Post-Model Quantitative Analysis

of Animal Avoidance Behavior and Mitigation Effectiveness

for Hawaii-Southern California Training and Testing

Technical Report

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1 INTRODUCTION

The Navy's *Hawaii-Southern California Training and Testing Final Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS)* (U.S. Department of the Navy 2013) quantitatively assesses potential impacts to marine mammals and sea turtles due to exposure to sonar, other active acoustic sources, explosives, and swimmer defense airguns. The quantitative analysis of acoustic and explosive impacts on marine mammals and sea turtles consists of two components: (1) acoustic modeling of exposures and (2) post-model analysis. The first component, acoustic modeling of exposures, is described in the Navy technical report titled *Determination of Acoustic Effects on Marine Mammals and Sea Turtles for the Hawaii-Southern California Training and Testing Environmental Impact Statement/ Overseas Environmental Impact Statement* (Marine Species Modeling Team 2013), available at www.hstteis.com, and are hereafter referred to as the model and the modeling technical report, respectively. The second component described herein, post-model analysis, quantitatively accounts for animal avoidance behavior based on best available science and implementation of mitigation to avoid or reduce acoustic exposures during Navy training and testing activities. Together, the acoustic modeling and post-model analysis provide the Navy's best estimate of quantitative acoustic impacts based on current available methodologies that, along with consideration of actual observation data during past Navy training and testing activities and best available science regarding marine species, informs the comprehensive analysis of impacts to marine species presented in the *Hawaii-Southern California Training and Testing Final EIS/OEIS*[1] (U.S. Department of the Navy 2013).

A basic understanding of the modeling of acoustic and explosive exposures undertaken for the *Hawaii-Southern California Training and Testing Final EIS/OEIS* is necessary to understand the purpose of the subsequent post-model analysis to account for animal avoidance behavior and implementation of mitigation (a detailed explanation can be found in the modeling technical report). The acoustic modeling assesses various scenarios that represent typical training and testing activities in typical locations and seasons in the Study Area, and takes into account predicted animal densities and environmental factors that affect sound propagation. The modeling considers the synergistic effects of multiple acoustic sources in a single event and tracks the acoustic exposure history of each animat (a dosimeter representing an animal) in the affected area. The exposure history of each animat is compared to acoustic impact thresholds to determine the worse-case acoustic effect assigned to that animat. Acoustic impact criteria and thresholds are provided in the Navy technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis* (Finneran and Jenkins 2012) available at www.hstteis.com. The predicted numbers of impacts on each species for each testing and training activity are summed to provide the overall model-estimated effects. The term "model-estimated effects" is used throughout this document to refer to the model results without any further post-model analysis.

As described in the modeling technical report, the model accounts for an animat's position vertically in the water column by taking into account species-specific dive profiles; however, it does not account for an animat's horizontal movement, so the model assumes that an animal would remain stationary and tolerate repeated intense sound exposures at very close distances. This assumption is invalid because animals are likely to leave the area to avoid intense sound exposure that could cause injury. Similarly,

[1] The quantitative acoustic impacts presented in the *Draft EIS/OEIS for Hawaii-Southern California Training and Testing* were the model-predicted impacts with consideration of during-activity avoidance behavior for exposures to sonar and other active acoustic sources. Additionally, the levels of certain activities were adjusted in the *Final EIS/OEIS for Hawaii-Southern California Training and Testing* to reflect more accurate estimates of future training and testing needs and to correct errors. These changes are specifically identified in the Foreword of the *Final EIS/OEIS for Hawaii-Southern California Training and Testing*. The general types and locations of training and testing did not change.

the modeling assumes that certain species known to avoid areas of high anthropogenic activity would remain in the very close vicinity of all Navy training and testing activities, regardless of how many vessels or low-flying aircraft (i.e., helicopters) are involved. The outputs of the model, therefore, present an unrealistically high estimate of acoustic impacts in close proximity to certain Navy training and testing activities.

Additionally, the modeling currently does not account for implementation of mitigation designed to avoid or reduce marine mammal and sea turtle exposures to explosives and high intensity sound, nor does it account for standard operating procedures (procedures designed for the safety of personnel and equipment) implemented to ensure safety and mission success, but which may have incidental environmental benefits. That is, the modeling assumes that any mitigations measures, such as sonar power-down or delay of a detonation, would not be implemented even if an animal could be sighted within the mitigation zone. The Navy's proposed mitigations were developed in cooperation with the National Marine Fisheries Service (NMFS) and are effective at reducing environmental impacts while being operationally feasible. The outputs of the model, therefore, present an unrealistically high estimate of acoustic impacts within the mitigation zones of certain Navy training and testing activities.

In order to provide a holistic quantitative assessment of acoustic impacts, the post-model analysis quantitatively assessed the effect of animal avoidance behavior and implementation of mitigation, considering the following:

- Best available science on species' behavior
- Number of platforms (i.e., aircraft, vessels) used during specific activities
- Ability to detect specific species
- Ability to observe the mitigation zone around different platforms during different activities

The following sections explain each of the post-model analysis considerations (pre-activity area avoidance by sensitive species, implementation of mitigation, and during activity avoidance of intense sound exposures). The steps of the post-model analysis are briefly summarized in Table 1-1 and presented in the order they are expected to occur during an actual training or testing activity, which is also the order in which they were mathematically considered in the post-model analysis. When feasible for a given activity, mitigation begins prior to the actual production of underwater sound (e.g., 10-30 minutes, dependent upon platform, prior to most sonar and explosive activities); therefore, mitigation effectiveness is applied in the post-model analysis before animal avoidance is quantified. The results of the post-model analysis are shown for each species in Section 5 (Summary) with estimated effects to marine species for each training and testing activity grouped and summed as they are in the *Hawaii-Southern California Training and Testing Final EIS/OEIS*[2]. Section 5 (Summary) shows the original model outputs and the reductions in impacts due to each step of the post-model analysis for training and testing activities proposed under the *Hawaii-Southern California Training and Testing Final EIS/OEIS*

[2] These are the combined summation of all exposures for all species in the Study Area for an annual total based on a maximum year (all non-annual and annual events occurring in the 12-month period). The predicted impacts from annual training and testing activities using sonar and other active acoustic sources and explosives as shown in Tables 3.4-18 through 3.4-29 in the Hawaii-Southern California Training and Testing Final EIS/OEIS, are broken out by stocks for some species (e.g., false killer whale), however, for this report, the summary tables in Section 5 are only broken out at the species level since the modeling results are by species only. The stock level predicted effects in the FEIS/OEIS are based on an additional step using a ratio to determine the potential effect on a stock based on abundance information NMFS published in the final 2012 Pacific Stock Assessment report (Carretta et al. 2013) and the location where activities are likely to occur. See Chapter 2 of the *Hawaii-Southern California Training and Testing Final EIS/OEIS* for a description of the activities and locations that compose annual training and annual testing.

preferred alternative (Alternative 2). Any reductions in model-estimated mortalities or injuries due to the post-model analysis are not removed from the overall sum of quantitative impact; in all cases, any reductions were added to the next highest-order impact (e.g., reductions in injury were added to temporary threshold shift [TTS]).

The resulting quantitative assessment of acoustic impacts is still assumed to be conservative (i.e., over-predicted).[3]

[3] Conservative assumptions are explained in Section 3.4.3.1.6.4 (Model Assumptions and Limitations) of the *Final EIS/OEIS for Hawaii-Southern California Training and Testing* (U.S. Department of the Navy 2013). In brief, they include: (1) animats are modeled as being underwater and facing the source and, therefore, always predicted to receive the maximum sound level at their position within the water column; (2) multiple exposures within any 24-hour period are considered one continuous exposure for the purposes of calculating the temporary or permanent hearing loss, because there are not sufficient data to estimate a hearing recovery function for the time between exposures; (3) explosive thresholds for onset mortality and onset slight lung injury are set on the threshold of effect for 1 percent likelihood for a calf-weight animal; and (4) animats are assumed to receive the full impulse of the initial positive pressure wave due to an explosion, although the impulse-based thresholds (onset mortality and onset slight lung injury) assume an impulse delivery time adjusted for animal size and depth.

Table 1-1: Post-Model Acoustic Impact Analysis Process

Is the Sound Source Sonar/Other Active Acoustic Source or Explosives?	
Sonar and Other Active Acoustic Sources	**Explosives**
S-1. Is the activity preceded by multiple vessel activity or hovering helicopter (local transits and event preparation prior to sonar use)? (discussed in Section 2)	**E-1. Is the activity preceded by multiple vessel activity or hovering helicopter (local transits and event preparation prior to explosive use)? (discussed in Section 2)**
Species sensitive to human activity (i.e., beaked whales) are assumed to avoid the activity area before the use of sonar, putting them out of the range to PTS. The model-estimated PTS to these species during these activities are unlikely to actually occur and, therefore, are considered to be TTS (animal is assumed to move into the range of potential TTS). The activities preceded by multiple vessel movements or hovering helicopters are listed in Table 2-1.	Species sensitive to human activity (i.e., beaked whales) are assumed to avoid the activity area before the use of explosives, putting them out of the range to mortality. Model-estimated mortalities to these species during these activities are unlikely to actually occur and, therefore, are considered to be injuries (animal is assumed to move into the range of potential onset of slight lung injury). The activities preceded by multiple vessel movements or hovering helicopters are listed in Table 2-2.
S-2. Can Lookouts observe the activity-specific mitigation zone up to and during the sound-producing activity? (discussed in Section 3)	**E-2. Can Lookouts observe the activity-specific mitigation zone up to and during the sound-producing activity? (discussed in Section 3)**
If Lookouts are able to observe the mitigation zone up to and during a sound-producing activity, the sound-producing activity would be halted or delayed if a marine mammal is observed and would not resume until the animal is thought to be out of the mitigation zone (per the mitigation measures in Chapter 5 of the Final EIS/OEIS for Hawaii-Southern California Training and Testing). Therefore, model-estimated PTS exposures are reduced by the portion of animals that are likely to be seen [Mitigation Effectiveness (1, 0.5, or 0) x Sightability, g(0)]. Any animals removed from the model-estimated PTS are instead assumed to be TTS (animal is assumed to move into the range of TTS). The g(0) value is associated with the platform (vessel or aircraft) with the dedicated Lookout(s). The g(0) values are provided in Table 3-5. The Mitigation Effectiveness values for activities using sonar or other active acoustic sources are provided in Table 3-3.	If Lookouts are able to observe the mitigation zone up to and during an explosion, the explosive activity would be halted or delayed if a marine mammal is observed and would not resume until the animal is thought to be out of the mitigation zone (per the mitigation measures in Chapter 5 of the Hawaii-Southern California Training and Testing Final EIS/OEIS). Therefore, model-estimated mortalities and injuries (onset slight lung injury and PTS) are reduced by the portion of animals that are likely to be seen [Mitigation Effectiveness (1, 0.5, or 0) x Sightability, g(0)]. Any animals removed from the model-estimated mortalities or injuries (onset slight lung injury or PTS) are instead assumed to be injuries (Onset slight lung injury) or behavioral disturbances (TTS), respectively (animals are assumed to move into the range of a lower effect). The g(0) value is associated with the platform (vessel or aircraft) with the dedicated Lookout(s). The g(0) values are provided in Table 3-5. The Mitigation Effectiveness values for explosive activities are provided in Table 3-4.
S-3. Does the activity cause repeated sound exposures which an animal would likely avoid? (discussed in Section 4)	**E-3. Does the activity cause repeated sound exposures which an animal would likely avoid? (discussed in Section 4)**
The Navy Acoustic Effects Model assumes that animals do not move away from a sound source and receive a maximum sound exposure level. In reality, an animal would likely avoid repeated sound exposures that would cause PTS by moving away from the sound source. Therefore, only the initial exposures resulting in model-estimated PTS to high-frequency cetaceans, low frequency cetaceans, and pinnipeds are expected to actually occur (after accounting for mitigation in step S-2). Model estimates of PTS beyond the initial pings are considered to actually be TTS, as the animal is assumed to move out of the range to PTS and into the range of TTS. Marine mammals in the mid-frequency hearing group would have to be close to the most powerful moving source (less than 10 m) to experience PTS. These model-estimated PTS exposures of mid-frequency cetaceans are unlikely to actually occur and, therefore, are considered to be TTS (animal is assumed to avoid PTS and move into the range of TTS).	The Navy Acoustic Effects Model assumes that animals do not move away from multiple explosions and receive a maximum sound exposure level. In reality, an animal would likely avoid repeated sound exposures that would cause PTS by moving away from the site of multiple explosions. Therefore, only the initial exposures resulting in model-estimated PTS are expected to actually occur (after accounting for mitigation in step E-2). Model estimates of PTS are reduced to account for animals moving away from an area with multiple explosions, out of the range to PTS, and into the range of TTS. Activities with multiple explosions are listed in Table 4-7.

2 BEAKED WHALE AVOIDANCE OF AREAS OF HIGH ACTIVITY PRIOR TO USE OF SONAR, OTHER ACTIVE ACOUSTIC SOURCES, OR EXPLOSIVES

- Species: beaked whales (family: Ziphiidae)
- Activities/ Sources: Only naval activities preceded by movements of multiple vessels or hovering aircraft
- Impact Zone (sonar and other active acoustic sources): Range to permanent threshold shift (PTS)
- Impact Zone (explosives): Range to onset mortality
- Post-Model Acoustic Impact Analysis Process step (from Table 1-1): S-1 and E-1

2.1 BACKGROUND

Some marine mammals may avoid sound exposures by avoiding areas with high levels of anthropogenic activity, such as multiple ships in transit or hovering aircraft. Navy ships do not intentionally approach or follow marine mammals and are generally not expected to elicit avoidance or alarm behavior, except for certain sensitive species (e.g., beaked whales). Cues preceding the commencement of a naval activity that will use sonars or explosives (e.g., multiple vessel presence and movement, aircraft overflight) may result in some animals departing the immediate area before commencement of sonar or explosive activity. Harbor porpoises and beaked whales have been observed to be more sensitive to human activity than other marine mammal species.

2.1.1 BEAKED WHALES

Research has shown that beaked whales are sensitive to the presence of human activity. Beaked whales have been documented to exhibit avoidance of human activity or respond to vessel presence (Pirotta et al. 2012). Most beaked whales were observed to react negatively to survey vessels or low-altitude aircraft by quick diving and other avoidance maneuvers, and none were observed to approach vessels (Wursig et al. 1998).

The behavioral sensitivity of this species is already acknowledged within the Navy's criteria and thresholds to assess potential acoustic impacts by the use of a low step-function of 140 dB re 1 µPa to assess behavioral reactions when exposed to sounds, based on observations of wild animals (McCarthy et al. 2011; Tyack et al. 2011).

2.2 POST-MODEL ANALYSIS

The model estimates of impacts are based on horizontally static animats; sensitive species, specifically beaked whales, were modeled as though they would tolerate very close encounters with vessels and low-flying aircraft. As a result, the model predicts unrealistically high numbers of impacts to this species at close ranges. Based on research and observations showing that beaked whales are likely to react to human activity by maintaining distance or exhibiting active avoidance, the post-model analysis assumed that beaked whales would avoid close interactions with certain Navy training and testing activities with multiple vessels and low flying aircraft. However, it was assumed that beaked whales would not move away from Navy training and testing activities before the start of sound-producing activities if an activity did not use multiple vessels or hovering aircraft.

Per the post-model analysis, beaked whales (mid-frequency cetaceans) are assumed to avoid a portion of the activity area closest to vessels and hovering aircraft prior to the start of sound-producing activities listed in Table 2-1 (activities using sonar and other active acoustic sources) and Table 2-2 (activities using explosives). To be conservative and account for uncertainty, the post-model analysis assumed the area of avoidance would be the region encompassing onset PTS (for the activities using sonar and other active acoustic sources) and the region encompassing onset mortality (for the activities using explosives). The assumed avoidance ranges are small compared to the distances at which these species have been observed to avoid human interaction. For example,

- for the most powerful naval sonar for which beaked whale human activity avoidance was analyzed, the AN/SQS-53, the single ping range to onset PTS is approximately 10 m

- for the largest explosive for which beaked whale human activity avoidance was analyzed, bin E12 (651-100 lb. net explosive weight), the average range to onset mortality for a calf-sized animal is approximately 199 m

Actual ranges to onset mortality would usually be substantially less for the explosive activities listed in Table 2-2 because charge sizes would be smaller and most animals would not be calf-sized (i.e., the impulse necessary for onset mortality increases with animal size).

For the Navy training and testing activities preceded by high levels of activity, the following post-model refinements were made:

- Activities using sonar and other active acoustic sources (Table 2-1):
    - Beaked whales modeled within the range to onset PTS are assumed to avoid the region close to the sound source prior to the beginning of sound producing activities.
    - Beaked whale modeled PTS are assumed to move within the range of onset TTS (i.e., model-estimated PTS were added to the model-estimated TTS; therefore, although some of the predicted impacts are re-categorized, the overall number of animals predicted to be affected is unchanged).

- Activities using explosives (Table 2-2):
    - Beaked whales modeled within the range to onset mortality are assumed to avoid the region close to the detonation area prior to the detonation.
    - Beaked whales modeled within the range to onset mortality are assumed to move within the range to onset slight lung injury (i.e., recoverable injury; model-estimated mortalities were added to the model-estimated slight lung injuries; therefore, although some of the predicted impacts are re-categorized, the overall number of animals predicted to be affected is unchanged).

Table 2-1: Activities Using Sonar and Other Active Acoustic Sources Preceded by Multiple Vessel Movements or Hovering Helicopters

ACTIVITY[1]	DESCRIPTION OF NAVY PRESENCE PRECEDING ACTIVITY
Training	
Airborne Mine Countermeasure – Mine Detection	Helicopter and towed-device present.
Civilian Port Defense	Multiple small boats or a helicopter present.
Composite Training Unit Exercise (COMPTUEX)	Multiple vessels present.
Group Sail	Multiple vessels present.
Integrated Anti-Submarine Warfare Course (IAC)	Multiple vessels present.
Joint Task Force Exercise/Sustainment Exercise (JTFEX)	Multiple vessels present.
Kilo Dip	Helicopter present.
Mine Countermeasures Exercise – Ship Sonar	Vessel and towed-device present.
Rim of the Pacific Exercise/Under Sea Warfare Exercise (RIMPAC/USWEX)	Multiple vessels and helicopters present.
Submarine Commanders Course	Multiple vessels present.
Tracking Exercise/Torpedo Exercise -Helicopter	Helicopter present.
Testing	
Airborne Mine Hunting Test	Helicopter and towed-device present.
Anti-Submarine Warfare Mission Package Testing	Helicopter present.
Anti-Submarine Warfare Tracking Test – Helicopter	Helicopter present.
Mine Countermeasure Mission Package Testing	Vessel and unmanned underwater vehicle present.
Mine Countermeasure/Neutralization Testing	Vessel and unmanned underwater vehicle or helicopter present.
Mine Detection/Classification Testing	Vessel and unmanned underwater vehicle or helicopter present.
Sonobuoy Lot Acceptance Testing	Aircraft or vessel present.
Torpedo (Explosive) Testing	Aircraft and vessel present.
Torpedo (Non-Explosive) Testing	Multiple vessels present.

[1] The potential for sensitive species to avoid areas near naval activity before use of sonar or other active acoustic sources was only quantified for the Hawaii-Southern California training and testing activities listed in this table. The potential for other training and testing activities to elicit these behaviors was not quantified, and model-estimated impacts for activities not listed here were not adjusted for pre-activity avoidance behavior.

Table 2-2: Activities Using Explosives Preceded by Multiple Vessel Movements or Hovering Helicopters

ACTIVITY[1]	DESCRIPTION OF NAVY PRESENCE PRECEDING ACTIVITY
Training	
Civilian Port Defense	Multiple vessels present.
GUNEX [S-S] – Boat – Medium-Caliber	Multiple vessels present, in addition to target setup.
GUNEX [S-S] – Ship – Medium-Caliber	Multiple vessels present, in addition to target setup.
Firing Exercise (FIREX)	Buoy field setup and non-explosive rounds fired first.
Mine Countermeasure – Mine Neutralization	Multiple vessels, unmanned surface vehicles, unmanned underwater vehicles, and helicopters present, in addition to target setup.
Mine Neutralization – Remotely Operated Vehicle	Vessel or helicopter present, in addition to target setup.
Mine Neutralization – Explosive Ordnance Disposal	Multiple small boats and helicopters
MISSILEX [A-S]	Target setup by support vessel.
Sinking Exercise (SINKEX)	Multiple vessels and aircraft present.
Underwater Demolition Qualification / Certification	Multiple small boats present
Testing	
Anti-Submarine Warfare Tracking Test – Helicopter	Helicopter present.
Mine Countermeasures- Mission Package Testing	Vessel or helicopter present, in addition to remotely operated vehicle and target setup.
Mine Countermeasure/Neutralization Testing	Vessel or helicopter present, in addition to target setup.
Pierside Integrated Swimmer Defense	Multiple vessels present.
Sonobuoy Lot Acceptance Testing	Aircraft or vessel present.
Torpedo (Explosive) Testing	Target setup by support vessel.

[1] The potential for sensitive species to avoid areas near naval activity before use of sonar or other active acoustic sources was only quantified for the Hawaii-Southern California training and testing activities listed in this table. The potential for other training and testing activities to elicit these behaviors was not quantified, and model-estimated impacts for activities not listed here were not adjusted for pre-activity avoidance behavior.

Note: A-S: air to surface; GUNEX: gunnery exercise

3 REDUCING ACOUSTIC EXPOSURES BY IMPLEMENTATION OF MITIGATION

- Species: all modeled marine mammal species
- Activities/ Sources: Training or testing activities for which, at a minimum, over half the mitigation zone can be continuously observed or the entire mitigation zone can be observed for the majority of the scenarios.
- Impact Zone (sonar and other active acoustic sources): Range to permanent threshold shift (PTS)
- Impact Zone (explosives): Range to onset mortality, range to slight lung injury, and range to PTS
- Post-Model Acoustic Impact Analysis Process step (from Table 1-1): S-2 and E-2

3.1 BACKGROUND

Mitigation measures are designed to help reduce or avoid potential impacts on marine resources. The mitigation measures proposed to be implemented during training and testing activities are described in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) of the *Hawaii-Southern California Training and Testing Final EIS/OEIS* (U.S. Department of the Navy 2013). Development of mitigation measures has been coordinated with the NMFS and the U.S. Fish and Wildlife Service through the consultation and permitting processes under the Endangered Species Act and Marine Mammal Protection Act.

Mitigation measures implemented during use of sonar, other active acoustic sources, and explosives typically include the use of Lookouts. Lookouts have multiple observation objectives, which include but are not limited to detecting the presence of biological resources and recreational or fishing boats, observing mitigation zones, and monitoring for vessel and personnel safety concerns. Mitigation zones are designed solely for the purpose of reducing potential impacts on marine mammals and sea turtles from training and testing activities. Mitigation zones are measured as the radius from a sound source. Unique to each activity category, each radius represents a distance that the Navy will visually observe to help reduce injury to marine species. Visual detections of applicable marine species will be communicated immediately to the appropriate watch station for information dissemination and appropriate action. Mitigation measures include powering down, halting, or delaying use of a sound source or explosives when marine mammals are observed in the mitigation zone.

The Navy developed each recommended mitigation zone to avoid or reduce the potential for onset of the lowest level of injury, permanent threshold shift (PTS), out to the predicted maximum range. For explosive activities, mitigating to the predicted maximum range to PTS consequently mitigates to the predicted maximum range to onset mortality, onset slight lung injury, and onset slight gastrointestinal tract injury, since the maximum range to effects for these effects are shorter than for PTS. Furthermore, in most cases, the predicted maximum range to PTS also consequently covers the predicted average range to TTS. Tables 3-1 and 3-2 summarizes the predicted average range to TTS, average range to PTS, maximum range to PTS, and recommended mitigation zone for each activity category, based on the Navy's acoustic propagation modeling results for the most sensitive functional hearing group.

Table 3-1: Predicted Range to Effects and Recommended Mitigation Zones

Activity Category	Representative Source (Bin)[1]	Predicted Average Range to TTS	Predicted Average Range to PTS	Predicted Maximum Range to PTS	Recommended Mitigation Zone
Non-Impulsive Sound					
Low-Frequency and Hull-Mounted Mid-Frequency Active Sonar	SQS-53 ASW hull-mounted sonar (MF1)	3,821 yd. (3.5 km) for one ping	100 yd. (91 m) for one ping	Not Applicable	6 dB power down at 1,000 yd. (914 m); 4 dB power down at 500 yd. (457 m); and shutdown at 200 yd. (183 m)
	Low-frequency sonar[2] (LF4/LF5)	3,821 yd. (3.5 km) for one ping	100 yd. (91 m) for one ping	Not Applicable	200 yd. (183 m)[2]
High-Frequency and Non-Hull Mounted Mid-Frequency Active Sonar	AQS-22 ASW dipping sonar (MF4)	230 yd. (210 m) for one ping	20 yd. (18 m) for one ping	Not applicable	200 yd. (183 m)
Explosive and Impulsive Sound					
Improved Extended Echo Ranging Sonobuoys	Explosive sonobuoy (E4)	434 yd. (397 m)	156 yd. (143 m)	563 yd. (515 m)	600 yd. (549 m)
Explosive Sonobuoys Using 0.6–2.5 lb. NEW	Explosive sonobuoy (E3)	290 yd. (265 m)	113 yd. (103 m)	309 yd. (283 m)	350 yd. (320 m)
Anti-Swimmer Grenades	Up to 0.5 lb. NEW (E2)	190 yd. (174 m)	83 yd. (76 m)	182 yd. (167 m)	200 yd. (183 m)
Mine Countermeasure and Neutralization Activities Using Positive Control Firing Devices	NEW dependent (see Table 3-2)				
Mine Neutralization Diver-Placed Mines Using Time-Delay Firing Devices	29 lb. NEW only (E7)[3]	846 yd. (774 m)	286 yd. (262 m)	541 yd. (495 m)	1,000 yd. (914 m)
Gunnery Exercises – Small- and Medium-Caliber Using a Surface Target	40 mm projectile (E2)	190 yd. (174 m)	83 yd. (76 m)	182 yd. (167 m)	200 yd. (183 m)
Gunnery Exercises – Large-Caliber Using a Surface Target	5 in. projectiles (E5 at the surface[4])	453 yd. (414 m)	186 yd. (170 m)	526 yd. (481 m)	600 yd. (549 m)

ASW: anti-submarine warfare; dB: decibel; in.: inches; km: kilometer; lb.: pound(s); m: meter; mm: millimeter; NEW: net explosive weight; PTS: permanent threshold shift; TTS: temporary threshold shift; yd.: yard

[1] This table does not provide an inclusive list of source bins; bins presented here represent the source bin with the largest range to effects within the given activity category.

[2] The representative source bin and mitigation zone applies to sources that cannot be powered down (e.g., LF4 and LF5).

[3] The ranges listed for this activity are based on a 29 lb. NEW, not the maximum E7 NEW of 60 lb.

[4] The representative source bin E5 has different range to effects depending on the depth of activity occurrence (at the surface or at various depths).

Table 3-1: Predicted Range to Effects and Recommended Mitigation Zones (Continued)

Activity Category	Representative Source (Bin)[1]	Predicted Average Range to TTS	Predicted Average Range to PTS	Predicted Maximum Range to PTS	Recommended Mitigation Zone
Missile Exercises (Including Rockets) up to 250 lb. NEW Using a Surface Target	Maverick missile (E9)	949 yd. (868 m)	398 yd. (364 m)	699 yd. (639 m)	900 yd. (823 m)
Missile Exercises Using 251–500 lb. NEW Using a Surface Target	Harpoon missile (E10)	1,832 yd. (1.7 km)	731 yd. (668 m)	1,883 yd. (1.7 km)	2,000 yd. (1.8 km)
Bombing Exercises	MK-84 2,000 lb. bomb (E12)	2,513 yd. (2.3 km)	991 yd. (906 m)	2,474 yd. (2.3 km)	2,500 yd. (2.3 km)[2]
Torpedo (Explosive) Testing	MK-48 torpedo (E11)	1,632 yd. (1.5 km)	697 yd. (637 m)	2,021 yd. (1.8 km)	2,100 yd. (1.9 km)
Sinking Exercises	Various sources up to the MK-84 2,000 lb. bomb (E12)	2,513 yd. (2.3 km)	991 yd. (906 m)	2,474 yd. (2.3 km)	2.5 nm[2]
At-Sea Explosive Testing	Various sources of 10 lb. NEW and less (E5 at various depths[3])	525 yd. (480 m)	204 yd. (187 m)	649 yd. (593 m)	1,600 yd. (1.4 km)[2]
Elevated Causeway System – Pile Driving	24 in. steel impact hammer	1,094 yd. (1 km)	51 yd. (46 m)	51 yd. (46 m)	60 yd. (55 m)

ASW: anti-submarine warfare; km: kilometer; lb.: pound; m: meter; NEW: net explosive weight; nm: nautical mile; PTS: permanent threshold shift; TTS: temporary threshold shift; yd.: yard

[1] This table does not provide an inclusive list of source bins; bins presented here represent the source bin with the largest range to effects within the given activity category.

[2] Recommended mitigation zones are larger than the modeled injury zones to account for multiple types of sources or charges being used.

[3] The representative source bin E5 has different range to effects depending on the depth of activity occurrence (at the surface or at various depths).

Table 3-2: Predicted Range to Effects and Recommended Mitigation Zones for Mine Countermeasure and Neutralization Activities Using Positive Control Firing Devices

Charge Size Net Explosive Weight (Bins)	General Mine Countermeasure and Neutralization Activities Using Positive Control Firing Devices[1]				Mine Countermeasure and Neutralization Activities Using Diver-Placed Charges Under Positive Control[2]			
	Predicted Average Range to TTS	Predicted Average Range to PTS	Predicted Maximum Range to PTS	Recommended Mitigation Zone	Predicted Average Range to TTS	Predicted Average Range to PTS	Predicted Maximum Range to PTS	Recommended Mitigation Zone
2.6–5 lb. (E4)	434 yd. (474 m)	197 yd. (180 m)	563 yd. (515 m)	600 yd. (549 m)	545 yd. (498 m)	169 yd. (155 m)	301 yd. (275 m)	350 yd. (320 m)
6–10 lb. (E5)	525 yd. (480 m)	204 yd. (187 m)	649 yd. (593 m)	800 yd. (732 m)	587 yd. (537 m)	203 yd. (185 m)	464 yd. (424 m)	500 yd. (457 m)
11–20 lb. (E6)	766 yd. (700 m)	288 yd. (263 m)	648 yd. (593 m)	800 yd. (732 m)	647 yd. (592 m)	232 yd. (212 m)	469 yd. (429 m)	500 yd. (457 m)
21–60 lb. (E7)[3]	1,670 yd. (1.5 km)	581 yd. (531 m)	964 yd. (882 m)	1,200 yd. (1.1 km)	1,532 yd. (1.4 km)	473 yd. (432 m)	789 yd. (721 m)	800 yd. (732 m)
61–100 lb. (E8)[4]	878 yd. (802 m)	383 yd. (351 m)	996 yd. (911 m)	1,600 yd. (1.4 km)	969 yd. (886 m)	438 yd. (400 m)	850 yd. (777 m)	850 yd. (777 m)
251–500 lb. (E10)	1,832 yd. (1.7 km)	731 yd. (668 m)	1,883 yd. (1.7 km)	2,000 yd. (1.8 km)				700 yd. (640 m)[5]
501–650 lb. (E11)	1,632 yd. (1.5 km)	697 yd. (637 m)	2,021 yd. (1.8 km)	2,100 yd. (1.9 km)				Not Applicable

km: kilometer; lb.: pound; m: meter; PTS: permanent threshold shift; TTS: temporary threshold shift; yd.: yard

[1] These mitigation zones are applicable to all mine countermeasure and neutralization activities conducted in all locations specified in HSTT FEIS/OEIS Tables 2.8-1 through 2.8-5.

[2] These mitigation zones are only applicable to mine countermeasure and neutralization activities involving the use of diver-placed charges. These activities are conducted in shallow water, and the mitigation zones are based only on the functional hearing groups with species that occur in these areas (mid-frequency cetaceans and sea turtles).

[3] The E7 bin was only modeled in shallow-water locations, so there is no difference for the diver-placed charges category.

[4] The E8 bin was only modeled for surface explosions, so some of the ranges are shorter than for sources modeled in the E7 bin, which occur at depth.

[5] This mitigation zone for the E10 charge applies only to very shallow water detonations and is based on empirical data as described in Section 5.3.2.1.2.4 (Mine Countermeasure and Neutralization Activities Using Positive Control Firing Devices).

3.2 POST-MODEL ANALYSIS

The Navy Acoustic Effects Model estimates acoustic effects without taking into account any shutdown or delay of the activity when marine mammals are present and detectable within the mitigation zone; therefore, the model overestimates impacts to marine mammals within mitigation zones. The post-model analysis considers and quantifies the potential for mitigation to reduce the likelihood or risk of PTS (due to sonar and other active acoustic sources) and injuries and mortalities (due to explosives).

Two factors are considered when quantifying the effectiveness of mitigation: (1) the extent to which the type of mitigation proposed for a sound-producing activity (e.g., active sonar) allows for observation of the mitigation zone prior to and during the activity and (2) the sightability of each species that may be present in the mitigation zone, which is affected by species-specific characteristics.

Mitigation Effectiveness Factor

Mitigation is considered in the quantified reduction of model-predicted effects when the mitigation zone can be fully or mostly observed prior to and during a sound-producing activity. The mitigation zones provided in Tables 3-1 and 3-2 encompass the estimated ranges to injury (including the range to mortality for explosives) for a given source. Mitigation for each activity is considered in its entirety, taking into account the different ways an event may take place (some events may have more than one scenario involving different mitigation zones, platforms, or number of Lookouts). The ability to observe the range to mortality (for explosive activities only) and the range to potential injury (for all sound-producing activities) were estimated for each training or testing event. The mitigation factors were assigned conservatively as follows:

- If the entire mitigation zone can be continuously visually observed based on the platform(s), number of Lookouts, and size of the range to effects zone, the mitigation is considered fully effective (Effectiveness = 1).
- If over half of the mitigation zone can be continuously visually observed; if there is one or more of the scenarios within the activity for which the mitigation zone cannot be continuously visually observed (but the range to effects zone can be visually observed for the majority of the scenarios); or if the mitigation zone can be continuously observed, but the activity may occur at night; the mitigation is considered mostly effective (Effectiveness = 0.5).
- If less than half of the mitigation zone can be continuously visually observed or if the mitigation zone cannot be continuously visually observed during most of the scenarios within the activity due to the type of surveillance platform(s), number of Lookouts, and size of the mitigation zone, the mitigation is not considered in the quantified reduction of model predicted acoustic effects and no reductions to mortalities or injuries due to mitigation were quantified (Effectiveness = 0). In reality, however, some protection from applied mitigation measures would be afforded even during these activities, even though it is not accounted for in the quantitative reduction of model-predicted impacts.

The Navy did not assign mitigation effectiveness factors based on detections made by other personnel that may be involved with an event in addition to Lookouts (such as range support personnel aboard a torpedo retrieval boat or support aircraft), even though in reality information about marine mammal sightings are shared amongst the units participating in the training or testing activity. Therefore, the mitigation effectiveness factors may under-estimate the likelihood that some marine mammals may be detected within the mitigation zones of some activities. Mitigation effectiveness factors are provided in Table 3-3 for activities using sonar and other active acoustic sources and in Table 3-4 for activities using explosives.

Table 3-3: Assignment of Mitigation Effectiveness Factors in the Acoustic Effects Analysis for Sonar and Other Active Acoustic Sources

Activity[1]	Mitigation Effectiveness Factor for Acoustic Analysis	Mitigation Platform[2]	Description of Mitigation
Training			
Airborne Mine Countermeasure – Mine Detection	1	Aircraft	Mitigation zone is 200 yd. with 1 Lookout in helicopter.
Civilian Port Defense	1	Vessel	Mitigation zone of 200 yd. with 1 Lookout in vessel or helicopter.
Composite Unit Training Exercise	1	Vessel	Mitigation zone of 200/500/1000 yd. with 2 Lookouts in vessel.
Integrated Anti-Submarine Warfare Course	1	Vessel	Mitigation zone of 200/500/1000 yd. with 2 Lookouts in vessel.
Joint Task Force Exercise/Sustainment Exercise	1	Vessel	Mitigation zone of 200/500/1000 yd. with 2 Lookouts in vessel.
Group Sail	1	Vessel	Mitigation zone of 200/500/1000 yd. with 2 Lookouts in vessel.
Kilo Dip	1	Aircraft	Mitigation zone of 200 yd. with 1 Lookout in helicopter
Mine Countermeasures Exercise – Ship Sonar	1	Vessel	Mitigation zone of 200 yd. with 1 Lookout from vessel.
Mine Neutralization – Remotely Operated Vehicle	1	Vessel	Mitigation zone of 200 yd. with 1 Lookout from vessel.
Submarine Navigational Exercise	1	Vessel	Mitigation zone of 200yd. with 1 Lookout in vessel.
Submarine Sonar Maintenance	0.5	Vessel	Half the scenarios would be pierside and therefore have a mitigation zone of 200/500/1000 yd. with 1 Lookout or 200 yd. with 1 Lookout.
Surface Ship Object Detection	1	Vessel	Mitigation zone of 200/500/1000 yd. with 2 Lookouts in vessel.
Surface Ship Sonar Maintenance	1	Vessel	Mitigation zone of 200/500/1000 yd. with 2 Lookouts in vessel when underway, 1 lookout in vessel when in port.
Tracking Exercise/Torpedo Exercise – Maritime Patrol Aircraft Sonobuoy	0.5	Aircraft	Mitigation zone of 200 yd. with 1 Lookout from aircraft. Sonobuoy pattern dropped over large area so may not have eyes on all zones constantly.
Tracking Exercise/Torpedo Exercise – Surface	0.5	Vessel	Mitigation zone of 200/500/1000 yd. with 2 Lookouts in vessel. Mitigation for most sources but no mitigation for torpedo.
Tracking Exercise/Torpedo Exercise – Helicopter	0.5	Aircraft	Mitigation zone of 200 yd. with 1 Lookout from helicopter, Mitigation for most sources but no mitigation for torpedo.
Testing			
Anti-Submarine Warfare Tracking Test – MPA	1	Aircraft	Mitigation zone of 200 yd. with 1 Lookout in from aircraft.
Combat System Ship Qualification Trials: In-Port	1	Vessel	Mitigation zone of 200/500/1000 yd. with 1 Lookout in vessel. Calm in-port waters good for viewing marine mammals and sea turtles.
Combat System Ship Qualification Trials: Undersea Warfare	0.5	Vessel	Mitigation zone is 200/500/1000 yd. with 2 Lookouts or 200 yd. with 1 Lookout. Mitigation for most sources but no mitigation for torpedo.
Countermeasure Testing	0.5	Vessel	Mitigation zone is 200/500/1000 yd. with 2 Lookouts or 200 yd. with 1 Lookout. Mitigation for most sources but no mitigation for torpedo.
Mine Countermeasure Mission Package Testing	1	Vessel	Mitigation zone of 200 yd. with 1 Lookout from vessel.

Mine Countermeasure/Neutralization Testing	1	Vessel	Mitigation zone of 200 yd. with 1 Lookout from vessel.
Mine Detection/Classification Testing	1	Vessel	Mitigation zone of 200 yd. with 1 Lookout from vessel.
Pierside Integrated Swimmer Defense	1	Vessel	Mitigation zone of 200 yd. with 1 Lookout from vessel.
Pierside Sonar Testing	1	Vessel	Mitigation zone of 200/500/1000 yd. with 1 Lookout or 200 yd. with 1 Lookout. Calm in-port waters good for viewing marine mammals and sea turtles.
Ship Signature Testing	1	Vessel	Mitigation zone of 200/500/1000 yd. with 1 Lookout or 200 yd. with 1 Lookout.
Sonobuoy Lot Acceptance Testing	1	Vessel	Mitigation zone of 200 yd. with 1 Lookout from vessel or aircraft.
Submarine Sonar Testing/Maintenance	0.5	Vessel	Half the scenarios would be pierside and therefore have a mitigation zone of 200/500/1000 yd. with 1 Lookout or 200 yd. with 1 Lookout.
Surface Combatant Sea Trials: Anti-Submarine Warfare Testing	1	Vessel	Mitigation zone of 200/500/1000 yd. with 2 Lookouts from a vessel.
Surface Combatant Sea Trials: Pierside Sonar Testing	1	Vessel	Mitigation zone of 200/500/1000 yd. with 1 Lookout or 200 yd. with 1 Lookout.
Surface Ship Sonar Testing/Maintenance	1	Vessel	Mitigation zone of 200/500/1000 yd. with 2 Lookouts in vessel when underway, 1 lookout in vessel when in port.
Torpedo (Non-Explosive) Testing	0.5	Vessel	Mitigation zone is 200/500/1000 yd. with 2 Lookouts or 200 yd. with 1 Lookout. Mitigation for most sources but no mitigation for torpedo.

[1] If less than half of the mitigation zone can be continuously visually observed or if the mitigation zone cannot be continuously visually observed during most of the scenarios within the activity due to the type of surveillance platform(s), number of Lookouts, and size of the mitigation zone, mitigation is not considered in the acoustic effects analysis of that activity and the activity is not listed in this table.

[2] The activity is scored based on the ability of the individual platform to implement the mitigation.

Table 3-4: Consideration of Mitigation in Acoustic Effects Analysis for Explosives

Activity[1,2]	Mitigation Effectiveness Factor for Acoustic Analysis		Mitigation Platform	Description of Mitigation and Range to Effects
	Injury Zone	Mortality Zone[4]		
Training				
BOMBEX [A-S] (HF/ LF)	0	1	Aircraft	Range to effects for up to bin E12 is <250 yd. radius (<500 yd. diameter) for all functional hearing groups for mortality at target location with 1 Lookout from aircraft. Range to effects for up to E12 for PTS is 2000 yd. radius (4000 yd. diameter) for HF cetaceans and 1000 yd. radius (2000 yd. diameter) for LF cetaceans.
BOMBEX [A-S] (MF)	0.5	1	Aircraft	Range to effects for up to bin E12 is <250 yd. radius (<500 yd. diameter) for all functional hearing groups for mortality at target location with 1 Lookout from aircraft. Range to effects for up to E12 for PTS is 500 yd. radius (1000 yd. diameter) for MF cetaceans. For MF cetaceans, mitigation is less than 1 but greater than 0 (assigned 0.5) due to platform speed and inability to continuously see entire 500 yd. range to effects zone on approach. However, >50% of range to effects zone for injury for MF cetaceans is expected to be visible.
Civilian Port Defense	1	1	Vessel	Range to effects for up to bin E4 is within 600 yd. radius (1200 yd. diameter) for all functional hearing groups for mortality and injury at target location with 1 Lookout from a vessel.
GUNEX [A-S] – Medium-Caliber (HF)	0.5	0.5	Aircraft	Range to effects for bin E1/E2 is within 200 yd. radius (400 yd. diameter) for all functional hearing groups for mortality and injury at target location with 1 Lookout from aircraft. Small groups not easy to see from distances that may be up to 4 km away (most of the time much closer, so 0.5 was given).
GUNEX [A-S] – Medium-Caliber (MF/LF)	1	1	Aircraft	Range to effects for bin E1/E2 is within 200 yd. radius (400 yd. diameter) for all functional hearing groups for mortality and injury at target location with 1 Lookout from aircraft. Large whales and dolphin pods can be seen, even if from further distance.
GUNEX [S-S] – Boat – Medium-Caliber (HF)	0.5	0.5	Vessel	Range to effects for bin E1/E2 is within 200 yd. radius (400 yd. diameter) for all functional hearing groups for mortality and injury at target location with 1 Lookout from aircraft. Small groups not easy to see from distances that may be up to 4 km away (most of the time much closer, so 0.5 was given).

Activity[1,2]	Mitigation Effectiveness Factor for Acoustic Analysis		Mitigation Platform	Description of Mitigation and Range to Effects
	Injury Zone	Mortality Zone[4]		
GUNEX [S-S] – Boat – Medium-Caliber (MF/LF)	1	1	Vessel	Range to effects for bin E1/E2 is within 200 yd. radius (400 yd. diameter) for all functional hearing groups for mortality and injury at target location with 1 Lookout from aircraft. Large whales and dolphin pods can be seen, even if from further distance.
GUNEX [S-S] – Ship – Medium-Caliber (HF)	0.5	0.5	Vessel	Range to effects for bin E1/E2 is within 200 yd. radius (400 yd. diameter) for all functional hearing groups for mortality and injury at target location with 1 Lookout from aircraft. Small groups not easy to see from distances that may be up to 4 km away (most of the time much closer, so 0.5 was given).
GUNEX [S-S] – Ship – Medium-Caliber (MF/LF)	1	1	Vessel	Range to effects for bin E1/E2 is within 200 yd. radius (400 yd. diameter) for all functional hearing groups for mortality and injury at target location with 1 Lookout from aircraft. Large whales and dolphin pods can be seen, even if from further distance.
Mine Neutralization – Explosive Ordnance Disposal	0.5	1	Vessel	Range to effects for up to bin E6 is within 100 yd. radius (200 yd. diameter) for all functional hearing groups for mortality. Range to effects for up to bin E6 for PTS is 700 yd. radius (1400 yd. diameter) for HF cetaceans and within 300 yd. radius (600 yd. diameter) for MF/LF/Phocid. There are 4 Lookouts from small boats during time delay activities. Mitigation is less than 1 but greater than 0 (assigned 0.5) for injury zone due to inability to continuously see entire range to effects zone when taking into account time-delay. However, greater than 50 percent of range to effects zone for injury is expected to be visible.
Mine Neutralization – Remotely Operated Vehicle	1	1	Vessel	Range to effects zone for bin E4 is less than 600 yd. radius (1200 yd. diameter) for all functional hearing groups for mortality and injury with 1 Lookout from vessel or aircraft.
SINKEX (HF/LF)	0	1	Aircraft	Range to effects for up to bin E12 is less than 250 yd. radius (500 yd. diameter) for all functional hearing groups for mortality at target location with 1 Lookout from aircraft. Range to effects for up to bin E12 for PTS is 2000 yd. radius (4000 yd. diameter) for HF cetaceans and 1000 yd. radius (2000 yd. diameter) for LF cetaceans.

Activity[1,2]	Mitigation Effectiveness Factor for Acoustic Analysis		Mitigation Platform	Description of Mitigation and Range to Effects
	Injury Zone	Mortality Zone[4]		
SINKEX (MF)	0.5	1	Aircraft	Range to effects for up to bin E12 is less than 250 yd. radius (500 yd. diameter) for all functional hearing groups for mortality at target location with 1 Lookout from aircraft. Range to effects for up to bin E12 for PTS is 500 yd. radius (1000 yd. diameter) for MF cetaceans. For MF cetaceans, mitigation is less than 1 but greater than 0 (assigned 0.5) due to platform speed and inability to continuously see entire 500 yd. range to effects zone on approach.
TRACKEX/TORPEX – Maritime Patrol Aircraft Sonobuoy	0.5	0.5	Aircraft	Range to effects for bin E4 is within 600 yd. radius (1200 yd. diameter) for all functional hearing groups for mortality and injury at target location with 1 Lookout from aircraft. Mitigation is less than 1 but greater than 0 (assigned 0.5) due to inability to continuously see entire 600 yd. range to effects zone for each sonobuoy over pattern area. However, greater than 50 percent of range to effects zone is expected to be visible.
Underwater Demolition Qualification/Certification	1	1	Vessel	Range to effects zone for up to bin E7 is less than 300 yd. radius (600 yd. diameter) for all functional hearing groups for mortality. Range to effects zone for up to bin E7 for injury is less than 160 yd. radius (320 yd. diameter) for MF cetaceans and pinniped are the species expected to occur in the nearshore areas where this event is occurring. Activities will have 1 Lookout from vessel.
Testing				
Airborne Mine Neutralization Systems	1	1	Aircraft	Range to effects for up to bin E11 is <600 yd. radius (<1200 yd. diameter) for mortality for all functional hearing groups and at target location with 1 Lookout in aircraft and 1 Lookout in support vessel. Range to effects for up to bin E11 for PTS is 800 yd. radius (1600 yd. diameter) for LF cetaceans and 350 yd. radius (700 yd. diameter) for MF cetaceans.
Anti-submarine Warfare Tracking Test – Helicopter	0.5	0.5	Aircraft	Range to effects for up to bin E3 is within 350 yd. radius (700 yd. diameter) for all functional hearing groups for mortality and injury at each sonobuoy location with 1 Lookout from aircraft. Mitigation is less than 1 but greater than 0 (assigned 0.5) due to inability to continuously see entire 600 yd. range to effects zone for each sonobuoy over pattern area. However, greater than 50 percent of the range to effects zone are expected to be visible.

Activity[1,2]	Mitigation Effectiveness Factor for Acoustic Analysis		Mitigation Platform	Description of Mitigation and Range to Effects
	Injury Zone	Mortality Zone[4]		
Mine Countermeasures Mission Package Testing	1	1	Vessel	Range to effects zone for up to bin E4 is less than 600 yd. radius (1200 yd. diameter) for all functional hearing groups for mortality and injury with 1 Lookout from vessel or aircraft.
Sonobuoy Lot Acceptance Testing	1	1	Vessel	Range to effects zone for bin E3 is 350 yd. radius (700 yd. diameter) and for bin E4 is 600 yd. radius (1200 yd. diameter) at sonobuoy test location with 1 Lookout from vessel or aircraft.
Torpedo (Explosive) Testing	0.5	1	Aircraft	Range to effects for up to bin E11 is <600 yd. radius (<1200 yd. diameter) for mortality for all functional hearing groups. Range to effects for up to bin E11 for PTS is 2000 yd. radius (4000 yd. diameter) for HF cetaceans, 1300 yd. radius (2600 yd. diameter) for phocid, 800 yd. radius (1600 yd. diameter) for LF cetaceans, and 350 yd. radius (700 yd. diameter) for MF cetaceans. Will have 1 lookout in aircraft. Range to effects zone for injury is 0 because zone too large based on time delay of torpedo explosion.

[1] Ranges to effect differ for functional hearing groups based on weighted threshold values. HF: high frequency cetaceans; MF: mid-frequency cetaceans; LF: low frequency cetaceans
[2] If less than half of the mitigation zone can be continuously visually observed or if the mitigation zone cannot be visually observed during most of the scenarios within the activity due to the type of surveillance platform(s), number of Lookouts, and size of the mitigation zone, mitigation is not considered in the acoustic effects analysis of that activity and the activity is not listed in this table. For activities in which only mitigation in the mortality zone is considered in the analysis, no value is provided for the injury zone.
[3] Activity employs vessel or aircraft based Lookouts. If vessels are the only platform, a sufficient number of vessel-based Lookouts will be used to effectively mitigate the area in a manner comparable to aerial mitigation. Cumulative probability of sightability between aircraft and vessel was used for mitigation post model analysis for ship shock trials.
[4] Mortality zone is conservatively based on the range to onset mortality (i.e., 1% mortality rate) for a calf-sized animal; range to onset mortality for a median sized animal would be shorter.
Note: A-S: air-to-surface; BOMBEX: bombing exercise; GUNEX: gunnery exercise; HF: high-frequency cetacean; IEER: Improved Extended Echo Ranging; LF: low frequency cetacean; MF: mid-frequency cetacean; SINKEX: sinking exercise; S-S: surface-to-surface; TORPEX: torpedo exercise; TRACKEX: tracking exercise; UNDET: underwater detonation.

Sightability

The ability of Navy Lookouts to detect marine mammals in or approaching the mitigation zone is dependent on the animal's presence at the surface and the characteristics of the animal that influence its sightability. The Navy considered what applicable data were available to numerically approximate the sightability of marine mammals and determined that the standard "detection probability" referred to as g(0) was most appropriate. The abundance of marine mammals is typically estimated using line-transect analyses (Buckland et al. 2001), in which g(0) is the probability of detecting an animal or group of animals on the transect line (the straight-line course of the survey ship or aircraft). This detection probability is derived from systematic line-transect marine mammal surveys based on species-specific estimates for vessel and aerial platforms. Estimates of g(0) are available from peer-reviewed marine mammal line-transect survey reports, generally provided through research conducted by the NMFS Science Centers.

There are two separate components of g(0): perception bias and availability bias (Marsh and Sinclair 1989). Perception bias accounts for marine mammals that are on the transect line and detectable, but were simply missed by the observer. Various factors influence the perception bias component of g(0), including species-specific characteristics (e.g., behavior and appearance, group size, and blow characteristics), viewing conditions during the survey (e.g., sea state, wind speed, wind direction, wave height, and glare), observer characteristics (e.g., experience, fatigue, and concentration), and platform characteristics (e.g., pitch, roll, speed, and height above water). To derive estimates of perception bias, typically an independent observer is present who looks for marine mammals missed by the primary observers. Mark-recapture methods are then used to estimate the probability that animals are missed by the primary observers. Availability bias accounts for animals that are missed because they are not at the surface at the time the survey platform passes by, which generally occurs more often with deep diving whales (e.g., sperm whale and beaked whale). The availability bias portion of g(0) is independent of prior marine mammal detection experience since it only reflects the probability of an animal being at the surface within the survey track and therefore available for detection.

Some g(0) values are estimates of perception bias only, some are estimates of availability bias only, and some reflect both, depending on the species and data that are currently available. The Navy used g(0) values with both perception and availability bias components if that data was available. If both components were not available for a particular species, the Navy determined that g(0) values reflecting perception bias or availability bias, but not both, still represent the best statistically-derived factor for assessing the likelihood of marine mammal detection by Navy Lookouts.

As noted above, line-transect surveys and subsequent analyses are typically used to estimate cetacean abundance. To systematically sample portions of an ocean area (such as the coastal waters off California or the east coast), marine mammal surveys are designed to uniformly cover the survey area and are conducted at a constant speed (generally 10 knots for ships and 100 knots for aircraft). Survey transect lines typically follow a pattern of straight lines or grids. Generally there are two primary observers searching for marine mammals. Each primary observer looks for marine mammals in the forward 90-degree quadrant on their side of the survey platform. Based on data collected during the survey, scientists determine the factors that affected the detection of an animal or group of animals directly along the transect line.

Visual marine mammal surveys (used to derive g(0)) are conducted during daylight[4]. Marine mammal surveys are typically scheduled for a season when weather at sea is more likely to be good, however,

[4] At night, passive acoustic data may still be collected during a marine mammal survey.

observers on marine mammal surveys will generally collect data in sea state conditions up to Beaufort 6 and do encounter rain and fog at sea which may also reduce marine mammal detections (Barlow 2006). For most species, g(0) values are based on the detection probability in conditions from Beaufort 0 to Beaufort 5, which reflects the fact that marine mammal surveys are often conducted in less than ideal conditions (Barlow 2003; Barlow and Forney 2007). The ability to detect some species (e.g., beaked whales, *Kogia* spp., and Dall's porpoise) decreases dramatically with increasing sea states, so g(0) estimates for these species are usually restricted to observations in sea state conditions of Beaufort 0 to 2 (Barlow 2003).

Navy training and testing events differ from systematic line-transect marine mammal surveys in several respects. These differences suggest the use of g(0), as a sightability factor to quantitatively adjust model-predicted effects based on mitigation, is likely to result in an underestimate of the protection afforded by the implementation of mitigation as follows:

- Mitigation zones for Navy training and testing events are significantly smaller (typically less than 1,000 yd. radius) than the area typically searched during line-transect surveys, which includes the maximum viewable distance out to the horizon.
- In some cases, Navy events can involve more than one vessel or aircraft (or both) operating in proximity to each other or otherwise covering the same general area. Additional vessels and aircraft can result in additional watch personnel observing the mitigation zone (e.g. ship shock trials). This would result in more observation platforms and observers looking at the mitigation zone than the two primary observers used in marine mammal surveys upon which g(0) is based.
- A systematic marine mammal line-transect survey is designed to sample broad areas of the ocean, and generally does not retrace the same area during a given survey. Therefore, in terms of g(0), the two primary observers have only a limited opportunity to detect marine mammals that may be present during a single pass along the trackline (i.e., deep diving species may not be present at the surface as the survey transits the area). In contrast, many Navy training and testing activities involve area-focused events (e.g., anti-submarine warfare tracking exercise), where participants are likely to remain in the same general area during an event. In other cases Navy training or testing activities are stationary (i.e., pierside sonar testing or use of dipping sonar), which allow Lookouts to focus on the same area throughout the activity. Both of these circumstances result in a longer observation period of a focused area with more opportunities for detecting marine mammals, than are offered by a systematic marine mammal line-transect survey that only passes through an area once.

Although Navy Lookouts on ships have hand-held binoculars and on some ships, pedestal mounted binoculars very similar to those used in marine mammal surveys, there are differences between the scope and purpose of marine mammal detections during research surveys along a trackline and Navy Lookouts observing the water proximate to a Navy training or testing activity to facilitate implementation of mitigation. The distinctions required careful consideration when comparing the Navy Lookouts to marine mammal surveys.[5]

- A marine mammal observer is responsible for detecting marine mammals in their quadrant of the trackline out to the limit of the available optics. Although Navy Lookouts are responsible for observing the water for safety of ships and aircraft, during specific training and testing activities, they need only detect marine mammals in the relatively small area that surrounds the mitigation zone (in most cases less than 1,000 yd. from the ship) for mitigation to be implemented.
- Navy Lookouts, personnel aboard aircraft and on watch onboard vessels at the surface will have less experience detecting marine mammals than marine mammal observers used for line-transit survey. However, Navy personnel responsible for observing the water for safety of ships and aircraft do have significant experience looking for objects (including marine mammals) on the water's surface and Lookouts are trained using the NMFS approved Marine Species Awareness Training.

Until results of the Navy's Lookout effectiveness study are available, the Navy must rely on the best available science to determine detection probabilities of marine mammals by Navy Lookouts. The factors affecting the detection of an animal or group of animals directly on the transect line may be probabilistically quantified as g(0). As a reference, a g(0) value of 1 indicates that animals on the transect line are always detected. Table 3-5 provides detection probabilities for cetacean species based largely on g(0) values derived from shipboard and aerial surveys in the Study Area, which vary widely based on g(0) derivation factors (e.g., species, sighting platforms, group size, and sea state conditions).

[5] Barlow and Gisiner (2006) provide a description of typical marine mammal survey methods from ship and aircraft and then provide "a crude estimate" of the difference in detection of beaked whales between trained marine mammal observers and seismic survey mitigation, which is not informative with regard to Navy mitigation procedures for the following reasons. The authors note that seismic survey differs from marine mammal surveys in that, "(1) seismic surveys are also conducted at night; (2) seismic surveys are not limited to calm sea conditions; (3) mitigation observers are primarily searching with unaided eyes and 7x binoculars; and (4) typically only one or possibly two observers are searching." When Navy implements mitigation for which adjustments to modeling output were made, the four conditions Barlow and Gisiner (2006) note are not representative of Navy procedures nor necessarily a difference in marine mammal line-transect survey procedures. Navy accounts for reduced visibility (i.e. activities which occur at night, etc.) by assigning a lower value to the mitigation effectiveness factor. . On Navy ships, hand-held binoculars are always available and pedestal mounted binoculars very similar to those used in marine mammal surveys, are generally available to Navy Lookouts on board vessels over 60'. Also like marine mammal observers, Navy Lookouts are trained to use a methodical combination of unaided eye and optics as they search the surface around a vessel. The implication that marine mammal surveys only occur in "calm sea conditions" is not accurate since the vast majority of marine mammal surveys occur and data is collected in conditions up to sea states of Beaufort 5. The specific g(0) values analyzed by Barlow and Gisiner (2006) were derived from Cuvier's and *Mesoplondon* beaked whale surveys conducted in sea states of Beaufort 0-2 during daylight hours which, as noted above, is common for marine mammal surveys conducted for these particular species. However, marine mammal surveys for most species are not similarly restricted to sea states of Beaufort 0-2 and, therefore, the conclusions reached by Barlow and Gisiner (2006) regarding the effect of sea state conditions on sightability do not apply to other species. Finally, when Lookouts are present, there are always more than the "one or two personnel" described by Barlow and Gisiner (2006) observing the area ahead of a Navy vessel (additional bridge watch personnel are also observing the water around the vessel).

Table 3-5: Sightability Based on Average g(0) Values for Marine Mammal Species in the Study Area

Species/Stocks	Family	Vessel Sightability	Aircraft Sightability
Baird's Beaked Whale	Ziphiidae	0.96	0.18
Blainville's Beaked Whale	Ziphiidae	0.40	0.074*
Blue Whale, Fin Whale; Sei Whale	Balaenopteridae	0.921	0.407
Bottlenose Dolphin, Fraser's Dolphin	Delphinidae	0.808	0.96
Bryde's Whale	Balaenopteridae	0.91	0.407
Cuvier's Beaked Whale	Ziphiidae	0.23	0.074*
Dall's Porpoise	Phocoenidae	0.822	0.221
Dwarf Sperm Whale, Pygmy Sperm Whale, *Kogia* spp.	Kogiidae	0.35	0.074*
False Killer Whale, Melon-headed Whale	Delphinidae	0.76	0.96
Gray Whale	Eschrichtiidae	0.921	0.482
Humpback Whale	Balaenopteridae	0.921	0.495
Killer Whale	Delphinidae	0.91	0.96
Long-Beaked/ Short-Beaked Common Dolphin	Delphinidae	0.97	0.99
Longman's Beaked Whale, Pygmy Killer Whale	Ziphiidae, Delphinidae	0.76	0.074*
Mesoplodon spp.	Ziphiidae	0.34	0.11
Minke Whale	Balaenopteridae	0.856	0.386
Northern Right Whale Dolphin	Delphinidae	0.856	0.96
Pacific White-Sided Dolphin	Delphinidae	0.856	0.96
Pantropical Spotted/Risso's/Rough Toothed/Spinner/Striped Dolphin	Delphinidae	0.76	0.96
Short-finned Pilot Whale	Delphinidae	0.76	0.96
Sperm Whale	Physeteridae	0.87	0.495
Harbor Seal, Hawaiian Monk Seal	Phocidae	0.281*	0.281
California Sea Lion	Otariidae	0.299*	0.299
Guadalupe Fur Seal, Northern Fur Seal	Phocidae	0.299*	0.299
Northern Elephant Seal	Phocidae	0.105*	0.105

*For species having no data, the g(0) for Cuvier's aircraft value (where g(0)=0.074) was used; or in cases where there was no value for vessels, the g(0) for aircraft was used as a conservative underestimate of sightability following the assumption that the availability bias from a slower moving vessel should result in a higher g(0). Some g(0) values in the table above are perception bias and others represent availability bias depending on the species and data that is currently available. References: Barlow (2010); Barlow and Forney (2007); Barlow et al. (2006); Carretta et al.(2000); Laake et al. (1997).

The Navy recognizes that g(0) values are estimated specifically for line-transect analyses; however, g(0) is still the best statistically-derived factor for assessing the likely marine mammal detection abilities of Navy Lookouts. Based on the points summarized above, as a factor used in accounting for the implementation of mitigation, g(0) is considered to be the best available scientific basis for Navy's representation of the sightability of a marine mammal as used in this analysis.

Line transect surveys are typically performed to detect cetacean species, and data to develop sightability values for other species are limited or unavailable. Additionally, sightability data are limited for certain cetacean species. If a g(0) value was unavailable or could not be estimated for this analysis for any species, the Navy conservatively did not consider how implementation of mitigation could potentially reduce impacts to that species within this post-model analysis. The post-model analysis did not predict how implementation of mitigation could reduce acoustic impacts for the some species or species groups such as all sea turtles and sea otters. Even though acoustic impact predictions for these species were not reduced due to implementation of mitigation, these species would be afforded some protection by implementation of mitigation during actual training and testing activities.

Quantifying marine mammals sighted in mitigation zones

To calculate the number of marine mammals that Lookouts could sight within the mitigation zones of sound-producing activities, thereby preventing a portion of model-estimated mortalities and injuries, the following equations were applied:

- Implementation of mitigation in the range to onset mortality (explosives only)

  The number of animals predicted to be sighted by Lookouts =

  Mitigation Effectiveness [factor of 0, 0.5, or 1] x

  Sightability [species-specific g(0) with a range of 0-1.0] x

  model-estimated mortalities

  The model-estimated mortalities that are calculated to be prevented by mitigation are added to the model-estimated injuries (specifically, onset slight lung injury); therefore, although some of the predicted impacts are re-categorized, the overall number of animals predicted to be affected is unchanged.

- Implementation of mitigation in the range to injury (PTS for sonar and other active acoustic sources, PTS and onset slight lung injury for explosives)

  The number of animals predicted to be sighted by Lookouts =

  Mitigation Effectiveness [factor of 0, 0.5, or 1] x

  Sightability [species-specific g(0) with a range of 0-1.0] x

  model-estimated injuries

  The model-estimated injuries that are calculated to be prevented by mitigation are added to the model-estimated non-injurious impacts (specifically, TTS); therefore, although some of the predicted impacts are re-categorized, the overall number of animals predicted to be affected is unchanged.

It is important to note that there are additional protections offered by mitigation measures that will further reduce exposures to marine mammals, but are not considered in the post-model analysis. Consistent with the Navy's impact assessment processes, the Navy considered mitigation in a conservative manner (erring on the side of overestimating the number of impacts) when quantitatively adjusting model-estimated effects to marine mammals within the applicable mitigation zones during Navy training and testing activities. Conservative considerations include the following:

- The Navy did not quantitatively account for mitigation during activities that were given a mitigation effectiveness factor of zero. A mitigation effectiveness factor of zero was given to activities where less than half of the mitigation zone can be continuously visually observed or if the mitigation zone cannot be continuously visually observed during most of the scenarios within the activity due to the type of surveillance platform(s), number of Lookouts, and size of the mitigation zone. However, some protection from applied mitigation measures would be afforded during these activities.
- The Navy only accounted for mitigation based on the required number of Lookouts, but did not account for detections that could be made by other personnel that may be involved with an event (such as range support personnel aboard a torpedo retrieval boat or support aircraft) or detections that could be made by watch personnel under implementation of Standard Operating Procedures, even though information about marine mammal sightings are shared among units participating in the training or testing activity.
- The Navy did not consider and quantify the potential for mitigation to reduce model-estimated TTS or behavioral impacts, although implementation of mitigation would likely prevent some of these impacts as well.
- Mitigation involving a power-down of sonar, cessation of sonar, or delay in use of explosives as a result of a marine mammal detection protects the observed animal and all unobserved (below the surface) animals in the vicinity. The consideration of implementation of mitigation in the post-model analysis, however, conservatively assumes that only observed animals, approximated by considering the species-specific g(0) and activity-specific mitigation effectiveness factor, would be protected by the applied mitigation (i.e., a power down, cessation of sonar, or event delay). The quantitative post-model mitigation analysis, therefore, does not capture the protection afforded to all marine mammals that may be near or within the mitigation zone.

4 MARINE MAMMAL AND SEA TURTLE AVOIDANCE OF REPEATED INTENSE SOUND EXPOSURES

- Species: all modeled species of sea turtles and marine mammals
- Activities/ Sources: Any naval activities using sonar and other active acoustic sources, or any naval activity with multiple non-concurrent underwater detonations
- Impact Zone (sonar and other active acoustic sources): Range to PTS
- Impact Zone (explosives): Range to PTS
- Flow Post-Model Acoustic Impact Analysis Process step (from Table 1-1): S-3 and E-3

4.1 BACKGROUND

4.1.1 MARINE MAMMALS

Various researchers have demonstrated that cetaceans can perceive the location and movement of a sound source (e.g., vessel, seismic source, etc.) relative to their own location and react with responsive movement away from the source, often at distances of a kilometer or more (Au and Perryman 1982; Jansen et al. 2010; Richardson et al. 1995; Tyack et al. 2011; Watkins 1986; Wursig et al. 1998).

Southall et al. (2007) synthesized data from many past behavioral studies and observations to determine the likelihood of behavioral reactions at specific sound levels. While in general, the louder the sound source the more intense the behavioral response, it was clear that the proximity of a sound source and the animal's experience, motivation, and conditioning were also critical factors influencing the response (Southall et al. 2007). After examining all of the available data, the authors felt that the derivation of thresholds for behavioral response based solely on exposure level was not supported because context of the animal at the time of sound exposure was an important factor in estimating response. Nonetheless, in some conditions, consistent avoidance reactions were noted at higher sound levels, depending on the marine mammal species or group, allowing conclusions to be drawn.

- Most low-frequency cetaceans (mysticetes) observed in studies usually avoided sound sources at levels of less than or equal to 160 dB re 1 µPa.
- Published studies of mid-frequency cetaceans analyzed include sperm whales, belugas, bottlenose dolphins, and river dolphins. These groups showed no clear tendency, but for non-impulsive sounds, captive animals tolerated levels in excess of 170 dB re 1 µPa before showing behavioral reactions, such as avoidance, erratic swimming, and attacking the test apparatus.
- High-frequency cetaceans (observed from studies with harbor porpoises) exhibited changes in respiration and avoidance behavior at levels between 90 and 140 dB re 1 µPa, with profound avoidance behavior noted for levels exceeding this.
- Phocid seals showed avoidance reactions at or below 190 dB re 1 µPa; thus, seals may actually receive levels adequate to produce TTS before avoiding the source.
- Recent studies with beaked whales have shown them to be particularly sensitive to noise, with animals during three playbacks of sound breaking off foraging dives at levels below 142 dB re 1 µPa sound pressure level, although acoustic monitoring during actual sonar exercises revealed some beaked whales continuing to forage at sound pressure levels up to 157 dB re 1 µPa (Tyack et al. 2011).

Section 3.4.3.1.2.6 (Behavioral Reactions) of the *Hawaii-Southern California Training and Testing Final EIS/OEIS* (U.S. Department of the Navy 2013) reviews additional research and observations of marine mammals' reactions to sound sources including sonar and impulsive sources.

4.1.2 Sea Turtles

Studies of sea turtle reactions to sound are limited, but they have shown that sea turtles respond to and avoid some sound exposures. A few studies examined sea turtle reactions to airguns, which produce broadband impulsive sound. O'Hara and Wilcox (1990) reported that loggerhead turtles kept in an enclosure maintained a standoff range of 98 ft. (30 m) from firing airguns. McCauley et al. (2000) estimated that the received level at which turtles avoided sound in the O'Hara and Wilcox (1990) experiment was 175–176 dB re 1 µPa root mean square. Moein-Bartol et al. (1995) investigated the use of air guns to repel juvenile loggerhead sea turtles from hopper dredges. The turtles avoided the airguns during the initial exposures (mean range of 24 m), but additional trials several days afterward did not elicit statistically significant avoidance. They concluded that this was due to either habituation or a temporary shift in the turtles' hearing capability. McCauley et al. (2000) exposed caged green and loggerhead sea turtles to an approaching-departing single air gun to gauge behavioral responses. The trials showed that above a received level of 166 dB re 1 µPa (root mean square), the turtles noticeably increased their swimming activity compared to nonoperational periods, with swimming time increasing as air gun levels increased during approach. Above 175 dB re 1 µPa (root mean square), behavior became more erratic, possibly indicating the turtles were in an agitated state (McCauley et al. 2000). The authors noted that the point at which the turtles showed the more erratic behavior and exhibited possible agitation would be expected to approximate the point at which active avoidance would occur for unrestrained turtles (McCauley et al. 2000).No studies have been performed to examine the response of sea turtles to sonar. However, based on their limited range of hearing, they may respond to sources operating below 2 kHz but are unlikely to sense higher frequency sounds.

4.2 Post-model analysis

At close ranges and high sound levels approaching those that could cause PTS, avoidance of the area immediately around the sound source is the assumed behavioral response for most cases. Because the Navy Acoustic Effects Model does not consider horizontal movement of animats, including avoidance of high-intensity sound exposures, it over-estimates the number of marine mammals and sea turtles that would be exposed to sound sources that could cause injury. In other words, the model estimates PTS impacts as though an animal would tolerate an injurious sound exposure without moving away from the sound source. Therefore, the potential for avoidance is considered in the post-model analysis.

Avoidance of high-intensity sonar exposures

Mid Frequency Cetaceans: Animal avoidance of the area immediately around the sonar or other active acoustic system would make the model-estimated PTS exposures of *mid-frequency* cetaceans unlikely. The single ping range to PTS for mid-frequency cetaceans for the most powerful sonar analyzed, the AN/SQS-53, is approximately 10 m, and the PTS range for five pings is about 20 m. The AN/SQS-53 can span as much as 270 degrees; however, an animal would need to maintain a position within a 20 m radius in front of or along the bow of the ship for over 3 minutes (given the time between five pings) to experience PTS. Additionally, odontocete have demonstrated directional hearing, with best hearing sensitivity facing a sound source (Kastelein et al. 2005a; Mooney et al. 2008; Popov and Supin 2009). An odontocete avoiding a source would receive sounds along a less sensitive hearing axis, potentially reducing impacts.

To account for the very short range to PTS for mid-frequency cetaceans and to acknowledge the likelihood that any mid-frequency cetacean would not likely maintain close travel within the injury zone of a sonar for durations long enough to accumulate energy leading to PTS, the following post-model analysis steps were applied:

- Mid-frequency cetaceans modeled to experience PTS due to sonar and other active acoustic sources are assumed to experience TTS[6].
- The model-estimated PTS for mid-frequency cetaceans exposed to sonars and other active acoustic sources are added to the model-estimated TTS; therefore, although some of the predicted impacts are re-categorized, the overall number of animals predicted to be affected is unchanged. (Note: Although implementation of mitigation to reduce mid-frequency cetacean PTS was considered in the preceding step of the post-model quantitative analysis, consideration of animal avoidance of multiple high-intensity sonar exposures in this step mathematically overrides the previous mid-frequency cetacean PTS reductions due to mitigation, as zero mid-frequency PTS are anticipated due to during activity avoidance.)

Other marine mammals and sea turtles: Marine mammals in other functional hearing groups (i.e., low-frequency and high-frequency cetaceans; and pinnipeds) and sea turtles, if present but not observed by Lookouts, are assumed to leave the area near the sound source after the first few pings, thereby reducing sound exposure levels and the potential for PTS. During the first few pings of an event, or after a pause in sonar activities, if animals are caught unaware and it was not possible to implement mitigation measures (e.g., animals are at depth and not visible at the surface) it is possible they could receive enough acoustic energy to suffer PTS. Based on nominal marine mammal and sea turtle swim speeds (i.e., 3 knots) and normal operating parameters for Navy vessels (i.e., 10-15 knots), it was determined that an animal can easily avoid PTS zones within the timeframe it takes an active sound source to generate one to two pings. Example ranges to PTS are provided in Table 4-1.

Table 4-1: Approximate Ranges to PTS Onset Threshold for Each Functional Hearing Group for a Single Ping from Three of the Most Powerful Sonar Systems

Functional Hearing Group	Ranges to the Onset of PTS for One Ping (meters)[1,2]		
	Sonar Bin MF1 (e.g., SQS-53; ASW Hull Mounted Sonar)	Sonar Bin MF4 (e.g., AQS-22; ASW Dipping Sonar)	Sonar Bin MF5 (e.g., SSQ-62; ASW Sonobuoy)
Low-Frequency Cetaceans	70	10	≤ 2
Mid-Frequency Cetaceans	10	≤ 2	≤ 2
High-Frequency Cetaceans	100	20	10
Phocid Seals	80	10	≤ 2
Otariid Seals,Sea Lions, & Mustelid (Sea Otters)	10	<2	<2

ASW: anti-submarine warfare; PTS: permanent threshold shift
[1] Approximate ranges are based on spherical spreading (Transmission Loss = 20 log R, where R = range in meters).
[2] These common Navy sonar sources operate in frequency ranges above sea turtle hearing, and therefore none of these sources would affect sea turtles.

Even though marine mammals in other functional hearing groups (i.e., low-frequency and high-frequency cetaceans and pinnipeds) and sea turtles could easily avoid PTS zones after one to two pings, to be conservative in this post-model analysis, animals that were model-estimated to be within the range to onset PTS for the first three to four pings of an activity are assumed to not avoid onset of PTS. However, animals present beyond the range to onset PTS for the first three to four pings are assumed to

[6] All mid-frequency cetacean (delphinids and small whales, including beaked whales) PTS for sonar and other active acoustic sources are reduced to zero (and applied to TTS) due to the S-3 avoidance factor. From a mathematical perspective, consideration of mitigation for mid-frequency cetaceans exposed to sonar and other acoustic sources is irrelevant in the final result. However, because mitigation occurs second in the post-modeling assessment process, the results of mitigation are included in the calculations for mid-frequency cetaceans to provide consistency across all other species.

avoid any additional exposures at levels that could cause PTS. The range of three to four pings accounts for differences in sonar systems and sound propagation environments.

To account for avoidance of high intensity sound exposures after the initial three to four pings, at the beginning of the activity or after a pause in sound transmission, the following post-model analysis steps were applied:

- High frequency cetaceans, low frequency cetaceans, pinnipeds, , and sea turtles modeled to experience PTS after the first three to four pings of an event are assumed to experience TTS.
- The model-estimated PTS for high frequency cetaceans, low frequency cetacean s pinnipeds, and sea turtles after the first three to four pings of an event are added to the model-estimated TTS; therefore, although some of the predicted impacts are re-categorized, the overall number of animals predicted to be affected is unchanged.

Avoidance of Repeated Explosive Exposures

During an activity with a series of explosions (not concurrent, i.e., not detonated concurrently in a cluster, but detonated one at a time), an animal is expected to exhibit an initial startle reaction to the first detonation followed by a behavioral response after multiple detonations. At close ranges and high sound levels approaching those that could cause PTS, avoidance of the area around the explosions is the assumed behavioral response for most cases. The ranges to PTS for each functional hearing group for a range of explosive sizes (single detonation) are shown in Table 4-2 through Table 4-7. Modeling for sound exposure level-based impulsive criteria assumed explosive event durations of one second. Actual durations may be less, resulting in smaller ranges to impact.

Table 4-2: Average Range to Effects from Explosions for Low-Frequency Cetaceans across Representative Acoustic Environments within the Study Area

Criteria/Predicted Impact	Range to Effects (meters)			
	Bin E3 (0.6-2.6 lb. NEW)	Bin E5 (6-10 lb. NEW)	Bin E9 (101-250 lb. NEW)	Bin E12 (651-1,000 lb. NEW)
Onset Mortality	10	20	65	95
Onset Slight Lung Injury	20	40	110	165
Onset Slight GI Tract Injury	40	80	145	250
PTS	85	170	255	485
TTS	215	445	515	1,760

GI: Gastrointestinal; lb.: pound; NEW: net explosive weight; PTS: permanent threshold shift; TTS: temporary threshold shift

Table 4-3: Average Range to Effects from Explosions for Mid-Frequency Cetaceans across Representative Acoustic Environments within the Study Area

Criteria/Predicted Impact	Range to Effects (meters)			
	Bin E3 (0.6-2.6 lb. NEW)	Bin E5 (6-10 lb. NEW)	Bin E9 (101-250 lb. NEW)	Bin E12 (651-1,000 lb. NEW)
Onset Mortality	25	45	135	200
Onset Slight Lung Injury	50	85	235	345
Onset Slight GI Tract Injury	40	80	145	250
PTS	35	70	170	265
TTS	100	215	355	720

GI: Gastrointestinal; lb.: pound; NEW: net explosive weight; PTS: permanent threshold shift; TTS: temporary threshold shift

Table 4-4: Average Range to Effects from Explosions for High-Frequency Cetaceans across Representative Acoustic Environments within the Study Area

Criteria/Predicted Impact	Range to Effects (meters)			
	Bin E3 (0.6-2.6 lb. NEW)	Bin E5 (6-10 lb. NEW)	Bin E9 (101-250 lb. NEW)	Bin E12 (651-1,000 lb. NEW)
Onset Mortality	30	50	145	215
Onset Slight Lung Injury	55	90	250	370
Onset Slight GI Tract Injury	40	80	145	250
PTS	140	375	470	855
TTS	500	705	810	2,415

GI: Gastrointestinal; lb.: pound; NEW: net explosive weight; PTS: permanent threshold shift; TTS: temporary threshold shift

Table 4-5: Average Range to Effects from Explosions for Phocid Seals across Representative Acoustic Environments within the Study Area

Criteria/Predicted Impact	Range to Effects (meters)			
	Bin E3i (0.6-2.6 lb. NEW)	Bin E5 (6-10 lb. NEW)	Bin E9 (101-250 lb. NEW)	Bin E12 (651-1,000 lb. NEW)
Onset Mortality	30	50	150	225
Onset Slight Lung Injury	60	100	265	385
Onset Slight GI Tract Injury	40	80	145	250
PTS	95	180	340	680
TTS	235	500	665	1,350

GI: Gastrointestinal; lb.: pound; NEW: net explosive weight; PTS: permanent threshold shift; TTS: temporary threshold shift

Table 4-6: Average Range to Effects from Explosions for Otariid Seals across Representative Acoustic Environments within the Study Area

Criteria/Predicted Impact	Range to Effects (meters)			
	Bin E3i (0.6-2.6 lb. NEW)	Bin E5 (6-10 lb. NEW)	Bin E9 (101-250 lb. NEW)	Bin E12 (651-1,000 lb. NEW)
Onset Mortality	35	65	175	260
Onset Slight Lung Injury	70	115	307	450
Onset Slight GI Tract Injury	40	80	145	250
PTS	30	50	50	150
TTS	40	85	220	400

GI: Gastrointestinal; lb.: pound; NEW: net explosive weight; PTS: permanent threshold shift; TTS: temporary threshold shift

Table 4-7: Average Range to Effects from Explosions for Sea Turtles across Representative Acoustic Environments within the Study Area

Criterion/ Predicted Impact[1]	Range to Effects (meters)			
	Bin E2 (0.26-0.5 lb. NEW)	Bin E5 (6-10 lb. NEW)	Bin E9 (101-250 lb. NEW)	Bin E12 (651-1,000 lb. NEW)
Onset Mortality	12	47	137	204
Onset Slight Lung Injury	25	87	240	352
Onset Slight GI Tract Injury	25	71	147	274
PTS	79	222	587	1,602
TTS	178	598	1,711	3,615

GI: gastrointestinal; lb.: pound; m: meters, NEW: net explosive weight; PTS: permanent threshold shift; TTS: temporary threshold shift; Ranges determined using REFMS, Navy's explosive propagation model.

Animals not observed by Lookouts within the ranges to PTS at the time of the initial couple of explosions are assumed to experience PTS; however, animals that exhibit avoidance reactions beyond the initial range to PTS are assumed to move away from the expanding range to PTS effects with each additional explosion. Because the Navy Acoustic Effects Model does not account for avoidance behavior, the model-estimated effects are based on unlikely behavior – in that animals would remain in the vicinity of potentially injurious sound sources. Therefore, only the initial exposures to explosive noise resulting in model-estimated PTS are expected to actually occur. To be conservative, those animals within the range to onset mortality and onset slight lung injury that are assumed to NOT be seen by Lookouts prior to the detonation [see Section 3.2 (Post-Model Analysis) for Reducing Acoustic Exposures by Implementation of Mitigation]are assumed to experience these model-estimated effects; in other words, no further post-model analysis is applied to model-estimated onset mortalities and onset slight lung injuries to account for avoidance of multiple explosive exposures. Accordingly, animals are assumed to not avoid any model-predicted gastrointestinal (GI) tract injuries (range to effect for GI tract injury is typically within the range to effect for onset slight lung injury).

For an event with a sequence of explosions which are separated temporally (e.g., by a few minutes) but detonate in the same area, the second detonation increases the zone of influence to onset-PTS by about 46 percent over the first detonation. Additional explosions, beyond the second detonation, further increase the onset-PTS zone of influence. Therefore, for events that include multiple non-current detonations, the model predicted PTS was reduced by 46 percent to account for animals avoiding the second and all subsequent detonations. This adjustment is conservative for all events that include more than two non-concurrent explosions since the ratio would be greater than 46 percent.

It should be noted that the zone of onset mortality and the zone of onset slight lung injury are not additive with multiple detonations. Any animals within these zones around a detonation location are predicted to experience these effects with the first detonation. Subsequent detonations do not increase the zones of effect for onset mortality or onset slight lung injury and do not increase the numbers of animals affected in these zones. Therefore, avoidance behavior during an explosive event is not assumed to change the predicted mortalities and slight lung injuries.

The following modifications to the model-estimates were performed in the post-model analysis for activities with multiple non-concurrent explosions listed in Table 4-8:

- All marine mammals and sea turtles modeled to receive PTS after the first explosion are assumed to move out of the range to PTS and receive TTS.

Table 4-8: Activities with Multiple Non-Concurrent Explosions

ACTIVITIES
Training
Airborne Mine Neutralization Systems
BOMBEX [A-S]
Civilian Port Defense
Gunnery Exercise [A-S]
Gunnery Exercise [S-S] - Large Caliber
Gunnery Exercise [S-S] - Medium Caliber
Mine Neutralization – EOD
Mine Neutralization – ROV
SINKEX
Underwater Demolition
Testing
MCM Mission Package Testing
Mine Countermeasure/Neutralization Testing
Pierside Integrated Swimmer Defense
Sonobuoy Lot Acceptance Testing

Note: A-S: air-to-surface; S-S: Surface to Surface; BOMBEX: bombing exercise; EOD: explosive ordnance disposal; FIREX: fire support exercise; GUNEX: gunnery exercise; MCM: mine countermeasure; ROV: remotely operated vehicle; SINKEX: sinking exercise.

5 SUMMARY

The adjustments made to the model-estimated effects to each species at each applicable step of the post-model quantitative analysis are shown for all of the categories of training and testing activities in Table 5-2 through Table 5-4. Adjustments to mortality (explosives only), slight lung injury (explosives only), and PTS (sonar, other active acoustic sources, and explosives) are shown. All exposures which were moved out of the zone of injury were counted as TTS; the additions to the predicted TTS are not shown to simplify presentation of results. Final predicted impacts are in **BOLD**. If a step in the post-model analysis did not apply to a particular species, the species impact box is shaded. Additionally, if a step in the post-model box did not apply to impacts due to a particular training or testing activity that was analyzed separately, the species impact box is also shaded.

To illustrate the post-model quantitative analysis, the adjustments made at each post-model analysis step are shown below for several hypothetical situations. These hypothetical situations show how the steps of the post-model analysis may or may not apply depending on the species and characteristics of the sound-producing activity. The impacts in the examples below are generally higher than those predicted for any actual single event; the numbers were inflated to provide clear and easy to understand examples using whole numbers. As a reminder, the post-model analysis steps are summarized in Table 1-1, and the reader is referred to the steps in the table in these hypothetical examples.

Example 1:

Source: Sonar or other active acoustic source
Activity description: not preceded by multiple vessels or helicopters, mitigation effectiveness factor of 1 (e.g., Surface Combatant Sea Trials: Anti-submarine Warfare Testing, Surface Ship Sonar Maintenance)
Species: Cuvier's beaked whale (MF cetacean)

Model-estimated effects:

$TTS_{model} = 100$ $PTS_{model} = 5$

Step S-1: Is the animal a sensitive species that avoids anthropogenic activity (i.e., beaked whale)?

Yes.

If yes, is the activity preceded by multiple vessel activity or hovering helicopter?

No. Model estimates are unchanged.

$TTS_{S-1} = 100$ $PTS_{S-1} = 5$

Step S-2: Can Lookouts observe the activity-specific mitigation zone up to and during the sound-producing activity?

Yes (vessel-based Lookouts for this example). Implementation of mitigation is quantified.

The number of animals predicted to be sighted by Lookouts =
Mitigation Effectiveness [1] x Sightability [$g(0)_{\text{Cuvier's beaked whale, vessel}}$ = 0.23] x PTS_{S-1} [5] = 1.15

Because 1.15 animals are predicted to be sighted by Lookouts within the mitigation zone, the number of predicted PTS is reduced by 1.15 and the number of TTS is increased by 1.15.

TTS_{S-2} = 101.15 PTS_{S-2} = 3.85

Step S-3: Does the activity cause repeated sound exposures which an animal would likely avoid?

Yes.

The single ping range to PTS for an MF cetacean is short (generally less than 10 m), so all MF cetaceans estimated to experience PTS are assumed to experience TTS.

TTS_{S-3} = 105 PTS_{S-3} = 0 (Final Prediction)

Example 2:

Source: Sonar or other active acoustic source
Activity description: preceded by multiple vessels or helicopters, mitigation effectiveness factor of 0.5 (e.g., Tracking Exercise/Torpedo Exercise -Helicopter, Anti-Submarine Warfare Mission Package Testing)
Species: beaked whale (MF cetacean)

Model-estimated effects:

TTS_{model} = 100 PTS_{model} = 2

Step S-1: Is the animal a sensitive species that avoids anthropogenic activity?

Yes.

If yes, is the activity preceded by multiple vessel activity or hovering helicopter?

Yes. Beaked whales modeled within the range to onset PTS are assumed to avoid the region close to the sound source prior to the beginning of sound producing activities. Beaked whale modeled PTS are assumed to move within the range of onset TTS.

TTS_{S-1} = 102 PTS_{S-1} = 0 (Final Prediction)

Because predicted PTS = 0, no further reductions to model-estimated impacts are possible for this activity.

Example 3:

Source: Sonar or other active acoustic source
Activity description: not preceded by multiple vessels or helicopters, mitigation effectiveness factor of 0 (e.g., Tracking Exercise/Torpedo Exercise –Sub, Submarine Sea Trial)
Species: minke whale (LF cetacean)

Model-estimated effects:

TTS_{model} = 100 PTS_{model} = 2

Step S-1: Is the animal a sensitive species that avoids anthropogenic activity (i.e., beaked whale)?

No. Model estimates are unchanged.

TTS_{S-1} = 100 PTS_{S-1} = 2

Step S-2: Can Lookouts observe the activity-specific mitigation zone up to and during the sound-producing activity?

No. Implementation of mitigation is not quantified (i.e., multiplying by a mitigation factor of zero predicts no animals would be observed in the mitigation zone). Model estimates are unchanged.

TTS_{S-2} = 100 PTS_{S-2} = 2

Step S-3: Does the activity cause repeated sound exposures which an animal would likely avoid?

Yes. Low frequency cetaceans modeled to experience PTS after the first three to four pings are assumed to experience TTS due to swimming away from the sound source and avoiding the injury zone.

TTS_{S-3} = 101.9 PTS_{S-3} = 0.1* (Final Prediction)

*Predicted impacts to a species are summed across all training or testing activities over a year, then rounded to an integer following general mathematic rounding rules.

Example 4:

Source: Explosive

Activity description: not preceded by multiple vessels or helicopters, mitigation effectiveness factors of 0 (mortality) and 0 (injury) (e.g., [A-S] MISSILEX, MISSILEX [S-S]), single or non-concurrent detonation

Species: beaked whale (MF cetacean)

Model-estimated effects:

TTS_{model} = 20 PTS_{model} = 2 SLI_{model} = 2 $Mortality_{model}$ =1

Step E-1: Is the animal a sensitive species that avoids anthropogenic activity (i.e., beaked whale)?

Yes.

If yes, is the activity preceded by multiple vessel activity or hovering helicopter?

No. Model estimates are unchanged.

TTS_{E-1} = 20 PTS_{E-1} = 2 SLI_{E-1} = 2 $Mortality_{E-1}$ =1

Step E-2: Can Lookouts observe the activity-specific mitigation zone up to and during the sound-producing activity?

No. Model estimates are unchanged.

TTS_{E-2} = 20 PTS_{E-2} = 2 SLI_{E-2} = 2 $Mortality_{E-2}$ =1

Step E-3: Does the activity cause repeated sound exposures which an animal would likely avoid?

No. Model estimates are unchanged.

TTS_{E-3} = 20 PTS_{E-3} = 2 SLI_{E-3} = 2 $Mortality_{E-3}$ =1 (Final Prediction)

Example 5:

Source: Explosive
Activity description: preceded by multiple vessels or helicopters, mitigation effectiveness factor of 1 (mortality) and 1 (injury) (e.g., At-sea explosives testing), single detonation
Species: Baird's beaked whale (MF cetacean)

Model-estimated effects:

TTS_{model} = 20 PTS_{model} = 2 SLI_{model} = 2 $Mortality_{model}$ =1

Step E-1: Is the animal a sensitive species that avoids anthropogenic activity (i.e., beaked whale)?

Yes.

If yes, is the activity preceded by multiple vessel activity or hovering helicopter?

Yes. Beaked whales modeled within the range to onset mortality are assumed to avoid the region close to the sound source prior to the beginning of sound producing activities. Beaked whale modeled mortalities are assumed to move within the range of onset slight lung injury.

TTS_{E-1} = 20 PTS_{E-1} = 2 SLI_{E-1} = 3 $Mortality_{E-1}$ =0

Step E-2: Can Lookouts observe the activity-specific mitigation zone up to and during the sound-producing activity?

Yes (vessel-based Lookouts for this example). Implementation of mitigation is quantified.

No animals are predicted to be present in the mortality zone after Step E-1; therefore, mortality prediction is unchanged from Step E-1.

The number of animals predicted to be sighted by Lookouts in the injury (SLI) zone= Mitigation Effectiveness for injury [1] x Sightability [$g(0)_{\text{Baird's beaked whale, vessel}}$ = 0.96] x SLI_{E-1} [3] = 2.88

The number of animals predicted to be sighted by Lookouts in the injury (PTS) zone= Mitigation Effectiveness for injury [1] x Sightability [$g(0)_{\text{Baird's beaked whale, vessel}}$ = 0.96]x PTS_{E-1} [2] = 1.92
Model estimated injury effects become:

PTS_{E-1} = 0.08 SLI_{E-1} = 0.12

The animals predicted to be sighted by Lookouts within the injury zone are assumed to not be injured and are added to the animals predicted to experience TTS.

TTS_{E-2} = 24.8 PTS_{E-2} = 0.08 SLI_{E-2} = 0.12 $Mortality_{E-2}$ =0

Step E-3: Does the activity cause repeated sound exposures which an animal would likely avoid?
No. Predictions are unchanged from Step E-2.
TTS_{E-3} = 24.8 PTS_{E-3} = 0.08 SLI_{E-3} = 0.12 $Mortality_{E-3}$ =0 (Final Prediction)

Example 6:

Source: Explosive
Activity description: preceded by multiple vessels or helicopters, mitigation effectiveness factor of 1 (mortality) and 0.5 (injury) (e.g., Mine Neutralization – EOD, SINKEX), multiple detonations
Species: bottlenose dolphin (MF cetacean)

Model-estimated effects:
TTS_{model} = 20 PTS_{model} = 2 SLI_{model} = 2 $Mortality_{model}$ =1

Step E-1: Is the animal a sensitive species that avoids anthropogenic activity (i.e., beaked whale)?
No. Model estimates are unchanged.
TTS_{E-1} = 20 PTS_{E-1} = 2 SLI_{E-1} = 2 $Mortality_{E-1}$ =1

Step E-2: Can Lookouts observe the activity-specific mitigation zone up to and during the sound-producing activity?
Yes (aircraft-based Lookouts for this example). Implementation of mitigation is quantified.

The number of animals predicted to be sighted by Lookouts in the mortality zone= Mitigation Effectiveness for mortality [1] x Sightability [$g(0)_{\text{bottlenose dolphin, aircraft}}$ = 0.96] x $Mortality_{E-1}$ [1] = 0.96

The number of animals predicted to be sighted by Lookouts in the injury (SLI) zone= Mitigation Effectiveness for injury [0.5] x Sightability [$g(0)_{\text{bottlenose dolphin, aircraft}}$ = 0.96]x SLI_{E-1} [2] = 0.96

The number of animals predicted to be sighted by Lookouts in the injury (PTS) zone= Mitigation Effectiveness for injury [0.5] x Sightability [$g(0)_{\text{bottlenose dolphin, aircraft}}$ = 0.96] x $PTS_{E\text{-}1}$ [2] = 0.96

The animals predicted to be sighted by Lookouts within the mortality zone are assumed to not be mortally injured and are added to the animals predicted to experience onset slight lung injury. The animals predicted to be sighted by Lookouts within the injury zone are assumed to not be injured and are added to the animals predicted to experience TTS.

$TTS_{E\text{-}2}$ = 21.92 $PTS_{E\text{-}2}$ = 1.04 $SLI_{E\text{-}2}$ = 2 $Mortality_{E\text{-}2}$ =0.04

Step E-3: Does the activity cause repeated sound exposures which an animal would likely avoid?

Yes. Animals modeled to receive PTS after the first explosion are assumed to move out of the range to PTS and receive TTS (approximately 46 percent or more of predicted PTS). $PTS_{E\text{-}3}$ = $PTS_{E\text{-}2}$ [1.04] x 0.46 = 0.48.

$TTS_{E\text{-}3}$ = 22.4 $PTS_{E\text{-}3}$ = 0.56 $SLI_{E\text{-}3}$ = 2 $Mortality_{E\text{-}3}$ = 0.04 (Final Prediction)

Table 5-1: Sonar and other Active Acoustic Sources - Annual Training

	PTS			
Species	**Model-Estimated**	**S-1 Pre-Activity Avoidance**	**S-2 Implementation of Mitigation**	**S-3 Avoidance of Repeated Exposures**
Blue whale	116		9	**0**
Fin whale	33		3	**0**
Humpback whale	64		11	**1**
Sei whale	18		2	**0**
Sperm whale	0		0	**0**
Guadalupe fur seal	1		1	**0**
Hawaiian monk seal	5		3	**0**
Bryde’s whale	5		1	**0**
Gray whale	356		28	**1**
Minke whale	12		2	**0**
Baird’s beaked whale	0	0	0	**0**
Blainville’s beaked whale	0	0	0	**0**
Bottlenose dolphin	11		2	**0**
Cuvier’s beaked whale	0	0	0	**0**
Dwarf sperm whale	1,014		724	**42**
Dall’s porpoise	3,561		644	**37**
False killer whale	0		0	**0**
Fraser’s dolphin	0		0	**0**
Killer whale	0		0	**0**
Kogia spp.	987		642	**32**
Long-beaked common dolphin	17		0	**0**
Longman’s beaked whale	0	0	0	**0**
Melon-headed whale	0		0	**0**
Mesoplodon beaked whales*	0	0	0	**0**
Northern right whale dolphin	11		2	**0**
Pacific white-sided dolphin	19		3	**0**
Pantropical spotted dolphin	1		0	**0**
Pygmy killer whale	0		0	**0**
Pygmy sperm whale	9		6	**0**
Risso’s dolphin	22		5	**0**
Rough-toothed dolphin	1		0	**0**
Short-beaked common dolphin	522		16	**0**
Short-finned pilot whale	2		0	**0**
Spinner dolphin	1		0	**0**
Striped dolphin	1		0	**0**
Southern sea otter	0			**0**
California sea lion	3		2	**0**
Northern fur seal	1		0	**0**
Harbor seal	297		213	**11**
Northern elephant seal	394		353	**18**
Green Sea Turtle	0			**0**
Pacific Sea Turtle Guild	4			**0**

Table 5-2: Sonar and Other Active Acoustic Sources - Annual Testing

	PTS			
Species	**Model-Estimated**	**S-1 Pre-Activity Avoidance**	**S-2 Implementation of Mitigation**	**S-3 Avoidance of Repeated Exposures**
Blue whale	1		0	**0**
Fin whale	0		0	**0**
Humpback whale	4		3	**0**
Sei whale	0		0	**0**
Sperm whale	3		3	**0**
Guadalupe fur seal	0		0	**0**
Hawaiian monk seal	14		13	**1**
Bryde's whale	0		0	**0**
Gray whale	21		13	**1**
Minke whale	0		0	**0**
Baird's beaked whale	4	4	4	**0**
Blainville's beaked whale	4	4	4	**0**
Bottlenose dolphin	75		74	**0**
Cuvier's beaked whale	4	4	3	**0**
Dwarf sperm whale	522		378	**19**
Dall's porpoise	838		505	**25**
False killer whale	1		1	**0**
Fraser's dolphin	0		0	**0**
Killer whale	1		1	**0**
Kogia spp.	101		81	**4**
Long-beaked common dolphin	48		45	**0**
Longman's beaked whale	1	1	1	**0**
Melon-headed whale	4		4	**0**
Mesoplodon beaked whales[*]	1	0	0	**0**
Northern right whale dolphin	71		64	**0**
Pacific white-sided dolphin	61		59	**0**
Pantropical spotted dolphin	0		0	**0**
Pygmy killer whale	3		3	**0**
Pygmy sperm whale	52		35	**2**
Risso's dolphin	166		161	**0**
Rough-toothed dolphin	2		2	**0**
Short-beaked common dolphin	2,757		2,656	**0**
Short-finned pilot whale	4		4	**0**
Spinner dolphin	0		0	**0**
Striped dolphin	8		6	**0**
Southern sea otter	0			**0**
California sea lion	0		0	**0**
Northern fur seal	0		0	**0**
Harbor seal	74		68	**3**
Northern elephant seal	44		41	**2**
Green Sea Turtle	28			**1**
Pacific Sea Turtle Guild	0			**0**

Table 5-3: Explosives – Annual Training

Species	PTS			Slight Lung Injury			Mortality		
	Model-Estimated	S-2 Implementation of Mitigation	S-3 Avoidance of Repeated Exposures	Model-Estimated	S-1 Pre-Activity Avoidance[1]	S-2 Implementation of Mitigation	Model-Estimated	S-1 Pre-Activity Avoidance[1]	S-2 Implementation of Mitigation
Blue whale	1	0	**0**	0		**0**	0		**0**
Fin whale	0	0	**0**	0		**0**	0		**0**
Humpback whale	0	0	**0**	0		**0**	0		**0**
Sei whale	0	0	**0**	0		**0**	0		**0**
Sperm whale	0	0	**0**	0		**0**	0		**0**
Guadalupe fur seal	0	0	**0**	1		**1**	0		**0**
Hawaiian monk seal	0	0	**0**	0		**0**	0		**0**
Bryde's whale	0	0	**0**	0		**0**	0		**0**
Gray whale	5	3	**2**	0		**0**	0		**0**
Minke whale	0	0	**0**	0		**0**	0		**0**
Baird's beaked whale	0	0	**0**	0	0	**0**	0	0	**0**
Blainville's beaked whale	0	0	**0**	0	0	**0**	0	0	**0**
Bottlenose dolphin	0	0	**0**	1		**1**	1		**0**
Cuvier's beaked whale	0	0	**0**	0	0	**0**	0	0	**0**
Dwarf sperm whale	6	6	**5**	0		**0**	0		**0**
Dall's porpoise	22	16	**9**	2		**2**	1		**0**
False killer whale	0	0	**0**	0		**0**	0		**0**
Fraser's dolphin	0	0	**0**	0		**0**	0		**0**
Killer whale	0	0	**0**	0		**0**	0		**0**
Kogia spp.	3	3	**2**	0		**0**	0		**0**
Long-beaked common dolphin	1	0	**0**	5		**2**	2		**0**
Longman's beaked whale	0	0	**0**	0	0	**0**	0	0	**0**
Melon-headed whale	0	0	**0**	0		**0**	0		**0**
Mesoplodon beaked whales*	0	0	**0**	0	0	**0**	0	0	**0**
Northern right whale dolphin	0	0	**0**	3		**2**	2		**0**
Pacific white-sided dolphin	0	0	**0**	3		**2**	2		**0**
Pantropical spotted dolphin	0	0	**0**	1		**1**	0		**0**
Pygmy killer whale	0	0	**0**	0		**0**	0		**0**
Pygmy sperm whale	0	0	**0**	0		**0**	0		**0**
Risso's dolphin	2	1	**0**	2		**1**	2		**0**
Rough-toothed dolphin	0	0	**0**	0		**0**	0		**0**
Short-beaked common dolphin	11	5	**3**	137		**68**	54		**3**

Species	PTS			Slight Lung Injury			Mortality		
	Model-Estimated	S-2 Implementation of Mitigation	S-3 Avoidance of Repeated Exposures	Model-Estimated	S-1 Pre-Activity Avoidance[1]	S-2 Implementation of Mitigation	Model-Estimated	S-1 Pre-Activity Avoidance[1]	S-2 Implementation of Mitigation
Short-finned pilot whale	0	0	**0**	0		**0**	0		**0**
Spinner dolphin	0	0	**0**	0		**0**	0		**0**
Striped dolphin	0	0	**0**	1		**0**	0		**0**
Southern Sea Otter	0		**0**	**0**			**0**		
California sea lion	22	19	**10**	17		**15**	7		**5**
Northern fur seal	2	2	**2**	4		**4**	1		**0**
Harbor seal	1	1	**1**	1		**1**	0		**0**
Northern elephant seal	8	8	**4**	2		**2**	1		**0**
Green Sea Turtle	0		**0**	**0**			**0**		
Pacific Sea Turtle Guild	44		**22**	**13**			**5**		

[1] Beaked whale model-estimated mortalities that are predicted not to occur due to avoidance of activities preceded by multiple vessel activity or hovering helicopters are added to the slight lung injury impact category.

Table 5-4: Explosives – Annual Testing

Species	PTS			Slight Lung Injury			Mortality		
	Model-Estimated	S-2 Implementation of Mitigation	S-3 Avoidance of Repeated Exposures	Model-Estimated	S-1 Pre-Activity Avoidance[1]	S-2 Implementation of Mitigation	Model-Estimated	S-1 Pre-Activity Avoidance[1]	S-2 Implementation of Mitigation
Blue whale	0	0	**0**	0		**0**	0		**0**
Fin whale	0	0	**0**	0		**0**	0		**0**
Humpback whale	0	0	**0**	0		**0**	0		**0**
Sei whale	0	0	**0**	0		**0**	0		**0**
Sperm whale	0	0	**0**	0		**0**	0		**0**
Guadalupe fur seal	0	0	**0**	1		**1**	0		**0**
Hawaiian monk seal	0	0	**0**	0		**0**	0		**0**
Bryde's whale	0	0	**0**	0		**0**	0		**0**
Gray whale	2	1	**1**	0		**0**	0		**0**
Minke whale	0	0	**0**	0		**0**	0		**0**
Baird's beaked whale	0	0	**0**	0	0	**0**	0	0	**0**
Blainville's beaked whale	0	0	**0**	0	0	**0**	0	0	**0**
Bottlenose dolphin	0	0	**0**	2		**1**	1		**0**
Cuvier's beaked whale	0	0	**0**	0	0	**0**	0	0	**0**
Dwarf sperm whale	10	10	**10**	0		**0**	0		**0**
Dall's porpoise	12	9	**7**	2		**1**	0		**0**
False killer whale	0	0	**0**	0		**0**	0		**0**
Fraser's dolphin	0	0	**0**	0		**0**	0		**0**
Killer whale	0	0	**0**	0		**0**	0		**0**
Kogia spp.	3	3	**2**	0		**0**	0		**0**
Long-beaked common dolphin	0	0	**0**	7		**3**	3		**1**
Longman's beaked whale	0	0	**0**	0	0	**0**	0	0	**0**
Melon-headed whale	0	0	**0**	0		**0**	0		**0**
Mesoplodon beaked whales*	0	0	**0**	0	0	**0**	0	0	**0**
Northern right whale dolphin	0	0	**0**	4		**1**	1		**1**
Pacific white-sided dolphin	0	0	**0**	3		**1**	1		**0**
Pantropical spotted dolphin	0	0	**0**	3		**3**	0		**0**
Pygmy killer whale	0	0	**0**	0		**0**	0		**0**
Pygmy sperm whale	0	0	**0**	0		**0**	0		**0**
Risso's dolphin	1	0	**0**	3		**1**	1		**0**
Rough-toothed dolphin	0	0	**0**	0		**0**	0		**0**
Short-beaked common dolphin	1	0	**0**	133		**40**	69		**13**
Short-finned pilot whale	0	0	**0**	0		**0**	0		**0**

Species	PTS			Slight Lung Injury			Mortality		
	Model-Estimated	S-2 Implementation of Mitigation	S-3 Avoidance of Repeated Exposures	Model-Estimated	S-1 Pre-Activity Avoidance[1]	S-2 Implementation of Mitigation	Model-Estimated	S-1 Pre-Activity Avoidance[1]	S-2 Implementation of Mitigation
Spinner dolphin	0	0	**0**	1		**1**	0		**0**
Striped dolphin	0	0	**0**	1		**1**	0		**0**
Southern Sea Otter	0		**0**	**0**			**0**		
California sea lion	4	3	**2**	19		**16**	8		**6**
Northern fur seal	1	1	**0**	4		**3**	1		**1**
Harbor seal	1	1	**0**	1		**1**	0		**0**
Northern elephant seal	3	3	**2**	1		**1**	0		**0**
Green Sea Turtle	0		**0**	**0**			**0**		
Pacific Sea Turtle Guild	5		**5**	**1**			**0**		

[1] Beaked whale model-estimated mortalities that are predicted not to occur due to avoidance of activities preceded by multiple vessel activity or hovering helicopters are added to the slight lung injury impact category.

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