level of sound. For example, at 165 dB SPL (dB re: 1µPa rms), the risk (or probability) of harassment is defined according to this function as 50 percent, and Navy/NMFS applies that by estimating that 50 percent of the individuals exposed at that received level are likely to respond by exhibiting behavior that NMFS would classify as behavioral harassment. The risk function is not applied to individual animals, only to exposed populations.

The data used to produce the risk function were compiled from four species that had been exposed to sound sources in a variety of different circumstances. As a result, the risk function represents a general relationship between acoustic exposures and behavioral responses that is then applied to specific circumstances. That is, the risk function represents a relationship that is deemed to be generally true, based on the limited, best-available science, but may not be true in specific circumstances. In particular, the risk function, as currently derived, treats the received level as the only variable that is relevant to a marine mammal's behavioral response. However, we know that many other variables—the marine mammal's gender, age, and prior experience; the activity it is engaged in during an exposure event, its distance from a sound source, the number of sound sources, and whether the sound sources are approaching or moving away from the animal—can be critically important in determining whether and how a marine mammal will respond to a sound source (Southall et al., 2007). The data that are currently available do not allow for incorporation of these other variables in the current risk functions; however, the risk function represents the best use of the data that are available.

As more specific and applicable data become available, NMFS can use these data to modify the outputs generated by the risk function to make them more realistic (and ultimately, data may exist to justify the use of additional, alternate, or multi-variate functions). As mentioned above, it is known that the distance from the sound source and whether it is perceived as approaching or moving away can affect the way an animal responds to a sound (Wartzok et al., 2003). In the HRC example, animals exposed to received levels between 120 and 130 dB SPL may be more than 65 nautical miles (131,651 yards) from a sound source; those distances would influence whether those animals might perceive the sound source as a potential threat, and their behavioral responses to that threat. Though there are data showing marine mammal responses to sound sources at that *received level*, NMFS does not currently have any data that describe the response of marine mammals to sounds at that *distance* (or to other contextual aspects of the exposure, such as the presence of higher frequency harmonics), much less data that compare responses to similar sound levels at varying distances. However, if data were to become available that suggested animals were less likely to respond (in a manner NMFS would classify as harassment) to certain levels beyond certain distances, or that they were more likely to respond at certain closer distances, Navy will re-evaluate the risk function to try to incorporate any additional variables into the "take" estimates.

Last, pursuant to the MMPA, an applicant is required to estimate the number of animals that will be "taken" by their activities. This estimate informs the analysis that NMFS must perform to determine whether the activity will have a "negligible impact" on the species or stock. Level B (behavioral) harassment occurs at the level of the individual(s) and does not assume any resulting population-level consequences, though there are known avenues through which behavioral disturbance of individuals can result in population-level effects. Alternately, a negligible impact finding is based on the lack of likely adverse effects to annual rates of recruitment or survival (i.e., population-level effects). An estimate of the number of Level B harassment takes, alone, is not enough information on which to base an impact determination. In addition to considering estimates of the number of marine mammals that might be "taken" through harassment, NMFS must consider other factors, such as the nature of any responses (their intensity, duration, etc.), the context of any responses (critical reproductive time or location, migration, etc.), or any of the other variables mentioned in the first paragraph (if known), as well as the number and nature of estimated Level A takes, the number of estimated mortalities, and effects on habitat. For example, in the case of sonar usage in HRC, a portion of the animals that are likely to be "taken" through behavioral harassment are expected to be exposed at relatively low received levels (120-140 dB SPL) where the significance of those responses would be reduced because of the distance (25-65 nm) from a sound source. Alternatively, only a relatively very small portion (approximately 2%) of the animals that are expected to be "taken" through behavioral harassment (inclusive of both risk function and EFD threshold modeling) are expected to occur when animals are exposed to higher received levels, such as the onset of TTS (195 dB re 1 μPa^2-s) or higher (Table 6-1). Since the modeling does not take into account the reduction of effects resulting from the Navy's standard mitigation, approximately 37% of all exposures are modeled as having occurred within the 1,000 yard mitigation safety zone where procedures are in place to reduce the received level of animals within this zone. Generally speaking, Navy and NMFS anticipate more severe effects from takes resulting from exposure to higher received levels (though this is in no way a strictly linear relationship throughout species, individuals, or circumstances) and less severe effects from takes resulting from exposure to lower received levels.

Table 6-1. Harassments at each Received Level Band

Received Level	Distance at which Levels Occur in HRC	Percent of Harassments Occurring at Given Levels
Below 140 dB SPL	36 km–125 km	<1%
140>Level>150 dB SPL	15 km–36 km	2%
150>Level>160 dB SPL	5 km–15 km	20%
160>Level>170 dB SPL	2 km–5 km	40%
170>Level>180 dB SPL	0.6–2 km	24%
180>Level>190 dB SPL	180–560 meters	9%
Above 190 dB SPL	0–180 meters	2%
TTS (195 dB EFDL)	0-110 meters	2%
PTS (215 dB EFDL)	0-10	<1%

NMFS will consider all available information (other variables, etc.), but all else being equal, takes that result from exposure to lower received levels and at greater distances from the exercises would be less likely to contribute to population level effects (Figure 6-4).

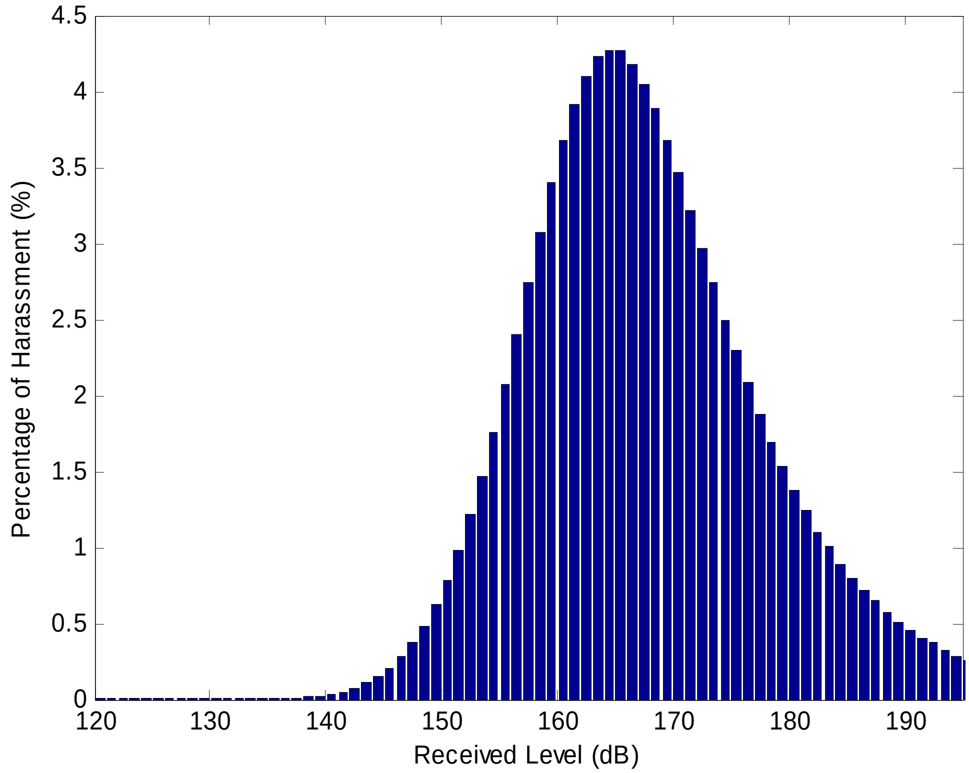

Figure 6-4: The percentage of behavioral harassments resulting from the risk function for every 5 dB of received level

6.7 Navy Post Acoustic Modeling Analysis

The environmental provinces used to characterize sound propagation throughout the HRC are the same in the Supplement to the DEIS/OEIS as those described in the DEIS/OEIS. The description of animal densities and their depth distributions for modeling purposes has not changed from the DEIS/OEIS.

In a change from the DEIS/OEIS, the quantification of sonar hours analyzed in the Supplement to the DEIS/OEIS were derived from SPORTS, which serves as a basis for a more accurate assessment of the training needs and sonar hours being modeled (see Chapter 1.0).

The acoustic sources in the Supplement to the DEIS/OEIS are the same as those described in the DEIS/OEIS. For modeling purposes, however, the sonar hours attributed to the AN/SQS 56, dipping sonar, and submarine sonar are now analyzed using the parameters for those systems. Estimates of HFA sonar use (MK-48 torpedo) remain unchanged from the DEIS/OEIS.

For this Supplement to the DEIS/OEIS, the acoustic modeling results include additional analysis to account for the model's previous overestimation of potential effects. Specifically, the previous modeling overestimated effects because:

- Acoustic footprints for sonar sources did not account for land masses.
- Acoustic footprints for sonar sources were added independently and, therefore, did not account for overlap they would have with other sonar systems used during the same active sonar activity. As a consequence, the area of the total acoustic footprint was larger than the actual acoustic footprint when multiple ships are operating together.
- Acoustic modeling did not account for limitations the NMFS defined refresh rate of 24 hours. This time period represents the amount of time in which individual marine mammals can be harasses no more than once.

The result of this change from the DEIS/OEIS will lead to more consistent and accurate modeling outputs. Table 6-2 provides a summary of the modeling protocols used in the analysis for the Supplement to the DEIS/OEIS and this update to the LOA.

Table 6-2. Navy Protocols Providing for Accurate Modeling Quantification of Marine Mammal Exposures

Historical Data	Sonar Positional Reporting System (SPORTS)	Annual active sonar usage data will be obtained from the SPORTS database to determine the number of active sonar hours and the geographic location of those hours for modeling purposes.
Acoustic Parameters	AN/SQS-53 and AN/SQS-56	Model the AN/SQS-53 and the AN/SQS-56 active sonar sources separately to account for the differences in source level, frequency, and exposure effects.
	Submarine Sonar	Submarine active sonar use will be included in effects analysis calculations using the SPORTS database
Post Modeling Analysis	Land Shadow	For sound sources within the acoustic footprint of land, (approximately 65 nautical miles [nm] for the Hawaii Range Complex [HRC]) subtract the land area from the marine mammal exposure calculation.
	Multiple Ships	Correction factors will be used to address overestimates of exposures to marine mammals resulting from multiple counting when there are more than one ship operating in the same vicinity.
	Multiple Exposures	The following refresh rates for HRC training events will be included to account for multiple exposures: • Other HRC ASW training – 13.5 hours • RIMPAC – 12 hours • USWEX – 16 hours • Multi-strike group – 12 hours.

6.8 CHANGES TO TTS AND PTS EXPOSURES FROM DEIS/OEIS

As described in detail in the DEIS/OEIS, acoustic exposures can result in noise induced hearing loss that is a function of the interactions of several factors, including individual hearing sensitivity and exposure amplitude, exposure duration, frequency, and other variables that have not been studied extensively (e.g., kurtosis, temporal pattern, directionality). Loss of hearing sensitivity is referred to as a "threshold shift." The extent and duration of threshold shift depends on a combination of several acoustic features and is specific to particular species. A shift in hearing sensitivity may be temporary (temporary threshold shift or TTS) or it may be permanent (permanent threshold shift or PTS) depending on how the frequency, amplitude, and duration of the exposure combine to produce damage and if that change is reversible.

There was no change in the acoustic effects modeling methodology involving PTS and TTS thresholds from the DEIS/OEIS, As a result of the change in sonar hours, the accurate modeling of the AN/SQS 56 sonar, and the modeling of submarine sonar, however, there was a decrease in the number of TTS and PTS exposures between the DEIS/OEIS and the Supplement to the DEIS/OEIS for all Alternatives. Quantification of the TTS and PTS exposures under each of the alternatives are described in detail in Sections 3.4 to 3.7.

6.8.1 New Monk Seal TTS/PTS Criteria

Research by Kastak et al. (1999; 2005) provided estimates of the average SEL (EFD level) for onset-TTS for a harbor seal, sea lion, and Northern Elephant seal. Although the exposure session's duration are well beyond those typically used with tactical sonars, the frequency ranges are similar (2.5 kHz - 3.5 kHz). This data provides good estimates for the onset of TTS in pinnipeds since the researchers tested different combinations of SPL and exposure duration, and plotted the growth of TTS with an increasing energy exposure level.

Of the three pinniped groups studied by Kastak et al. (1999; 2005) elephant seals are the most closely related to the Hawaiian monk seal (the family *Monachinae*). The onset-TTS number, provided by Kastak et al. for elephant seals and used to analyze impacts to monk seals is 204 dB re 1µPa^2-s. Using the same rationale described previously for the establishment of the PTS threshold based on odontocete onset-TTS (20 dB up from onset-TTS), the PTS threshold for monk seals used in the HRC analysis is 224 dB re 1µPa^2-s.

6.8.2 Summary of Exposures

Table 6-3 details the amount of sonar usage for ASW training under the Alternative 3. The sonar modeling input includes surface ship and submarine MFA tactical sonar, the associated DICASS sonobuoy, dipping sonar, and MK-48 torpedo sonar. Table 6-4 provides a summary of the total sonar exposures from all Alternative 3 ASW training that will be conducted over the course of a year. These exposure numbers are generated by the model without consideration of mitigation measures that would reduce the potential for marine mammal exposures to sonar.

The behavioral patterns and acoustic abilities for each species were analyzed in the DEIS/OEIS. Based on that analysis, results of past training, and the implementation of mitigation measures the Navy found that the HRC training events would not result in any death or injury to any marine mammal species. The DEIS/OEIS also found that while the acoustic modeling results indicated MFA sonar may expose all species to acoustic energy levels resulting in temporary behavioral effects, these exposures would have negligible impact on annual survival, recruitment, and birth rates.

Table 6-3. Sonar Usage for Alternative 3

Supplement to the DEIS/OEIS Hours/Events Modeled		
Other HRC ASW Training		
	Source	**Modeled**
	53	360 hours[1]
	56	75 hours
	Dipping	110 dips
	Sonobuoy	1,278 buoys
	MK-48	309 runs
	Submarine	200 hours
RIMPAC		
	Source	**Modeled**
	53	399 hours
	56	133 hours
	Dipping	400 dips
	Sonobuoy	497 buoys
	MK-48	4 runs
USWEX (5 Exercises)		
	Source	**Modeled**
	53	525 hours
	56	175 hours
	Dipping	500 dips
	Sonobuoy	648 buoys
Totals		
	Source	**Modeled**
	53	1,284 hours
	56	383 hours
	Dipping	1,010 dips
	Sonobuoy	2,423 buoys
	MK-48	313 runs
	Submarine	200 hours

Notes: [1] Includes 27 hours for Kingfisher

Table 6-4. Alternative 3 Sonar Modeling Summary—Yearly Marine Mammal Exposures From all ASW (RIMPAC, USWEX and HRC ASW Training)

Marine Mammals	Risk Function 120-195 dB SPL	DEIS/OEIS Dose Function	TTS[3]	PTS[4]
Bryde's whale	88	173	0	0
Fin whale[1, 2]	68	53	0	0
Sei whale[1, 2]	68	53	0	0
Humpback whale[1]	15,254	28,359	228	0
Sperm whale[1]	1,050	767	10	0
Dwarf sperm whale	2,799	1,653	40	0
Pygmy sperm whale	1,141	675	16	0
Cuvier's beaked whale	1,435	1,025	5	0
Longman's beaked whale	143	113	1	0
Blainville's beaked whale	471	391	6	0
Unidentified beaked whale	47	33	0	0
Bottlenose dolphin	1,061	887	19	0
False killer whale	68	53	0	0
Killer whale	68	53	0	0
Pygmy killer whale	279	214	4	0
Short-finned pilot whale	2,559	2,012	46	0
Risso's dolphin	710	559	12	0
Melon-headed whale	852	671	15	0
Rough-toothed dolphin	1,431	869	20	0
Fraser's dolphin	1,660	1,003	22	0
Pantropical spotted dolphin	3,211	2,770	56	0
Spinner dolphin	555	338	7	0
Striped dolphin	4,684	4,043	84	0
Monk seal[1]	161	362	3	0
TOTAL	39,863	47,129	594	0

Notes: [1] Endangered Species
[2] Due to a lack of density data for fin and sei whales, false killer whale results were used because they have a similar size population within the HRC.
[3] For cetacea TTS is the following range 195-215 dB re 1 μPa^2-s. For monk seals TTS is 204-224 dB re 1 μPa^2-s
[4] For cetacea PTS is >215 dB re 1 μPa^2-s. For monk seals PTS is >224 dB re 1 μPa^2-s
Risk Function Curve
195 dB – TTS 195-215 dB re 1 μPa^2
215 dB – PTS >215 dB re 1 μPa^2
dB = decibel
TTS = temporary threshold shift
PTS = permanent threshold shift

6.8.3 Estimated Behavioral Effects on ESA Listed Marine Mammal Species

ESA listed species that may be affected as a result of implementation of the HRC Alternative 3 include the blue whale (*Balaenoptera musculus*), fin whale (*Balaenoptera physalus*), Hawaiian monk seal (*Monachus schauinslandi*) humpback whale (*Megaptera novaeangliae*), North Pacific right whale (*Eubalaena japonica*), sei whale (*Balaenoptera borealis*) and sperm whale (*Physeter macrocephalus*).

Blue Whale (*Balaenoptera musculus*)

There is no change from the DEIS/OEIS or LOA application with regard to blue whales. There is no density information available for blue whales in Hawaiian waters given they have not been seen during any surveys. Given they are so few in number, it is unlikely that HRC training events will result in the exposure of any blue whales to accumulated acoustic energy in excess of any energy flux threshold or an SPL that would result in a behavioral response

Fin Whale (*Balaenoptera physalus*)

There is no density information for fin whales in the Hawaiian Islands (Barlow, 2006). For purposes of acoustic effects analysis, it was assumed that the number and density of fin whales did not exceed that of false killer whales (given that previous abundance estimates for the two species were identical in Barlow 2003); the modeled number of exposures for both species will therefore be the same. The risk function and Navy post-modeling analysis estimates 68 fin whales will exhibit behavioral responses NMFS will classify as harassment under the MMPA. The Navy believes this may affect fin whales, therefore the Navy has initiated ESA Section 7 consultation with NMFS (Table 6-4). Modeling indicates there would be no exposures to accumulated acoustic energy above 195 dB re 1 μPa^2-s, which is the threshold established indicative of onset TTS.

Humpback Whale (*Megaptera novaeangliae*)

The risk function and Navy post-modeling analysis estimates 15,254 humpback whales will exhibit behavioral responses NMFS will classify as harassment under the MMPA. The Navy believes this may affect humpback whales, therefore the Navy has initiated ESA Section 7 consultation with NMFS (Table 6-4). Modeling indicates there would be 228 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa^2-s (the thresholds established to be indicative of onset TTS and onset PTS respectively). Modeling indicates there would be no exposures to accumulated acoustic energy above 215 dB re 1 μPa^2-s.

North Pacific Right Whale (*Eubalaena japonica*)

There is no change from the DEIS/OEIS and the LOA application with regard to effects on North Pacific right whales. There is no density information available for North Pacific right whales in Hawaiian waters since they have not been seen during surveys. Given they are so few in number, it is unlikely that HRC training events will result in the exposure of any North Pacific right whales to accumulated acoustic energy in excess of any energy flux threshold or an SPL that would result in a behavioral response.

Sei Whale (*Balaenoptera borealis*)

For purposes of the acoustic effects analysis, the same assumptions made previously regarding fin whales are also made for sei whales. It was therefore assumed that the number and density of sei whales did not exceed that of false killer whales, and the modeled number of exposures for both species would therefore be the same. The risk function and Navy post-modeling analysis estimates 68 sei whales will exhibit behavioral responses NMFS will classify as harassment under the MMPA. The Navy believes this may affect sei whales, therefore the Navy has initiated ESA Section 7 consultation with NMFS (Table 6-4). Modeling indicates there would be no exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 µPa^2-s (the thresholds established to be indicative of onset TTS and onset PTS respectively). Modeling indicates no exposures for sei whales to accumulated acoustic energy above 215 dB re 1 µPa^2-s.

Sperm Whales (*Physeter macrocephalus*)

The risk function and Navy post-modeling analysis estimates 1,050 sperm whales will exhibit behavioral responses NMFS will classify as harassment under the MMPA. The Navy believes this may affect sperm whales; therefore, the Navy has initiated ESA Section 7 consultation with NMFS (Table 6-4). Modeling indicates there would 10 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 µPa^2-s (the thresholds established to be indicative of onset TTS and onset PTS respectively). Modeling indicates no exposures for sperm whales to accumulated acoustic energy above 215 dB re 1 µPa^2-s.

Hawaiian Monk Seal (*Monachus schauinslandi*)

The risk function and Navy post-modeling analysis estimates 161 Hawaiian monk seals will exhibit behavioral responses NMFS will classify as harassment under the MMPA. The Navy believes this may affect Hawaiian monk seals, therefore the Navy has initiated ESA Section 7 consultation with NMFS (Table 6-4). Modeling indicates there would be three exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 µPa^2-s (the thresholds established to be indicative of onset TTS and onset PTS respectively). Modeling indicates there would be no exposures for monk seals to accumulated acoustic energy above 224 dB re 1 µPa^2-s.

6.8.4 Estimated Behavioral Harassment Exposures for Non-ESA Species

Bryde's Whale (*Balaenoptera edeni*)

The risk function and Navy post-modeling analysis estimates 88 Bryde's whales will exhibit behavioral responses NMFS will classify as harassment under the MMPA (Table 6-4). Modeling indicates there would be no exposures to accumulated acoustic energy above 195 dB re 1 µPa^2-s, which is the threshold established indicative of onset TTS.

Minke Whale (*Balaenoptera acutorostrata*)

There is no change from the DEIS/OEIS and the LOA application with regard to effects on minke whales.

Blainville's Beaked Whale (*Mesoplodon densirostris*)

The risk function and Navy post-modeling analysis estimates 471 Blainville's beaked whales will exhibit behavioral responses NMFS will classify as harassment under the MMPA (Table 6-4). Modeling indicates six exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 µPa^2-s (the thresholds established to be indicative of onset TTS and onset PTS respectively). Modeling for all alternatives indicates that no Blainville's beaked whales would be exposed to accumulated acoustic energy at or above 215 dB re 1 µPa^2-s.

Bottlenose Dolphin (*Tursiops truncatus*)

The risk function and Navy post-modeling analysis estimates 1,061 bottlenose dolphins will exhibit behavioral responses NMFS will classify as harassment under the MMPA (Table 6-4). Modeling indicates 19 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 µPa^2-s (the thresholds established to be indicative of onset TTS and onset PTS respectively). Modeling for all alternatives indicates that no bottlenose dolphins would be exposed to accumulated acoustic energy at or above 215 dB re 1 µPa^2-s.

Cuvier's Beaked Whale (*Ziphius cavirostris*)

The risk function and Navy post-modeling analysis estimates 1,435 Cuvier's beaked whales will exhibit behavioral responses NMFS will classify as harassment under the MMPA (Table 6-4). Modeling indicates five exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 µPa^2-s (the thresholds established to be indicative of onset TTS and onset PTS respectively). Modeling for all alternatives indicates that no Cuvier's beaked whales would be exposed to accumulated acoustic energy at or above 215 dB re 1 µPa^2-s.

Dwarf Sperm Whale (*Kogia sima*)

The risk function and Navy post-modeling analysis estimates 2,799 dwarf sperm whales will exhibit behavioral responses NMFS will classify as harassment under the MMPA (Table 6-4). Modeling indicates 40 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 µPa^2-s (the thresholds established to be indicative of onset TTS and onset PTS respectively). Modeling for all alternatives indicates that no dwarf sperm whales would be exposed to accumulated acoustic energy at or above 215 dB re 1 µPa^2-s.

False Killer Whale (*Pseudorca crassidens*)

The risk function and Navy post-modeling analysis estimates 68 false killer whales will exhibit behavioral responses NMFS will classify as harassment under the MMPA (Table 6-4). Modeling indicates there would be no exposures to accumulated acoustic energy above 195 dB re 1 µPa^2-s, which is the threshold established indicative of onset TTS.

Fraser's Dolphin (*Lagenodelphis hosei*)

The risk function and Navy post-modeling analysis estimates 1,660 Fraser's dolphins will exhibit behavioral responses NMFS will classify as harassment under the MMPA (Table 6-4). Modeling indicates 22 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 µPa^2-s (the thresholds established to be indicative of onset TTS and onset PTS respectively). Modeling for all alternatives indicates that no Fraser's dolphins would be exposed to accumulated acoustic energy at or above 215 dB re 1 µPa^2-s.

Killer Whale (*Orcinus orca*)

The risk function and Navy post-modeling analysis estimates 68 killer whales will exhibit behavioral responses NMFS will classify as harassment under the MMPA (Table 6-4). Modeling indicates there would be no exposures to accumulated acoustic energy above 195 dB re 1 µPa^2-s, which is the threshold established indicative of onset TTS.

Longman's Beaked Whale (*Indopacetus pacificus*)

The risk function and Navy post-modeling analysis estimates 143 Longman's beaked whales will exhibit behavioral responses NMFS will classify as harassment under the MMPA (Table 6-4). Modeling indicates one exposure to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa^2-s (the thresholds established to be indicative of onset TTS and onset PTS respectively). Modeling for all alternatives indicates that no Longman's beaked whale would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa^2-s.

Melon-headed Whale (*Peponocephala electra*)

The risk function and Navy post-modeling analysis estimates 852 melon-headed whales will exhibit behavioral responses NMFS will classify as harassment under the MMPA (Table 6-4). Modeling indicates 15 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa^2-s (the thresholds established to be indicative of onset TTS and onset PTS respectively). Modeling for all alternatives indicates that no melon-headed whales would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa^2-s.

Pantropical Spotted Dolphin (*Stenella attenuata*)

The risk function and Navy post-modeling analysis estimates 3,211 pantropical spotted dolphins will exhibit behavioral responses NMFS will classify as harassment under the MMPA (Table 6-4). Modeling indicates 56 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa^2-s (the thresholds established to be indicative of onset TTS and onset PTS respectively). Modeling for all alternatives indicates that no pantropical spotted dolphins would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa^2-s.

Pygmy Killer Whale (*Feresa attenuata*)

The risk function and Navy post-modeling analysis estimates 279 pygmy killer whales will exhibit behavioral responses NMFS will classify as harassment under the MMPA (Table 6-4). Modeling indicates four exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa^2-s (the thresholds established to be indicative of onset TTS and onset PTS respectively). Modeling for all alternatives indicates that no pygmy killer whales would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa^2-s.

Pygmy Sperm Whale (*Kogia breviceps*)

The risk function and Navy post-modeling analysis estimates 1,141 pygmy sperm whales will exhibit behavioral responses NMFS will classify as harassment under the MMPA (Table 6-4). Modeling indicates 16 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa^2-s (the thresholds established to be indicative of onset TTS and onset PTS respectively). Modeling for all alternatives indicates that no pygmy sperm whales would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa^2-s.

Risso's Dolphin (*Grampus griseus*)

The risk function and Navy post-modeling analysis estimates 710 Risso's dolphins will exhibit behavioral responses NMFS will classify as harassment under the MMPA (Table 6-4). Modeling indicates 12 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 µPa^2-s (the thresholds established to be indicative of onset TTS and onset PTS respectively). Modeling for all alternatives indicates that no Risso's dolphins would be exposed to accumulated acoustic energy at or above 215 dB re 1 µPa^2-s.

Rough-Toothed Dolphin (*Steno bredanensis*)

The risk function and Navy post-modeling analysis estimates 1,431 rough-toothed dolphins will exhibit behavioral responses NMFS will classify as harassment under the MMPA (Table 6-4). Modeling indicates 20 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 µPa^2-s (the thresholds established to be indicative of onset TTS and onset PTS respectively). Modeling for all alternatives indicates that no rough-toothed dolphins would be exposed to accumulated acoustic energy at or above 215 dB re 1 µPa^2-s.

Short-finned Pilot Whale (*Globicephala macrorhynchus*)

The risk function and Navy post-modeling analysis estimates 2,559 short-finned pilot whales will exhibit behavioral responses NMFS will classify as harassment under the MMPA (Table 6_4). Modeling indicates 46 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 µPa^2-s (the thresholds established to be indicative of onset TTS and onset PTS respectively). Modeling for all alternatives indicates that no short-finned pilot whales would be exposed to accumulated acoustic energy at or above 215 dB re 1 µPa^2-s.

Spinner Dolphin (*Stenella longirostris*)

The risk function and Navy post-modeling analysis estimates 555 spinner dolphins will exhibit behavioral responses NMFS will classify as harassment under the MMPA (Table 6-4). Modeling indicates seven exposures to accumulated acoustic energy above 195 dB re 1 µPa^2-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no spinner dolphins would be exposed to accumulated acoustic energy at or above 215 dB re 1 µPa^2-s, which is the threshold indicative of onset PTS.

Striped Dolphin (*Stenella coeruleoalba*)

The risk function and Navy post-modeling analysis estimates 4,684 striped dolphins will exhibit behavioral responses NMFS will classify as harassment under the MMPA (Table 6-4). Modeling indicates 84 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 µPa^2-s (the thresholds established to be indicative of onset TTS and onset PTS respectively). Modeling for all alternatives indicates that no striped dolphins would be exposed to accumulated acoustic energy at or above 215 dB re 1 µPa^2-s.

Unidentified Beaked Whales

The risk function and Navy post-modeling analysis estimates 47 unidentified beaked whales will exhibit behavioral responses NMFS will classify as harassment under the MMPA (Table 6-4). Modeling indicates no exposures to accumulated acoustic energy above 195 dB re 1 µPa^2-s, which is the threshold established indicative of onset TTS.

6.8.5 Summary of Exposures by Exercise

HRC ASW Training—Alternative 3

The Alternative 3 modeling included surface ship sonar, submarine sonar, associated sonobuoys, MK-48 torpedo sonar, and dipping sonars per twelve month period. The modeled exposures for marine mammals during ASW training, without consideration of mitigation measures are presented in Table 6-5. Effects on marine mammals from these exposures are included in the previous discussion in Sections 6.8.3 for ESA listed species and 6.8.4 for non-ESA listed species.

Major Exercises—Alternative 3

Rim of the Pacific (RIMPAC)

There are no changes in the Alternatives for the RIMPAC exercise between the DEIS/OEIS and the Supplement to the DEIS/OEIS and this update to the LOA. The modeled exposures for marine mammals during RIMPAC, without consideration of mitigation measures are presented in Table 6-6.

Undersea Warfare Training Exercise (USWEX)

The Alternative 3 for USWEX has changed from the Alternatives presented in the DEIS/OEIS and the Supplement to the DEIS/OEIS and this update to the LOA. There were six USWEX analyzed in the DEIS/OEIS proposed under the Alternative 3 and in the Supplement to the DEIS/OEIS and this update to the LOA there are five USWEX proposed (Table 6-7).

Table 6-5. Alternative 3 Sonar Modeling Summary—Yearly Marine Mammal Exposures From HRC ASW Training

Marine Mammals	Risk Function	DEIS/OEIS Dose Function	195 dB TTS	215 dB PTS
Bryde's whale	34	84	0	0
Fin whale[1, 2]	29	28	0	0
Sei whale[1, 2]	29	28	0	0
Humpback whale[1]	6,703	8,938	63	0
Sperm whale[1]	415	391	2	0
Dwarf sperm whale	1,089	836	11	0
Pygmy sperm whale	444	342	4	0
Cuvier's beaked whale	521	490	1	0
Longman's beaked whale	55	56	0	0
Blainville's beaked whale	183	191	2	0
Unidentified beaked whale	18	16	0	0
Bottlenose dolphin	457	454	5	0
False killer whale	29	28	0	0
Killer whale	29	28	0	0
Pygmy killer whale	118	110	1	0
Shortfinned pilot whale	1,090	1,044	13	0
Risso's dolphin	302	290	3	0
Melonheaded whale	363	348	4	0
Roughtoothed dolphin	558	439	5	0
Fraser's dolphin	647	507	6	0
Pantropical spotted dolphin	1,402	1,424	15	0
Spinner dolphin	216	171	2	0
Striped dolphin	2,046	2,078	23	0
Monk seal[1]	81	177	1	0
TOTAL	16,858	18,498	160	0

Note: [1] Endangered Species
[2] Due to a lack of density data for fin and sei whales, false killer whale results were used because they have a similar size population within the HRC.
Risk Function Curve
195 dB – TTS 195-215 dB re 1 μPa^2-s
215 dB- PTS >215 dB re 1 μPa^2-s
dB = decibel
TTS = temporary threshold shift
PTS = permanent threshold shift

Table 6-6. Alternative 3 Sonar Modeling Summary—Yearly Marine Mammal Exposures for RIMPAC (Conducted Every Other Year)

Marine Mammals	Risk Function	DEIS/OEIS Dose Function	195 dB TTS	215 dB PTS
Bryde's whale	21	2	0	0
Fin whale[1, 2]	15	7	0	0
Sei whale[1, 2]	15	7	0	0
Humpback whale[1]	-	-	-	-
Sperm whale[1]	264	115	3	0
Dwarf sperm whale	650	211	13	0
Pygmy sperm whale	264	89	5	0
Cuvier's beaked whale	372	157	2	0
Longman's beaked whale	35	16	0	0
Blainville's beaked whale	109	54	2	0
Unidentified beaked whale	12	5	0	0
Bottlenose dolphin	242	128	6	0
False killer whale	15	7	0	0
Killer whale	15	7	0	0
Pygmy killer whale	62	30	1	0
Shortfinned pilot whale	588	289	14	0
Risso's dolphin	163	80	4	0
Melonheaded whale	196	96	5	0
Roughtoothed dolphin	332	115	7	0
Fraser's dolphin	386	133	7	0
Pantropical spotted dolphin	737	409	18	0
Spinner dolphin	129	45	2	0
Striped dolphin	1,074	596	27	0
Monk seal[1]	37	49	1	0
TOTAL	5,733	2,676	117	0

Note: [1] Endangered Species
[2] Due to a lack of density data for fin and sei whales, false killer whale results were used because they have a similar size population within the HRC.
Risk Function Curve
195 dB – TTS 195-215 dB re 1 μPa^2-s
215 dB- PTS >215 dB re 1 μPa^2-s
dB = decibel
TTS = temporary threshold shift
PTS = permanent threshold shift

Table 6-7. Alternative 3 Sonar Modeling Summary—Yearly Marine Mammal Exposures From USWEX (5 per year)

Marine Mammals	Risk Function	DEIS/OEIS Dose Function	195 dB TTS	215 dB PTS
Bryde's whale	33	65	0	0
Fin whale[1, 2]	24	19	0	0
Sei whale[1, 2]	24	19	0	0
Humpback whale[1]	8,551	19,421	166	0
Sperm whale[1]	371	262	5	0
Dwarf sperm whale	1,060	599	16	0
Pygmy sperm whale	433	244	7	0
Cuvier's beaked whale	542	378	2	0
Longman's beaked whale	53	41	1	0
Blainville's beaked whale	179	145	2	0
Unidentified beaked whale	17	12	0	0
Bottlenose dolphin	362	305	8	0
False killer whale	24	19	0	0
Killer whale	24	19	0	0
Pygmy killer whale	99	74	2	0
Shortfinned pilot whale	881	679	19	0
Risso's dolphin	245	189	5	0
Melonheaded whale	293	226	6	0
Roughtoothed dolphin	541	315	8	0
Fraser's dolphin	627	363	9	0
Pantropical spotted dolphin	1,072	938	23	0
Spinner dolphin	210	122	3	0
Striped dolphin	1,564	1,368	34	0
Monk seal[1]	43	136	1	0
TOTAL	17,272	25,958	317	0

Note: [1] Endangered Species
[2] Due to a lack of density data for fin and sei whales, false killer whale results were used because they have a similar size population within the HRC.
Risk Function Curve
195 dB – TTS 195-215 dB re 1 µPa^2-s
215 dB- PTS >215 dB re 1 µPa^2-s
dB = decibel
TTS = temporary threshold shift
PTS = permanent threshold shift

7. IMPACTS TO MARINE MAMMAL SPECIES OR STOCKS

There are no changes to Chapter 7 as described under the July 2007 Request for Letter of Authorization.

8. IMPACTS ON SUBSISTENCE USE

There are no changes to Chapter 8 as described under the July 2007 Request for Letter of Authorization.

9. IMPACTS TO THE MARINE MAMMAL HABITAT AND THE LIKELIHOOD OF RESTORATION

There are no changes to Chapter 9 as described under the July 2007 Request for Letter of Authorization.

10. IMPACTS TO MARINE MAMMALS FROM LOSS OR MODIFICATION OF HABITAT

There are no changes to Chapter 10 as described under the July 2007 Request for Letter of Authorization (LOA).

11. MEANS OF EFFECTING THE LEAST PRACTICABLE ADVERSE IMPACTS – MITIGATION MEASURES

There are no changes to Chapter 11 as described under the July 2007 Request for Letter of Authorization.

12. MINIMIZATION OF ADVERSE EFFECTS ON SUBSISTENCE USE

There are no changes to Chapter 12 as described under the July 2007 Request for Letter of Authorization.

13. MONITORING AND REPORTING MEASURES

There are no changes to Chapter 13 as described under the July 2007 Request for Letter of Authorization.

14. RESEARCH

There are no changes to Chapter 14 as described under the July 2007 Request for Letter of Authorization.

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