UPDATE

BIOLOGICAL ASSESSMENT
HAWAII RANGE COMPLEX

Submitted to:

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April 2008

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1 INTRODUCTION

1.1 Background

In September 2007, the United States (U.S.) Department of the Navy (Navy) published the Hawaii Range Complex (HRC) Marine Biological Assessment (Marine BA), which identified and addressed potential effects of sustainable range usage and enhancements in the Navy's HRC (U.S. Department of the Navy [DoN] 2007b) on marine species listed under the federal Endangered Species Act (ESA). The HRC Marine BA analyzed potential impacts of Navy training activities that use acoustic sources on marine mammals. Since the publication of the Marine BA, in coordination with National Marine Fisheries Service (NMFS), the Navy has re-evaluated its analysis. This re-evaluation led the Navy to determine that an update to the Marine BA was needed. Accordingly, this Update was prepared to supplement the analysis contained in the Marine BA. It focuses on the following issues:

- Modifications of the analytical methods used to evaluate the effects of mid-frequency active (MFA) sonar on marine mammals; and
- Changes in the amounts and types of sonar allocated to each of the alternatives.

The primary acoustic concern of this Update is the potential effects of using MFA sonar. Effects of high-frequency active (HFA) sonar from MK-48 torpedoes on marine mammals remain unchanged from the original assessment presented in the Marine BA.

The analysis presented herein differs from the Marine BA in that the analytical methods for evaluating marine mammal behavioral responses to MFA sonar in the HRC were modified. 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 Modifications of Analytical Methods

The original Marine BA used a dose function analytical approach. After the Marine BA was published, the Navy worked with NMFS to define a new mathematically representative curve with appropriate input parameters. In an effort to define the mathematical function and input parameters that best quantify behavioral harassment from Navy readiness activities, the Navy and NMFS considered several different methods. The agencies identified two possible approaches that could relate an acoustic "dose" (i.e., MFA sonar exposure) to the probability of a significant behavioral response. As the regulating agency, NMFS presented the two approaches to five marine mammalogists and an acoustician for an independent review. Two scientists, including one from NMFS's Office of Science and Technology, synthesized the reviews of the six scientists and made recommendations to NMFS's Office of Protected Resources.

Based on this recommendation, NMFS's Office of Protected Resources selected a mathematical function adapted from a solution in Feller (1968) to assess sonar effects on marine mammals, while recognizing the limitations of the underlying data as well as past NMFS rulings (*Surveillance Towed Array Sensor System Low Frequency Active [SURTASS LFA] Sonar Final Environmental Impact Statement [EIS]*). This function is applicable to situations where the data are limited (Feller, 1968), which is the state of the science for assessing the effects of MFA and HFA sonar on the behavior of marine mammals. This mathematical function was used by the

Navy in its *Final SURTASS LFA Sonar EIS/OEIS* (DoN 2001), and was relied upon in the impact analysis for the *Supplemental SURTASS LFA Sonar EIS* (DoN 2007a). Accordingly, for this Update, the Navy is applying the risk function (previously referred to as the dose function) to estimate the numbers of individuals of ESA-listed species that could experience harassment when exposed to MFA/HFA sonar. NMFS also has modified the model input parameters for MFA sonar effects on mysticetes, odontocetes, and pinnipeds.

Beyond application of the risk function, this Update further analyzes the acoustic modeling results to reduce the potential for overestimating MFA sonar hours, and thus to more-accurately assess the potential acoustical effects. These corrections were necessary because the original modeling overestimated sonar impacts on marine mammals for the following reasons:

- The acoustical footprints of the sonar sources did not account for land masses.
- The acoustical footprints of the sonar sources were added independently, and thus did not account for overlaps with other sonar systems in use during the same period.
- Acoustic modeling did not adjust for the NMFS-defined refresh rate of 24 hours. This period represents the amount of time which individual marine mammals are assumed to need to recover from behavioral harassment.

2 PROPOSED ACTION

2.1 Changes in the Amounts and Types of Sonar

The amounts and types of sonar that are analyzed in this Update differ from those analyzed in the Marine BA. The sonar hours upon which this Update is based are derived from data obtained from the Sonar Positional Reporting System (SPORTS). The SPORTS database was established by Commander, U.S. Fleet Forces Command in March 2006 to identify the locations where sonar was used. All commands that use MFA sonar and sonobuoys are required to report MFA sonar use each day for entry into the SPORTS database. After submitting the Marine BA, the Navy determined that SPORTS data could be used to refine the estimates of sonar use analyzed therein. Accordingly, SPORTS data are used in this Update to assist in determining the amount of MFA sonar hours appropriate for modeling potential sonar effects on marine mammals. The changes in modeled sonar hours and events are presented below (Table 1-1). Estimates of HFA sonar use (MK-48 torpedo) remain unchanged from the Marine BA.

Table 2-1: Changes in Modeled Sonar Hours

Marine BA		Update	
ASW		**ASW**	
Source	**Modeled**	**Source**	**Modeled**
53 SONAR	1,796 hours	53 SONAR	360 hours[1]
56 SONAR	NA	56 SONAR	75 hours
Dipping SONAR	NA	Dipping SONAR	110 dips
Sonobuoy	1,292 buoys	Sonobuoy	1,278 buoys
MK-48 Torpedo	309 runs	MK-48 Torpedo	309 runs
Submarine	NA	Submarine	200 hours
RIMPAC		**RIMPAC**	
Source	**Modeled**	**Source**	**Modeled**
53 SONAR	532 hours	53 SONAR	399 hours
56 SONAR	NA	56 SONAR	133 hours
Dipping SONAR	336 dips	Dipping SONAR	400 dips
Sonobuoy	480 buoys	Sonobuoy	497 buoys
MK-48 Torpedo	4 runs	MK-48 Torpedo	4 runs
USWEX (6 Exercises)		**USWEX (5 Exercises)**	
Source	**Modeled**	**Source**	**Modeled**
53 SONAR	1,167 hours	53 SONAR	525 hours
56 SONAR	NA	56 SONAR	175 hours
Dipping SONAR	576 dips	Dipping SONAR	500 dips
Sonobuoy	768 buoys	Sonobuoy	648 buoys
Totals		**Totals**	
Source	**Modeled**	**Source**	**Modeled**
53 SONAR	3,495 hours	53 SONAR	1,284 hours
56 SONAR	NA	56 SONAR	383 hours
Dipping SONAR	912 dips	Dipping SONAR	1,010 dips
Sonobuoy	2,540 buoys	Sonobuoy	2,423 buoys
MK-48 Torpedo	313 runs	MK-48 Torpedo	313 runs
Submarine	NA	Submarine	200 hours

Notes: [1] Includes 27 hours for Kingfisher

3 ENVIRONMENTAL BASELINE

Chapter 3 of the Marine BA, *Environmental Baseline*, remains unchanged.

4 LISTED AND PROPOSED SPECIES AND CRITICAL HABITAT THAT MAY BE AFFECTED BY THE ACTION

Chapter 4 of the Marine BA, *Listed and Proposed Species And Critical Habitat That May Be Affected By The Action*, remains unchanged.

5 EFFECTS ON LISTED AND PROPOSED SPECIES OR CRITICAL HABITAT

5.1 Background

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

Studies of behavioral effects of human-made sounds in marine environments have been inconclusive. Many of those studies lacked adequate controls, applied only to certain kinds of exposures (which are often different from the exposures being analyzed in the study), or had limited ability to detect behavioral changes that may be significant to the biology of the animals. Such studies are complicated by the range of behavioral responses marine mammals can exhibit; those responses can vary substantially by species, by individual, and by context. In some circumstances, individuals will exhibit normal behavior 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 sound 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.

Marine mammal behavioral reactions to anthropogenic sound may include strandings. Several “mass stranding” events—strandings that involve two or more individuals of the same species (excluding a single cow-calf pair)—in the past two decades were 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 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 instances, exposure to acoustic energy was considered to be an indirect cause of the death of marine mammals (Cox et al. 2006). Based on studies of lesions in beaked whales that stranded in the Canary Islands and Bahamas, in association with exposure to naval exercises that involved sonar, several investigators have hypothesized that there are two potential physiological mechanisms that might explain why the marine mammals stranded: tissue damage from resonance effects (Ketten 2005) and tissue damage from “gas and fat embolic syndrome” (Fernandez et al. 2005, Jepson et al. 2003, 2005). Stranding could be a behavioral response to sound in certain contexts, with the subsequently observed physiological effects of the strandings (e.g., overheating, decomposition, or internal hemorrhaging from being on shore) resulting from the stranding rather than from exposure to sonar (Cox et al. 2006).

5.2 Development of the Risk Function

In the Marine BA, the Navy presented a dose approach to assessing 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 the submission of the Marine BA, the Navy continued working with National Marine Fisheries Service (NMFS) to refine the mathematically representative curve previously used, along with applicable input parameters, to increase the accuracy of the Navy's assessment. As the regulating and cooperating agency, NMFS presented two methods to six scientists (marine mammalogists and acousticians from within and outside the federal government) for an independent review (NMFS 2008). Two scientists, including one from NMFS's Office of Science and Technology, then synthesized the reviews from the six scientists and developed a recommendation.

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

The second method was derived from a mathematical function used to assess the percentage of a marine mammal population experiencing the risk of harassment from the Navy's use of the Surveillance Towed Array Sensor System Low-Frequency Active (SURTASS LFA) sonar (DoN 2001). This function is applicable to instances with limited data (Feller, 1968), and this methodology is subsequently identified as "the risk function" in this Update.

NMFS's Office of Protected Resources decided to use the risk function and appropriate input parameters to estimate the risk of marine mammal behavioral harassment from exposure to MFA sonar. This determination was based on the recommendation of the two NMFS scientists; consideration of independent reviews of six scientists; 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).

5.3 Applying the Risk Function

To assess the potential effects of active sonar on marine mammals during training activities, the Navy and NMFS first investigated a series of mathematical models and methods that estimate the number of times that individual marine mammals might be exposed to MFA sonar at different received sound levels. The Navy's effects analyses assumed that the potential consequences of exposing individual animals to MFA sonar would be a function of the received sound pressure level (decibels re 1 micropascal [dB re 1 μPa]). These analyses assume that MFA sonar does not constitute harassment of marine mammals if they are exposed to levels of MFA sonar below a certain basement sound pressure value.

The second step of the assessment procedure required the Navy and NMFS to identify how marine mammals would respond when they were exposed to active sonar. Marine mammals can exhibit a variety of responses to sound, including sensory impairment (permanent and temporary threshold shifts and acoustical masking), physiological responses (particularly stress responses), behavioral responses, social responses that might reduce the fitness of individual animals, and social responses that would not reduce the fitness of individual marine mammals.

Previously, the Navy and NMFS used acoustical thresholds to identify the number of marine mammals that might experience temporary or permanent hearing losses or behavioral harassment when exposed to MFA sonar (see Figure 5-1 left panel). These acoustical thresholds were represented by sound exposure level (SEL), by sound pressure level (SPL), or by other metrics, such as peak pressure level and acoustic impulse (not considered in this Update). The general approach was to apply these threshold functions so that a marine mammal is counted as behaviorally harassed or as experiencing hearing loss when exposed to received sound levels above a certain threshold, and not counted as behaviorally harassed or as 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 for the Navy's 2006 Rim-of-the Pacific (RIMPAC) Major Exercise (FR 71.38710-38712, 2006) used 173 decibels re 1 micropascal squared-second (dB re 1 μPa^2-s) as the threshold energy level (i.e., SEL) for Level B behavioral harassment of cetaceans. If the accumulated energy from transmitted sonar 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 accumulated received 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 5-1 illustrates a typical step-function or threshold that might relate a sonar exposure to the probability of a response. As this figure illustrates, past Navy and NMFS acoustical thresholds assumed that every marine mammal exposed to sonar above a particular received sound level (for example, to the right of the red vertical line in the figure) would exhibit an identical response. These acoustical thresholds further assumed that the responses of marine mammals would not be affected by differences in acoustical conditions; differences between species and populations; or differences in gender, age, reproductive status, social behavior; or the prior experience of the individuals.

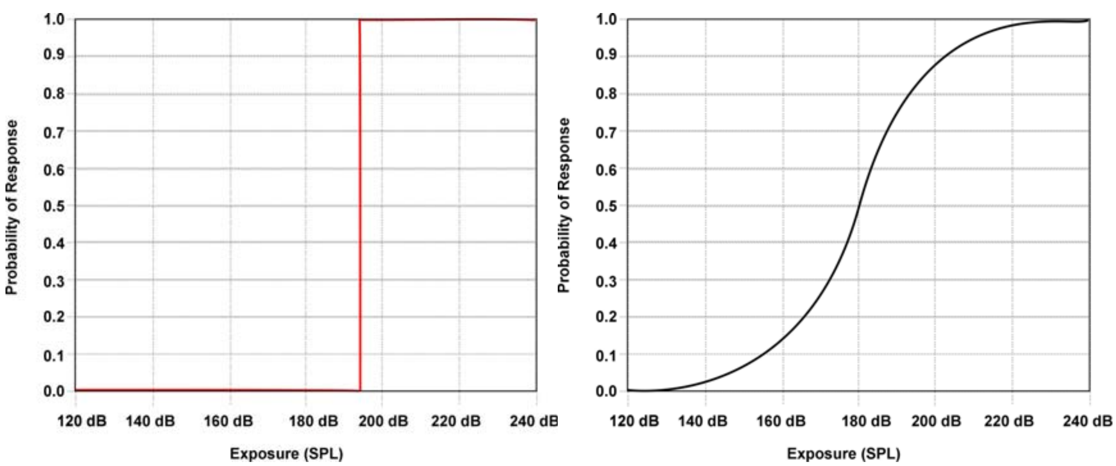

Figure 5-1: Typical Step Function (left) and Typical Risk Continuum-Function (right)
(SPL - sound pressure level in decibels referenced to 1 micropascal root mean square [1 μPa rms]).

The Navy and NMFS agree that studies to date of marine mammals do not support these assumptions—different species of marine mammals and different individuals of the same species respond differently to sonar exposure. Geographic and bathymetric conditions also influence the responses of marine mammals to sonar, so different populations may respond differently to sonar exposure. Furthermore, studies of animal physiology suggest that gender, age, reproductive status, and social behavior, among other variables, may affect marine mammal responses to sonar (Wartzok et al. 2003, Southall et al. 2007).

For several years, the Navy and NMFS have been developing a MFA sonar acoustical risk function to replace the acoustical 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 acoustical thresholds, expressed as SELs, to estimate temporary or permanent threshold shifts. Unlike acoustical thresholds, acoustic risk continuum functions (also called exposure-response functions, dose-response functions, or stress-response functions in other risk assessment contexts) assume that (a) the probability of a response depends on the "dose" (in this case, the received sound level) and (b) that the probability of a response increases as the "dose" increases. The probabilities associated with acoustic risk functions do not apply to individuals, but rather identify the portion of a population that may respond to an exposure.

The right panel in Figure 5-1 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 level increases, the probability of a response increases as well, but the relationship between exposure and 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, an acoustic risk function is a more robust predictor than a step function of the probable behavioral responses of marine mammals to sonar and other acoustic sources.

The Navy and NMFS previously used the acoustic risk function to estimate the probable responses of marine mammals to acoustical exposures for other training and research programs. Examples of previous applications include the Navy's *Final SURTASS LFA Sonar EIS* (DoN 2001); North Pacific Acoustic Laboratory experiments conducted off the Island of Kauai (Office of Naval Research 2001), and *Supplemental EIS for SURTASS LFA sonar* (DoN 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]) 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 Level B behavioral harassment from exposure to MFA sonar. The agencies will continue to use acoustical 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 a new concept for risk assessments. Common elements are used in developing air, water, radiation, and ambient noise standards and for assessing the effects of air, water, and noise pollution. The U.S. Environmental Protection Agency (USEPA) uses dose-functions in developing water quality criteria and in regulating pesticides (USEPA 1998); the Nuclear Regulatory Commission (NRC) uses dose-functions to estimate the consequences of radiation exposures (NRC 1997, 10 Code of Federal Regulations 20.1201); the Centers for Disease Control and Prevention (CDCP) and the Food and Drug Administration (FDA) use dose-functions in their assessments (CDCP 2003, FDA 2001); and the Occupational Safety and Health Administration uses dose-functions in assessing the potential effects of noise and chemicals on workers' health (FR 61:56746-56856, 1996; FR 71:10099-10385, 2006).

5.3.2 Risk Function Adapted from Feller

The acoustic risk function developed by the Navy and NMFS estimates the probability of behavioral responses that NMFS would classify as harassment at 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* (DoN 2001) and relied on in the *Supplemental SURTASS LFA Sonar EIS* (DoN 2007a), for the probability of MFA sonar risk for Level B behavioral harassment, with input parameters modified by NMFS for MFA sonar for mysticetes, odontocetes, and pinnipeds.

The risk function should have a value near zero for very low exposures, and a value near one for very high exposures. One class of functions that satisfies this criterion is cumulative probability distributions. In selecting a particular risk function, several criteria were identified. The function should:

- Use parameters to focus discussion on areas of uncertainty;
- Contain a limited number of parameters;
- Be capable of accurately fitting experimental data; and
- Be reasonably convenient for algebraic manipulations.

As described by the Navy (2001), the mathematical function shown 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 Section 5.5).

To use this function, the values of the three parameters (<u>B</u>, <u>K</u>, and <u>A</u>) need to be established. As further explained in Section 5.5, the values used in this Update are based on three sources of data: TTS experiments conducted at SSC and documented by 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 (NMFS 2005, DoN 2004, Fromm 2004a, 2004b); and observations of the behavioral response of North Atlantic right whales exposed to alert stimuli containing mid-frequency components documented by 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.

5.4 Data Sources Used for Risk Function

Cetacean responses to MFA sound need to be better defined through controlled experiments. The Navy is contributing to an ongoing behavioral study in the Bahamas that will provide some initial information on beaked whales, the cetaceans that are most sensitive to MFA sonar. NMFS is leading this international effort with scientists from various academic institutions and research organizations to study how marine mammals respond to underwater sound.

Among the data that are now available, NMFS and the Navy have determined that the following three data sets are the best data for developing risk function parameters for MFA and HFA sonar. These data sets are the only known data that specifically relate altered behavioral responses to exposure to MFA sonar.

5.4.1 SSC's Controlled Experiments

Most of the observations of the behavioral responses of toothed whales to sound 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 on command, 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 exposure site during subsequent tests (Schlundt et al. 2000, Finneran et al. 2002). Bottlenose dolphins exposed to one-second (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), and some animals exhibited aggressive behavior (Ridgway et al. 1997; Schlundt et al. 2000).

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-sec tones. These data 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) summarized 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 and 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 test animals had been trained to exhibit, occurred as the animals were exposed to increasing levels of fatiguing stimuli.

b. Finneran et al. (2001, 2003, 2005) conducted TTS experiments using 3 kHz tones. The test method was similar to that of Schlundt et al. (2000), except the tests were conducted in a pool with an ambient noise level below 50 dB re 1 μPa/hertz [Hz], and no masking noise. Two separate experiments were conducted using 1-sec tones. In the first experiment, 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.

5.4.2 Studies of Baleen (Mysticetes) Whale Responses

The only available mysticete data resulted from field experiments with baleen whales (mysticetes) exposed to sound over a range of frequencies from 120 Hz to 4,500 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.

Nowacek et al. (2004) observed 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 record the responses of whales to passing ships and test their responses to controlled sound exposures, which included recorded 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. 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 to (a) provoke an action from the whales via the auditory system with disharmonic signals that cover the whales estimated hearing range; (b) maximize the signal-to-noise ratio (obtain the largest difference between background noise) and (c) 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).

5.4.3 Observations of Killer Whales in Haro Strait in the Wild

In May 2003, killer whales (*Orcinus orca*) exhibited behavioral responses while the USS SHOUP was engaged in MFA sonar operations in Haro Strait near Puget Sound, Washington. These observations were made in an uncontrolled environment, so the sound field that may have been associated with the sonar operations had to be estimated. The behavioral observations were reported for groups of whales rather than for individual whales. However, the USS SHOUP observations are the only data available on behavioral responses of wild animals exposed to AN/SQS-53 MFA sonar.

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

5.4.4 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 challenges are largely attributable to the sparseness of the data. Ultimately, different functions should be derived for different marine mammals, but the available data are insufficient to support such an approach. The goal is for risk functions to be based on empirical measurement.

The risk function presented in this Update 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 that each of these data sets has its limitations. If informed by the limited available data relevant to the MFA sonar application, however, this risk function has the advantages of simplicity, estab lished precedent for its application, and a foundation in marine mammal research.

While NMFS weights all data sets equally in developing the risk function, the Navy believes that the SSC San Diego data are the most rigorous and applicable for the following reasons:

- The data are 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 within the MFA sonar bandwidth.

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

- These data sets represent the responses of only four species: trained bottlenose dolphins and beluga whales, and North Atlantic right whales 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, and 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 Belugas

- 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 observed behavioral responses were from exposure to alert stimuli that contained mid-frequency components, but which were 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. 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, each 1-sec long. This 18-minute alert stimulus contrasts with 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

- The observations of behavioral harassment were complicated by other nearby sources of harassment (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 any observed response as opposed to baseline conditions.

5.5 Risk Function Parameters

The values of <u>B</u>, <u>K</u>, and <u>A</u> need to be specified to use the risk function. The risk continuum function approximates the dose-response function in a manner analogous to pharmacological risk assessment (DoN 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.

5.5.2 Basement Value for Risk—The <u>B</u> Parameter

The <u>B</u> parameter is the basement value below which the risk is so low that calculations are impractical. This 120-dB level is taken as the estimated received sound level (RL) below which the risk of significant change in a biologically important behavior approaches zero. This level is based on a broad review of the levels at which multiple species reportedly responded to a variety of sounds, including mid-frequency. It 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. The convention of ending the risk calculation at 120 dB for MFA sonar has no effect on the subsequent calculations, because the risk function does not attain appreciable values at received levels that low.

5.5.3 The K Parameter

NMFS and the Navy used the mean of the following values to define the midpoint of the function: (1) the mean (185.3 dB) of the lowest received sound levels at which individuals responded with altered behavior to 3-kHz tones in the SSC data set; (2) the estimated mean received sound level 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 (139.2 dB SPL) of the five maximum received levels at which Nowacek et al. (2004) observed significantly altered responses of right whales to the alert stimuli relative to the control (no input signal). 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.

5.5.4 Risk Transition—The A Parameter

The A parameter controls how rapidly risk transitions from low to high values with increasing received sound 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 5-2) (NMFS 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* (DoN 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*). (NMFS 2008)

Based on NMFS's 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 5-3). (NMFS 2008)

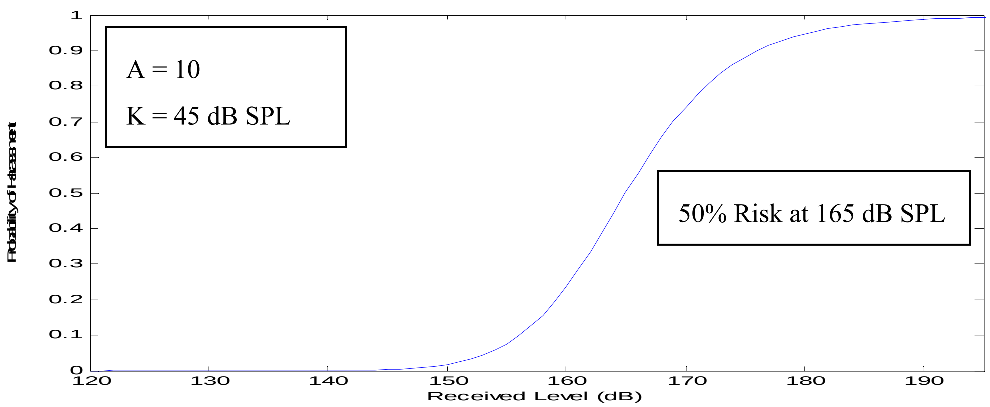

Figure 5-2: Risk Function Curve for Odontocetes (Toothed Whales) and Pinnipeds

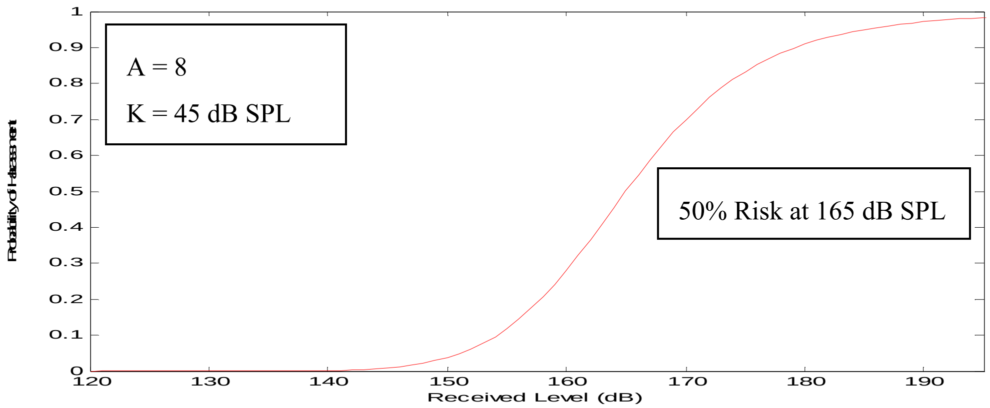

Figure 5-3: Risk Function Curve for Mysticetes (Baleen Whales)

5.6 Basic Application of the Risk Function

5.6.2 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 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 and NMFS apply 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 observations of four species that were 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 expresses 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 sound level as the only variable that is relevant to a marine mammal's behavioral response. However, 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 available do not allow for incorporation of these other variables into the risk function; 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). 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 sound 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 indications that marine mammals respond to sound sources at that *received level*, NMFS has no data that describe the responses 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, the Navy will re-evaluate the risk function to incorporate any additional variables into the "take" estimates.

Lastly, the number of animals that will be "taken" by Navy training activities must be estimated. Level B behavioral harassment occurs at the level of the individual, and does not assume any population-level consequences. A negligible impact finding is based on the lack of likely adverse effects on 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 (e.g., intensity, duration), the context of any responses (e.g., critical reproductive time or location, migration), 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 sound 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 two percent) 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). The modeling does not take into account the reduction of effects resulting from the Navy's standard mitigation, so approximately 37 percent of all exposures are modeled as occurring within the 1,000-yard mitigation safety zone, where procedures are in place to reduce the received sound level of animals. Generally speaking, Navy and NMFS anticipate more severe effects of takes resulting from exposure to higher received sound levels (though this is not a strictly linear relationship for all species, individuals, or circumstances) and less severe effects of takes from exposure to lower received sound levels.

Table 5-1: Distribution of Harassment by Received Sound Level Range

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 (e.g., other variables). All else being equal, takes that result from exposure to lower received sound levels and at greater distances from the exercises would be less likely to contribute to population level effects (Figure 5-4).

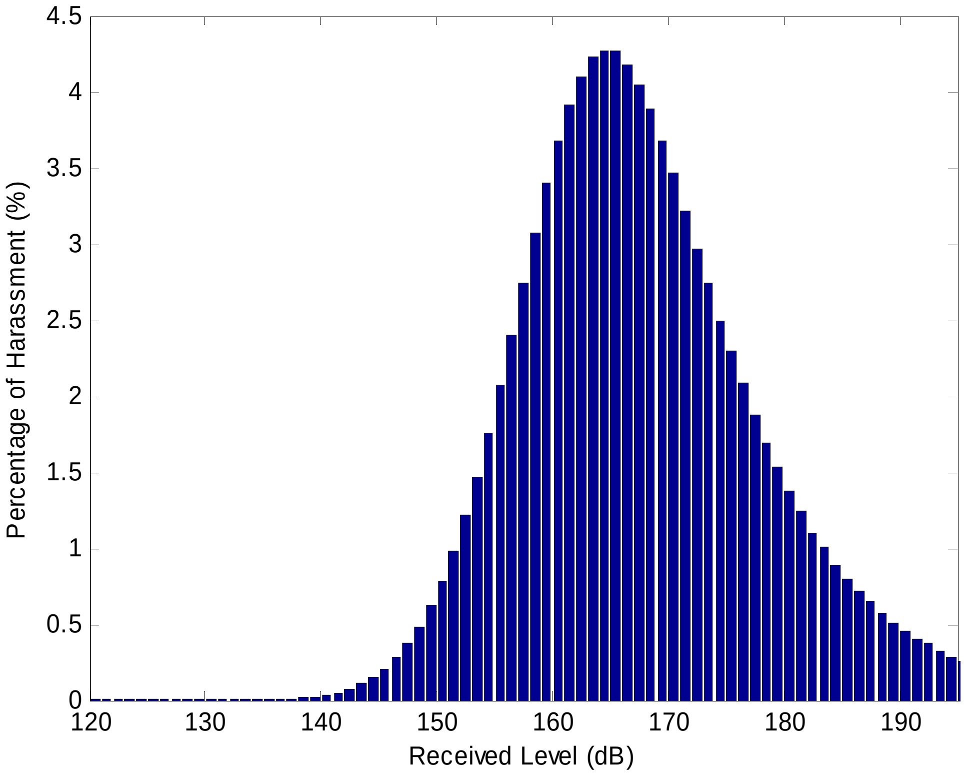

Figure 5-4: Distribution of Behavioral Harassments by Received Sound Level

5.7 Navy Post-Acoustic Modeling Analysis

The environmental provinces used to characterize sound propagation throughout the HRC are the same in the Update as those described in the Marine BA. The description of animal densities and their depth distributions for modeling purposes has not changed. In a change from the Marine BA, the quantification of sonar hours analyzed in this Update were derived from SPORTS, which provides the basis for a more-accurate assessment of the training needs and sonar hours being modeled (see Chapter 1.0).

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

For this Update, the acoustical 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 in the NMFS-defined refresh rate of 24 hours. This period represents the amount of time which individual marine mammals require to recover completely from a behavioral harassment.

This change from the Marine BA will lead to more consistent and accurate model outputs. Table 5-2 summarizes the modeling protocols used in the analysis for this Update.

Table 5-2: Navy Protocols for Accurate Modeling Quantification of Marine Mammal Exposures

Historic 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	AN/SQS-53 and the AN/SQS-56 active sonar sources will be modeled 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]) the land area will be subtracted 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 is more than one ship operating in the same area.
	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.

5.8 Changes In TTS And PTS Exposures

As described in the Marine BA, acoustic exposures can induce hearing losses that are a function 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 a 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 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.

The acoustic effects modeling methods for PTS and TTS thresholds have not changed from the Marine BA. 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, the numbers of TTS and PTS exposures in the Update are less than in the Marine BA.

5.8.2 New Monk Seal TTS and PTS Criteria

Kastak et al. (1999; 2005) estimated the average SEL (EFD level) for onset-TTS for a harbor seal, sea lion, and northern elephant seal. Although the exposure session durations are well beyond those typical of tactical sonars, the frequency ranges are similar (2.5 kHz - 3.5 kHz). These data provide good estimates of the onset of TTS in pinnipeds because the researchers tested different combinations of SPL and exposure duration, and plotted the growth of TTS with increasing energy exposure levels.

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 value, provided by Kastak et al. for elephant seals and used to analyze impacts to monk seals, is 204 dB re $1\mu Pa^2$-s. Using the same rationale described previously to establish the PTS threshold based on odontocete onset-TTS (20 dB up from onset-TTS), the PTS threshold for monk seals is 224 dB re $1\mu Pa^2$-s.

5.8.3 Summary of Exposures

Table 5-3 describes the amount of sonar usage for ASW training under the Proposed Alternative. Inputs for the sonar modeling include surface ship and submarine MFA tactical sonar, the associated DICASS sonobuoy, dipping sonar, and MK-48 torpedo sonar. Table 5-4 summarizes annual sonar exposures from all ASW training. These exposure numbers are generated by the model without consideration of mitigation measures that would reduce the potential for marine mammal exposures from sonar.

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

Table 5-3: Sonar Usage

Hours/Events Modeled		
	Source	**Modeled**
Other HRC ASW Training	53	360 hours[1]
	56	75 hours
	Dipping	110 dips
	Sonobuoy	1,278 buoys
	MK-48	309 runs
	Submarine	200 hours
	Source	**Modeled**
RIMPAC	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 5-4: 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]
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
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. 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.

5.8.4 Estimated Effects on Behavior of ESA-Listed Marine Mammal Species

ESA-listed species that may be affected by implementation of the HRC Preferred Alternative 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)

The analysis of possible effects on blue whales of implementing the Proposed Action did not change from that presented in the Marine BA. No density information is available for blue whales in Hawaiian waters because they have not been seen during any surveys. Because they are so few in number, HRC training events are not likely to expose 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)

No density information is available for fin whales in the Hawaiian Islands (Barlow 2006). For the acoustic effects analysis, the numbers and density of fin whales were assumed to not exceed those of false killer whales (because previous abundance estimates for the two species were identical in Barlow 2003); the modeled number of exposures of both species will thus be the same. The risk function and Navy post-modeling analysis indicate that 68 fin whales will exhibit behavioral responses that NMFS will classify as harassment. The Navy believes that this level of harassment may affect fin whales, and has initiated ESA Section 7 consultation with NMFS (Table 5-4). Modeling indicates that 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 estimate that 15,254 humpback whales will exhibit behavioral responses NMFS will classify as harassment. The Navy believes that this level of harassment may affect humpback whales, therefore the Navy has initiated ESA Section 7 consultation with NMFS (Table 5-4). Modeling indicates that 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*)

The analysis of possible effects on North Pacific right whales of implementing the Proposed Action did not change from that presented in the Marine BA. No density information is available for North Pacific right whales in Hawaiian waters because they have not been seen during surveys. Because they are so few in number, HRC training events are not likely to expose 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 the acoustic effects analysis, the same assumptions made previously regarding fin whales are also made for sei whales. The number and density of sei whales were assumed to not exceed those 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 estimate that 68 sei whales will exhibit behavioral responses that NMFS will classify as harassment. The Navy believes that this level of harassment may affect sei whales, so the Navy has initiated ESA Section 7 consultation with NMFS (Table 5-4). Modeling indicates that 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 of 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 estimate that 1,050 sperm whales will exhibit behavioral responses NMFS will classify as harassment. The Navy believes that this level of harassment may affect sperm whales; so the Navy has initiated ESA Section 7 consultation with NMFS (Table 5-4). Modeling indicates that 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 of 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 estimate that 161 Hawaiian monk seals will exhibit behavioral responses that NMFS will classify as harassment. The Navy believes that this level of harassment may affect Hawaiian monk seals, so the Navy has initiated ESA Section 7 consultation with NMFS (Table 5-4). Modeling indicates that 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 that there would be no exposures of monk seals to accumulated acoustic energy above 224 dB re 1 µPa^2-s.

5.8.5 Summary of Exposures by Exercise

HRC ASW Training

Modeling included surface ship sonar, submarine sonar, associated sonobuoys, MK-48 torpedo sonar, and dipping sonars. The modeled exposures of marine mammals during ASW training, without consideration of mitigation measures, are presented in Table 5-5.

Major Exercises

Rim of the Pacific (RIMPAC)

The analysis of the RIMPAC exercise in this Update remains unchanged from the Marine BA. The modeled exposures of marine mammals during RIMPAC, without consideration of mitigation measures, are presented in Table 5-6.

Undersea Warfare Training Exercise (USWEX)

The analysis of USWEX has changed from that presented in the Marine BA. Six USWEX were analyzed in the Marine BA. This Update addresses five USWEX (Table 5-7).

Table 5-5: 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
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
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 5-6: 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
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
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 5-7: 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
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
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

6 CUMULATIVE EFFECTS ANALYSIS

Chapter 6 of the Marine BA, *Cumulative Effects Analysis*, remains unchanged.

7 MITIGATION MEASURES

Chapter 7 of the Marine BA, *Mitigation Measures*, remains unchanged.

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