INCIDENTAL HARASSMENT AUTHORIZATION APPLICATION FOR NAVY TRAINING CONDUCTED WITHIN THE SILVER STRAND TRAINING COMPLEX

Submitted to:

Office of Protected Resources,

National Marine Fisheries Service,

National Oceanographic and Atmospheric Administration

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Department of The Navy

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Update #1 of September 1, 2010

Update #2 November 4, 2010

Update #3 December 28, 2010

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UPDATE #1 ADDENDUM NOTES (September 1, 2010)

Update #1 contains technical clarifications to the original Silver Strand Training Complex Incidental Harassment Authorization application of February 16,2010. These clarifications arose after subsequent discussions with the National Marine Fisheries Service, Office Of Protected Resources in Washington D.C., and National Marine Fisheries Service, Southwest Region in Long Beach, CA.

These organizations requested that the Navy integrate responses to National Marine Fisheries Service's comments into a revised version of this Incidental Harassment Authorization application in order to make the application more accurate in its description of the SSTC training events and explanation of how impacts were determined.

For clarity and understand of what new information is included in Update #1, significant new text is indicated in "**blue**" font within this document.

UPDATE #2 ADDENDUM NOTES (November 4, 2010)

Update #2 contains corrections to Table 6-3 that were necessitated by subsequent re-review of the zones of influence (ZOI) distances from underwater detonations. Table 6-3 was hand generated and reorganized several times during the IHA application process for enhanced clarity based on NMFS questions about SSTC training events. During these revisions, some table values were transposed. These have now been fixed in Update #2. Note, this change is merely a correction of erroneous table values. The Navy impact modeling used the correct propagation ZOIs and effects in their marine mammal exposure estimates, so the table change in Update #2 does NOT change any affects analysis presented in this IHA application, just the final mitigation zone discussed below.

During the Table 6-3 update, one correction changed the 23 psi table entry (for the *11) Marine Mammal Systems 29-lb NEW* event) to 490 yards. Since the Navy's proposed mitigation zone is based on the maximum ZOI under the dual TTS criteria, this revision changed from the previous maximum of 470 yards to 490 yards, an addition of 20 yards.

As an added protective buffer, therefore, the Navy has elected to change the Shallow Water Mitigation Zone from 470 yards to 500 yards. This change has been reflected in Section 11.

Finally, in Section 6.5.3 (Estimated Marine Mammal Exposures From ELCAS pile driving\removal), the Navy expanded its discussion on how exposures were calculated including some of the conservative (i.e., over predictive) business rules and assumptions underlying these calculations.

For clarity and understand of what new information is included in Update #2, significant new text is indicated in "**green**" font within this document.

UPDATE #2 ADDENDUM NOTES (December 28, 2010)

Update #3 contains slight language adjustments in Section 11.3 to highlight a 30 minute pre-vent monitoring and 30 minute post-event monitoring for ELCAS pile driving and removal. The intent was present in the existing mitigation, but the mitigation itself was re-written to ensure the 30 minute time intervals were clearly stated.

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EXECUTIVE SUMMARY

The U.S. Navy (Navy) is applying for an Incidental Harassment Authorization for training within the Silver Strand Training Complex (SSTC), as permitted by the Marine Mammal Protection Act of 1972, as amended. Concurrent with the development of this Incidental Harassment Authorization application, a Draft Environmental Impact Statement for all Navy training events at the SSTC was completed. This application is based on the proposed training events of the Navy's preferred alternative (Alternative 1 in the Draft Environmental Impact Statement). All training events from vessel and small craft movement, helicopter overflight, and other training events were analyzed in the Draft Environmental Impact Statement for potential impact to marine mammals (DoN 2010b). For this Incidental Harassment Authorization application, the Navy determined that only underwater detonations and Elevated Causeway System (ELCAS) training events at SSTC have the potential to rise to the level of harassment as defined under Marine Mammal Protection Act.

There are four common species of marine mammals present within the SSTC. These include California sea lions, the Pacific harbor seals, bottlenose dolphins, and gray whales. These species may be expected to occur year-round at SSTC with the exception of the gray whale. Gray whales are a transient species passing through Southern California with typical migration routes seaward of SSTC during certain portions of the cold season.

Navy annual underwater detonation training would involve detonation of up to 415 small explosive detonations [< 29 pounds (lbs)] during up to 311 training events. Of the 311 training events, up to 74 very small explosive charges (0.03 lbs) would occur within an open water area of SSTC in south San Diego Bay.

Charge weights in the ocean portions of SSTC would range from 0.03 lbs (0.5 ounces) of the explosive pentaerythritol tetranitrate (PETN) to 29 pounds (lbs) net explosive weight (NEW) of explosives with varying compositions of Cyclotrimethylenetrinitramine or more commonly Royal Demolition Explosive (RDX). Only 0.03 lbs PETN charges would be detonated in south San Diego Bay. Bay-side detonations would occur within the SSTC range, in designated open Bay waters between the City of Coronado and the City of Imperial Beach. For both ocean and Bay underwater detonations, charges would be placed at varying depths in the water column, although Bay detonations would not occur near the Bay bottom. The Navy has a long history of conducting similar explosive training in the ocean portion of SSTC using the same basic charge weights for decades without any reported effects to marine mammals.

ELCAS training at SSTC involves the installation, construction, and removal of a temporary pier over approximately 13 days. The pier structure is removed at the conclusion of the training. The installation training includes the driving of approximately 101 steel piles in the shoreline and nearshore area of the Pacific Ocean and south San Diego Bay over approximately 10 days via impact hammer. The pier may stay up for a period of days to less than two weeks to practice moving vehicles and cargo from ship to shore. After the training event concludes, piles are removed using a vibratory extractor over a period of approximately 3 days.

For underwater detonations, the Navy used National Marine Fisheries Service promulgated Marine Mammal Protection Act criteria (outlined in Section 6). These criteria were similar to those used in a recent previous Navy National Environmental Policy Act document and subsequent National Marine Fisheries Service rulemaking [i.e., the Southern California Range Complex Final Environmental Impact Statement/Overseas Impact Statement (DoN 2008), and 75 FR 3882]. Similarly, for ELCAS training, the Navy used National Marine Fisheries Service promulgated criteria for assessing pile driving impacts (70 FR 1871, 74 FR 41684).

For underwater detonations conducted in shallow water depths between 24 to 72 feet, the Navy conducted modeling using the Reflection and Refraction in Multi-Layered Ocean/Ocean Bottoms with Shear Wave Effects (REFMS) model. Predicted exposures are outlined in Section 6 and represent the maximum number of harassment incidents of cetaceans and pinnipeds from underwater explosives training at SSTC without the consideration and application of the mitigation measures proposed in Section 11. The model predicted no Level A harassment would occur, suggesting injuries are unlikely given low impulse pressures and short radii for the impact zones during training. In the absence of mitigation measures, raw acoustic modeling results predict 267 level B harassments per year resulting from exposure from underwater detonations. However, the conservative assumptions (including marine mammal densities and modeling assumptions) used to estimate exposure incidents likely overestimates the potential number of exposures and their severity. In addition, application of mitigation measures implemented by the Navy for underwater detonations are not considered in this exposure assessment.

Measurements of pressure-wave propagation are available for detonations in deep and shallow water (greater than 24 foot water depth), but only fragmentary data exists for propagation in very shallow water (VSW) near shorelines (<24 ft). The lack of data is due to the complicated nature of the VSW environment. To develop an understanding of pressure-wave propagation in VSW, the Navy conducted empirical testing of explosives in VSW at SSTC. Actual empirically measured test results from underwater detonations in this area were used to evaluate existing underwater explosive propagation models in VSW conditions and establish a mitigation buffer zone for VSW detonations at SSTC based on representative charge weights. Given the low presence of marine mammals and high probability of visually detecting marine mammals in the shallow VSW waters, it is the Navy's contention that buffering measures are expected to effectively mitigate the potential for Level A harassment by injury and Level B harassment associated with TTS or behavioral changes. As a conservative approach (i.e., over prediction of exposure) all VSW underwater detonations were modeled as if they occurred in deeper water (longer propagation potential and hence over prediction of marine mammal exposure).

To estimate potential marine mammal exposures from ELCAS pile driving and removal, the Navy used a practical spreading loss equation recommended for the California Department of Transportation for pile driving assessments, and empirically measured source levels from similar 24-inch steel pile driving events permitted through National Marine Fisheries Service. Predicted exposures are outlined in Section 6. Without consideration of the mitigation measured outlined for ELCAS in Section 11, the exposure calculations predicted no Level A or B harassment would occur associated with pile driving, no Level A harassment would occur associated with pile removal, and 348 level B harassment exposures per year would occur for pile driving and removal. Conservative assumptions (including marine mammal densities and other assumptions) used to estimate the exposures are likely to overestimate the potential number of exposures and their severity. In addition, application of mitigation measures implemented by the Navy for ELCAS training events are not considered in this exposure assessment

In conclusion, the Navy asserts that SSTC underwater detonations and ELCAS training events will have minimum impact to marine mammal individuals and stocks within the region due to low overall marine mammal presence as discussed in this application, relatively low explosive charge weights used for underwater detonation events, limited propagation of underwater blast and sound because of these low charge weights, and application of mitigation safety zones which would further limit marine mammal exposure.

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ACRONYMS AND ABBREVIATIONS

dB	Decibel
ELCAS	Elevated Causeway System
FR	Federal Register
kHz	Kilohertz
μPa	Micropascal
msec	Millisecond
NEW	Net Explosive Weight
nm	Nautical mile
NMFS	National Marine Fisheries Service
PETN	Pentaerythritol tetranitrate
psi	Pounds per Square Inch
PTS	Permanent Threshold Shift
REFMS	Reflection and Refraction in Multi-Layered Ocean/Ocean Bottoms with Shear Wave Effects
SEL	Sound Exposure Level (dB re 1μPa^2-sec)
SSTC	Silver Strand Training Complex
SSTC-NORTH	Silver Strand Training Complex- North
SSTC-SOUTH	Silver Strand Training Complex- South
SWAG	Shock Wave Action Generator
TNT	trinitrotoulene
TTS	Temporary Threshold Shift
VSW	Very Shallow Water
ZOI	Zone of Influence

1 DESCRIPTION OF ACTIVITIES

The Navy has been training and operating in the area now defined as the Silver Strand Training Complex (SSTC) for over 60 years. The land, air, and sea spaces of the SSTC have provided, and continue to provide, a safe and realistic training environment for naval forces charged with defense of the Nation. Section 1 describes the mission activities conducted within the (SSTC). Concurrent with the development of this Incidental Harassment Authorization application, a Draft Environmental Impact Statement for all Navy training events at the SSTC was completed. This application is based on the proposed events of the Navy's preferred alternative (Alternative 1 in the Draft Environmental Impact Statement). All training events from vessel and small craft movement, helicopter overflight, and other training events were analyzed in the Draft Environmental Impact Statement for potential impact to marine mammals. For this Incidental Harassment Authorization application, the U.S. Navy (Navy) determined that only underwater detonations and Elevated Causeway System (ELCAS) pile driving and pile removal training events at SSTC have the potential to rise to the level of harassment as defined under Marine Mammal Protection Act of 1972, as amended in 1994.

1.1 Overview of SSTC

The SSTC, described in **Table 1-1** and depicted in **Figure 1-1**, is located south of the City of Coronado, California and north of the City of Imperial Beach, California. It is composed of ocean and bay training lanes, adjacent beach training areas, ocean anchorages, and inland training areas. To facilitate range management and scheduling, SSTC is divided into numerous training sub-areas (**Figure 1-1**). In-water training sub-areas include: the ocean side of the SSTC divided into two non-contiguous areas, SSTC-NORTH (Boat Lanes 1-10) and SSTC-SOUTH (Boat Lanes 11-14); SSTC-NORTH also includes south San Diego Bay in-water training areas, designated Alpha through Hotel and the Lilly Ann Drop Zone.

1.2 Proposed Action

The Navy's mission is to maintain, train, and equip combat-ready naval forces capable of winning wars, deterring aggression, and maintaining freedom of the seas. Title 10, U.S. Code Section 5062 directs the Chief of Naval Operations to train all naval forces for combat. The Chief of Naval Operations meets that direction, in part, by conducting littoral training exercises and ensuring naval forces have access to ranges where they can develop and maintain skills for wartime missions. For purposes of this Incidental Harassment Authorization application, exercises and training include those conducted as part of the various training cycles at SSTC. The Navy is proposing the following at SSTC: continue current training, increase training tempo and types of training, conduct existing routine training at additional locations within SSTC established training areas, construct a demolition pit on inland training areas, and increase access availability of existing beach and inland training areas. For this Incidental Harassment Authorization application, the Navy determined that only underwater detonations and ELCAS pile driving and pile removal training events at SSTC have the potential to rise to the level of harassment as defined under Marine Mammal Protection Act of 1972, as amended in 1994, and are therefore considered in this application.

The Proposed Action would result in selectively focused but critical increases in training, and range enhancements to address training resource shortfalls, as necessary to ensure SSTC supports Navy and Marine Corps training and readiness objectives.

Table 1-1. Description of SSTC in-water training sub-areas.

Training Sub-Area	Description	How Sub-area Applies To This Application
South San Diego Bay In-water Training Areas	Bayside in-water training areas, designated "Alpha" through "Hotel". This area also includes the Lilly Ann Drop Zone.	Very small charge weight (0.03 lbs) underwater detonations in the open Bay waters on sub-area "Echo"; no marine mammal occurrence within this region
SSTC-NORTH Boat Lanes (1-10) and Beach Training Areas	Comprised of 10 ocean training lanes are each 500 yards wide stretching 4,000 yards seaward to form a 5,000-yard-long contiguous training area. Boat lanes are identified by color and number (Yellow 1 through Orange 2, see Figure 1-1). Each boat lane is 500 yards wide (or 1,000 yards per color).	Small charge weight (≤29 lbs) underwater detonations at various water depths between shore to 74 feet. ELCAS pile driving and removal training
Anchorages	These US Coast Guard designated anchorages are numbered 101 through 178 and are each 654 yards in diameter. Both commercial civilian ships and military ships used these anchorages as needed. The anchorages are grouped together in an area located primarily due west of SSTC-NORTH, east of Zuniga Jetty and the restricted areas on approach to the San Diego Bay entrance.	No training events deemed to rise to the level of harassment as defined under Marine Mammal Protection Act of 1972, as amended in 1994
SSTC- SOUTH Boat Lanes (11-14) and Beach Training Areas	There are four beach training areas as well as four contiguous boat lanes (11-14) at SSTC- SOUTH. The four ocean training lanes are each 500 yards wide stretching 4,000 yards seaward. Each boat lane (1,000 yards per color) follows the other boat lanes by stretching 2,000 yards north to south and are divided (for scheduling purposes) into White 1 and 2 and Purple 1 and 2. Each color section is 1,000 yards wide for a total of 2,000 yards.	Small charge weight (≤29 lbs) underwater detonations at various water depths between shore to 74 feet. ELCAS pile driving and removal training
Naval Air Station North Island Beach and Ocean littoral area	Naval Air Station North Island training area, now formally realigned as part of Naval Base Coronado, composed of the beaches and nearshore waters from Breaker's Beach to Zuniga Jetty, west of the City of Coronado. Southern nearshore areas of Naval Air Station North Island geographically separate from SSTC-NORTH and SSTC-SOUTH.	No training events deemed to rise to the level of harassment as defined under Marine Mammal Protection Act of 1972, as amended in 1994

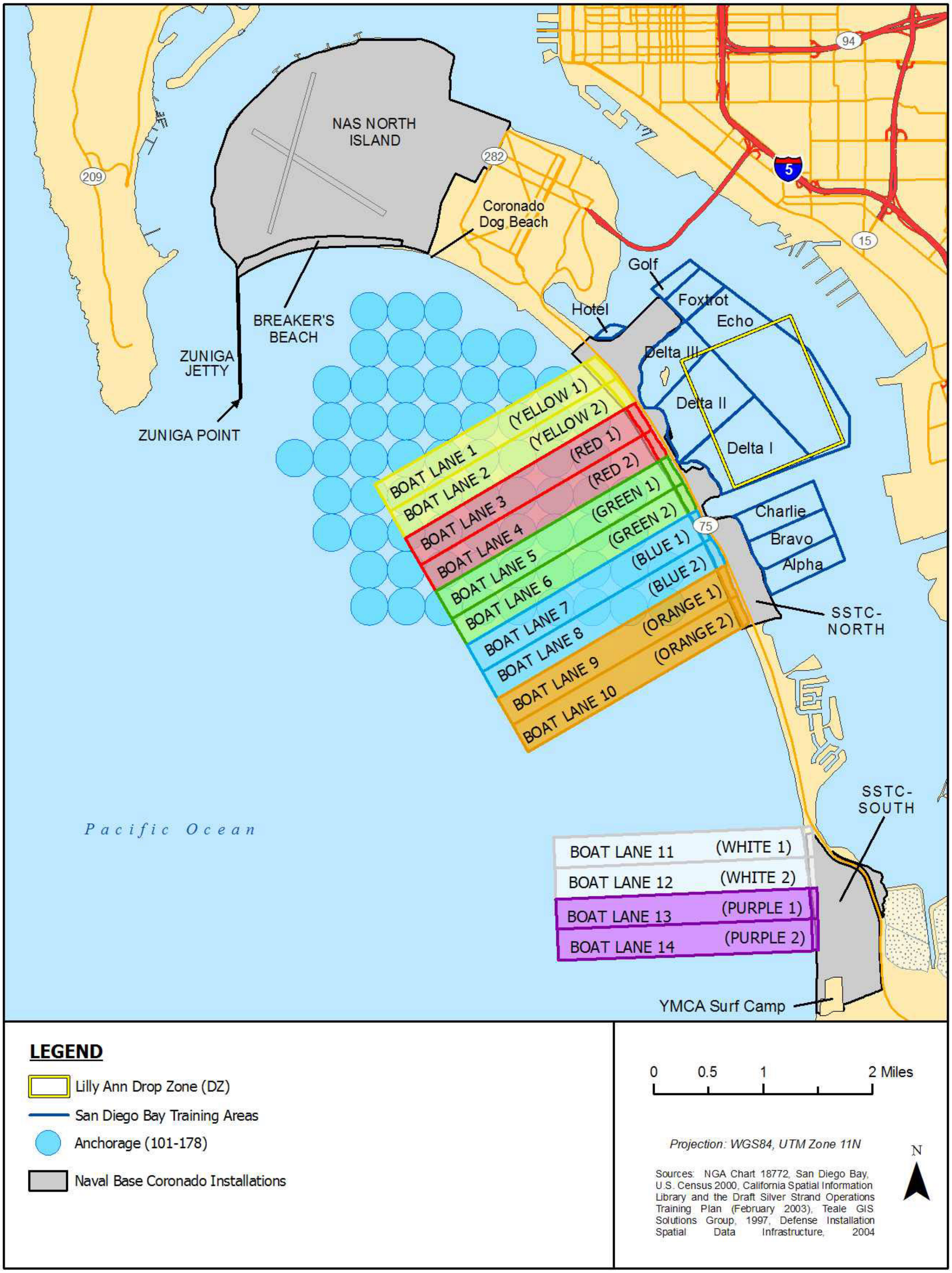

Figure 1-1. Silver Strand Training Complex

1.3 Description of Training

The Navy has conducted a review of its continuing and proposed training conducted at SSTC to determine whether there is a potential for harassment of marine mammals. The following discussion describes the underwater detonation training and pile driving conducted at SSTC. Other training events conducted at SSTC, which are not anticipated to rise to the level of harassment to marine mammals as defined under the Marine Mammal Protection Act, are more completely described in the SSTC Draft Environmental Impact Statement.

1.3.1 Underwater Detonations

Underwater detonations are conducted by Explosive Ordnance Disposal (EOD) units, Naval Special Warfare (NSW) units, MH-60S Mine Countermeasure helicopter squadrons, and Mobile Diving and Salvage units at the SSTC. The training provides Navy personnel with hands-on experience with the design, deployment, and detonation of underwater clearance devices of the general type and size that they are required to understand and utilize in combat. EOD groups conduct most of the underwater detonation training at SSTC as part of its training in the detection, avoidance, and neutralization of mines to protect Navy ships and submarines, and offensive mine laying in naval operations (**Figure 1-2**).

For safety reasons, underwater detonation training only occurs during daylight and can only be conducted in sea-states of up to Beaufort 3 (presence of large wavelets, crests beginning to break, presence of glassy foam, and/or perhaps scattered whitecaps).

Table 1-2 describes the types of underwater detonation training events conducted within the SSTC.

Figure 1-2. Representative U.S. Navy Explosive Ordnance Disposal in-water training.

Figure

Table 1-2. Detailed descriptions of SSTC underwater detonation training events.

TRAINING Event /duration	Description (Table 1-2 details total amount of annual underwater explosive use for SSTC. Below descriptions talk about % of training that may also include non-explosive training periods.)
Shock Wave Action Generator (SWAG) 1 day	SWAG is a tool used by Explosive Ordnance Disposal (EOD) to disarm enemy limpet mines which have been attached to the hull of a ship. The SWAG is composed of a cylindrical steel tube, 3 inches long and 1 inch wide, containing approximately 0.033 lbs of explosives. The single explosive charge is highly focused. For SWAG training, a metal sheet containing an inert mine is lowered from the side of a small vessel, or small boat. Divers place a single SWAG on the mine that is located mid-water column, within water depths of 10-20 feet. A bag is placed over the mine to catch falling debris.
Mine Counter Measure 1 day	Events are performed from a small craft to locate and identify suspected ordnance either at mid-column or on the sea floor at a water depth of ≤ 72 feet. A detachment dives to locate the suspected ordnance. Once located, a single explosive charge (10-20 lbs NEW) is placed next to the ordnance to neutralize it. The neutralized mine is then raised, towed to shore, and beached.
Floating Mine 1 day	Personnel are inserted into the ocean via helicopter or 24-foot vessel, swim to the floating mine in water depths of less than 72 feet, and place a single explosive countercharge (less than 5 lbs NEW) on the mine. The team retreats a safe distance prior to command detonation of a single countercharge.
Dive Platoon 1 day	Divers are inserted into the ocean via helicopter or 24-foot vessel, dive to depths of 30-72 feet and detonate sequential charges on an inert mine shape placed on the bottom with 3.5 lbs NEW.
Very Shallow Water Mine Counter Measure 1 day	Locating, identifying, and neutralizing mines (placing explosives on mines for the purposes of destroying them) placed either mid-column or on the sea floor at a water depth of ≤ 24 feet (10-20 lbs NEW). Use of explosives will occur during approximately 60 % of training events and will ONLY occur in the SSTC oceanside Boat Lanes. All in-Bay training (40%) will not use any explosives. Personnel are transported to a location in one to two RHIBs and place transponders into the water. The transponders hover over the bottom to provide divers with shallow-water navigation instruction.
Unmanned Underwater Vehicle (UUV) 1 day	Training on use of UUVs. One to two RHIBs are used to transport personnel to a site. Two transponders are placed in the water, with an UUV between them. UUVs explore the area, photograph, and collect hydrographic information. After analysis is complete, appropriate Navy marine mammals are dispatched to localize and mark potential objects, followed by divers who clear the area of identified hazards. Approximately 3% of events involve placing a single 10-15 lbs NEW charge in water depths from 10 to 72 feet on the oceanside of SSTC-NORTH (on the bottom or up to 20 feet from the surface) to neutralize a simulated mine. Use and detonation of explosives will only occur in the SSTC oceanside Boat Lanes 1-14. Bayside UUV use in the Bay will be for operator training and not contain explosives.
MK8 Marine Mammal / Marine Mammal Systems (MMS) 1 day	Navy divers work with the help of the Navy's trained marine mammals to detect underwater objects. Approximately 10% of training involves the setting of a 13- or 29 lbs NEW charge to detonate the objects. Sequential detonations operate at water depths of 10 to 72 feet and are bottom laid. Single charges are laid within water depths of 24 to 72 feet, 20 feet from the surface or below. Use of explosives will only occur in the SSTC oceanside Boat Lanes 1-14.
Mine Neutralization 1 day	Personnel are inserted via helicopter or vessel for underwater demolition training. Training consists of eight sequential charges placed on the sea floor using 3.5 lbs NEW explosive charges on various inert mine shapes in water depths of 30 to 72 feet to maintain qualifications.
Surf Zone Test Detachment/ Equipment T&E 1 day	To support clearance capability in the surf zone (out to 10 feet of water), EOD would test and evaluate the effectiveness of new detection and neutralization equipment (i.e., generally explosive counter-techniques to safely disarm/render safe mines) in surf conditions. Use of explosives will occur during 1% of training events (0.1 to 20 lbs NEW) and will only occur in the SSTC oceanside Boat Lanes 1-14.

TRAINING Event /duration	Description (Table 1-2 details total amount of annual underwater explosive use for SSTC. Below descriptions talk about % of training that may also include non-explosive training periods.)
Unmanned Underwater Vehicle Neutralization 1 day	Training consists of placing 2 sequential charges consisting of a Seafox (3.3 lbs) or Archerfish (3.57 lbs) charge placed from depths of 10 feet to the bottom in water depth less than 72 feet.
Airborne Mine Neutralization System (AMNS) 1 day	The training would involve an MH-60S helicopter deploying an AMNS underwater vehicle into the water that searches for, locates, and destroys mines. The vehicle is self-propelled and unmanned. Approximately 20% of the training would involve the AMNS being remotely detonated (3.5 lbs NEW) when it encounters a simulated (inert) mine shape.
Naval Special Warfare Underwater Demolition Qualification/ Certification 1 day	Demolition Requalifications and Training provides teams with experience in underwater detonations by conducting detonations on metal plates near the shoreline. At water depths of 10 to 72 feet two sequential 12.5-13.75 lbs NEW charges are placed on the bottom or a single 25.5 lbs charge is placed from a depth of 20 feet to the bottom.
Naval Special Warfare Underwater Demolition Training 1 day	Up to 40 persons participate in the activity, which involves small groups swimming to shore from four inflatable boats located approximately 1,000 yards offshore; boats may be beached on shore. A single charge of less than 10 lbs NEW (if detonated on the bottom) or less than 3.6 lbs NEW (if within five feet of the surface) is manually detonated near the shoreline in water less than 24 feet deep.
SEAL Delivery Vehicle /Advanced SEAL Delivery System Certification to Deploy 14 day	Designed to certify SDV Team operators for deployment, events include direct action, reconnaissance, and/or counter-terrorism events. Training may include navigation runs into and out of the San Diego Bay, hydrographic reconnaissance, over the beach (OBT) training, combat swimmer, and underwater detonation training. Based on training tempo, multiple events could occur. Underwater detonation events involve a single timed charge of 10 lbs or less NEW in water depths of 24 feet or less placed from mid-water column to the seafloor that may be conducted in coordination with other training events. Use of explosives will only occur in the SSTC oceanside Boat Lanes 1-10. The whole Certification process is a 14 day evolution, although explosive would not be used every day.

Navy Explosive Ordnance personnel deploying an unmanned underwater vehicle (UUV) from an 11-m jet-water propulsion Rigid Hull Inflatable Boat (RHIB)

1.3.2 ELCAS Training

Elevated Causeway System (ELCAS) is a modular pre-fabricated causeway pier (**Figure 1-2**). ELCAS provides a link between offshore amphibious supply ships with associated lighterage (i.e., small cargo boats and barges) and the shore by bridging the surf zone. Offloaded vehicles and supplies can be driven on the causeway to and from shore.

In relation to this application, installation and removal of ELCAS support piles were deemed by the Navy to most likely have the potential to harass marine mammals.

During ELCAS training events, 24-inch wide hollow steel piles are driven into the sand in the surf zone with an impact hammer (**Figure 1-3**). Approximately 101 piles are driven into the beach and surf zone with a diesel impact hammer over the course of approximately 10 days, 24-hours a day (i.e., during the day and night). Each pile takes an average of 10 minutes to install, with around 250 to 300 impacts per pile. Pile driving includes a semi-soft start as part of the normal operating procedure based on the design of the drive equipment. The pile driver increases impact strength as resistance goes up. At first, the pile driver piston drops a few inches. As resistance goes up, the pile driver piston will drop from a higher distance thus providing more impact due to gravity. The pile driver can take 5 to 7 minutes to reach full impact strength. As sections of piles are installed, causeway platforms are then hoisted and secured onto the piles with hydraulic jacks and cranes (**Figure 1-3**). At the conclusion of training, the ELCAS piles are removed with a vibratory extractor. Removal takes approximately 15 minutes per pile over a period of around 3 days. ELCAS training can occur along both the ocean side (SSTC-North boat and beach lanes) and with the designated training lane within Bravo beach on the bayside of SSTC (Figure 1-1). Up to four ELCAS training\installation events per year are proposed.

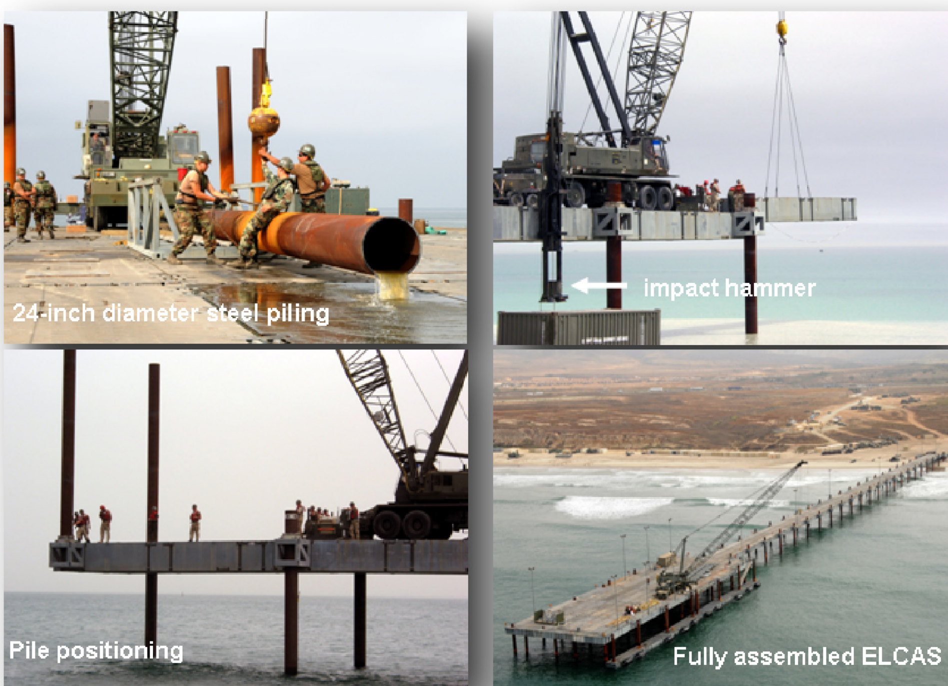

Figure 1-3. ELCAS construction stages.

1.3.3 Other Training

In addition to underwater detonations and ELCAS, the Navy performs a variety of other shallow water and amphibious training at SSTC. This training includes amphibious vessel and vehicle maneuvering, beach landings, causeway (floating pier) insertions onto the beach, swimming, land demolitions, transfer of fluids from vessel to the shore through a flexible conduit (seawater is used as the fluid during training), and helicopter overflight events,. The Navy is in the process of developing an environmental impact statement for the training it currently conducts and proposes to conduct at SSTC (DoN 2010b).

The SSTC Draft Environmental Impact Statement released in January 2010 addressed the potential of training-specific impacts for each of approximately 80 SSTC training events.

This Incidental Harassment Authorization application is based on the proposed events of the Navy's preferred alternative [Alternative 1 in the SSTC Draft Environmental Impact Statement DoN 2010b)].

Potential impacts to marine mammals were analyzed from other training events including helicopter overflights, and marine boat and vessel movement within the SSTC Environmental Impact Statement (Section 3.9 in the SSTC Draft Environmental Impact Statement).

In its final assessment, the Navy concluded for the SSTC Draft Environmental Impact Statement and this Incidental Harassment Authorization application, that underwater detonations and ELCAS training are the only Navy training events at SSTC to rise to the level of harassment as defined under the Marine Mammal Protection Act.

However, in consideration of these issues for this Incidental Harassment Authorization application, the SSTC Draft Environmental Impact Statement is extracted and included below.

Helicopter Use within the SSTC

Various types of helicopters are regularly used in training exercises throughout the SSTC. These aircraft overflights produce airborne noise and some of this energy is transmitted into the water. Marine mammals could be exposed to noise associated with aircraft overflights while at the surface or while submerged. In addition to sound, marine mammals could react to the shadow of a low-flying aircraft and/or, in the case of helicopters, surface disturbance from the downdraft. However, as discussed below, the Navy asserts that such disturbance would not quantify as harassment under the Marine Mammal Protection Act.

Transmission of sound from a moving airborne source to a receptor underwater is influenced by numerous factors and has been addressed by Urick (1972), Young (1973), Eller and Cavanagh (2000), Laney and Cavanagh (2000), and others.

Sound is transmitted from an airborne source to a receptor underwater by four principal means:

1. Direct path, refracted upon passing through the air-water interface.
2. Direct-refracted paths reflected from the bottom in shallow water.
3. Lateral (evanescent) transmission through the interface from airborne sound directly above.
4. Scattering from interface roughness due to wave motion.

Aircraft sound is refracted upon transmission into water because sound waves move faster through water than through air (a ratio of about 0.23:1). Based on this difference, the direct sound path is totally reflected if the sound reaches the surface at an angle more than 13 degrees from vertical. As a result, most of the acoustic energy transmitted into the water from an aircraft arrives through a relatively narrow cone with a 26-degree apex angle extending vertically downward from the aircraft (**Figure 1-4**).

The intersection of this cone with the surface traces a “footprint” directly beneath the flight path, with the width of the footprint being a function of aircraft altitude.

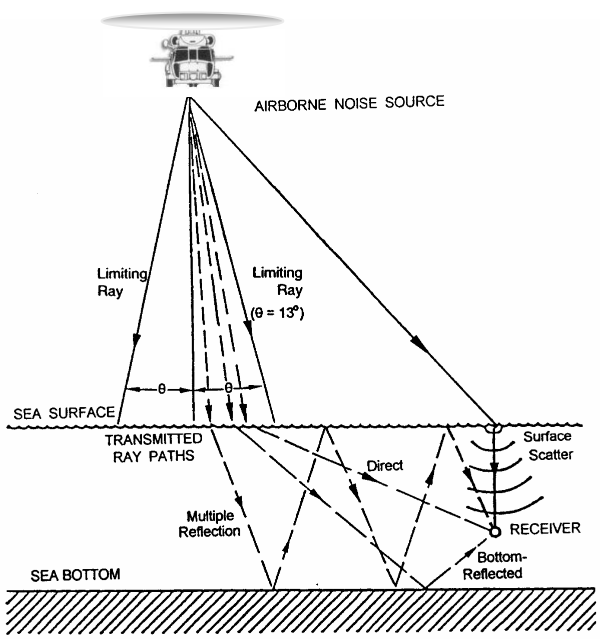

Figure 1-4. Characteristics of airborne sound transmission through air-water interface.

Helicopter overflights can occur throughout SSTC for a variety of training, such as mine countermeasure events, amphibious events, and Naval Special Warfare events.

Unlike fixed-wing aircraft, helicopter training events can occur at low altitudes (approximately 100 feet) over the water. Very little data are available regarding reactions of cetaceans to helicopters. One study observed that sperm whales showed no reaction to a helicopter until the whales encountered the downdrafts from the propellers (Clarke 1956). Other species such as bowhead whales and beluga whales show a range of reactions to helicopter overflights, including diving, breaching, change in direction or behavior, and alteration of breathing patterns, with belugas exhibiting behavioral reactions more frequently than bowheads (38 and 14 percent of the time, respectively) (Patenaude et al. 2002). These reactions were less frequent as the altitude of the helicopter increased to 150 yards or higher. Helicopter events would have the greatest impact when flying low and hovering at altitudes down to 100 feet. Noise modeling indicates that the predicted sound level at a depth of 1 foot resulting from the overflight of a SH-60 helicopter at 100 feet would be approximately 100 to 118 dB re 1 µPa (with frequencies of 20 Hz and 5 kHz).

Noise transmitted via the air-sea interface (Figure 1-4), could potentially could cause some marine mammals to dive or move away from the helicopter, although as stated below, the Navy believes this would be limited in relation to the SSTC. For example, gray whales reacted 10 percent of the time to helicopter sounds transmitted underwater in excess of 115 dB re 1 µPa and reacted 50 percent of the time to sounds in excess of 120 dB re 1 µPa (Moore and Clarke 2002). However, given the variable and sparse seasonal density of gray whales within the SSTC ocean area, the probability of a helicopter overflight occurring over a migrating whale is low. In addition, a significant amount of helicopter use at SSTC occurs over south San Diego Bay where there are no marine mammal occurrences. Aircraft overflights over a cetacean (gray whale, bottlenose dolphin) in the water may or may not elicit short-term reactions such as a dive from a transitory animal, but such limited and low noise as compared to typical whale watching boats in the region, are highly unlikely to disrupt overall behavioral patterns such as migrating, feeding, or transit, nor would helicopter overflight be likely to result in harassment or serious injury.

Two pinniped species are likely to occur within the SSTC, California sea lion (the most common) and Pacific harbor seal (see Sections 3 and 4). Helicopters are often used in studies of several species of seals hauled out and is considered an effective means of observation (Gjertz and Børset 1992, Bester et al. 2002, Bowen et al. 2006), although they have been known to elicit behavioral reactions such as fleeing (Hoover 1988). Jehl and Cooper (1980) indicated that low-flying helicopters, humans on foot, sonic booms, and loud boat noises were the most disturbing influences to pinnipeds, however, in other studies, harbor and other species of seals and sea lions showed no reaction to helicopter overflights (Gjertz and Børset 1992). In addition, there are no known haul-out locations for these two pinniped species within the SSTC. Thus, the likelihood of a harbor seal or California sea lion being hauled out and underneath the flight path of helicopter engaged in SSTC training events is extremely low. Finally, pinnipeds within the greater San Diego region may have become quite acclimated to both vessel transits and frequent aircraft overflights. This can be observed in the frequent haul-out activity of California sea lions on north San Diego Bay floating piers and buoys adjacent to busy shipping lanes and under civilian and military flight paths not associated with SSTC training events (See Figures 4-1 and 4-2 in Section 4).

Therefore, disturbance associated with helicopter overflight at the SSTC is not expected to result in Level A or Level B harassment as defined by the MMPA. Helicopter use in the SSTC would have no notable effect on marine mammals, and would be highly unlikely to disrupt overall behavior patterns such as migrating, breeding, feeding and sheltering.

Marine vessels and boats use within the SSTC

A variety of vessels including standard and amphibious ships, small boats, and hovercraft (collectively referred to as vessels) will be used for SSTC events. Vessel movements have the potential to affect marine mammals by directly striking or disturbing individual animals. The probability of vessel and marine mammal interactions occurring in the SSTC is dependent upon several factors including numbers, types, and speeds of vessels; the regularity, duration, and spatial extent of events; the presence/absence and density of marine mammals; and protective measures implemented by the Navy. Events involving vessel movements occur intermittently and are variable in duration, ranging from a few hours up to two weeks. The vast majority of SSTC training events use less than five marine vessels or boats, both mechanically driven (i.e., powered) and self-propelled (i.e., human rowed). These events are widely dispersed throughout the marine areas of SSTC, which encompasses approximately 15 square nautical miles. Consequently, as these training events are spread throughout the year, as well as on any particular day, the density of ships and small boats the SSTC at any given time is extremely low.

Marine mammals are frequently exposed to vessels due to research, ecotourism, commercial and private fishing traffic, and government activities. The presence of vessels has the potential to alter the behavior patterns of marine mammals. It is difficult to differentiate between responses to vessel sound and visual cues associated with the presence of a vessel; thus, it is assumed that both play a role in prompting reactions from animals. Marine vessels are one of the most frequent sources of sound in the marine environment within SSTC, and within the busy commercial and recreation port of San Diego. Vessel noise is caused by both engine noise transmission through the hull and cavitations from propellers producing both narrow and broadband sounds (Richardson et al. 1995).

Marine mammals react to vessels in a variety of ways (Watkins 1986, Würsig et al. 1998, Terhune and Verboom, 1999, David 2002, Ritter 2002, Lusseau 2003, Bejder et al. 2006, Courbia and Timmel 2008, Hawkins and Gartside 2009, Jensen et al 2009, Tosi and Ferreira 2009). Some respond negatively by retreating or engaging in antagonistic responses (breaching, fluke-slapping, etc.) while other animals ignore the stimulus altogether (Watkins 1986, Terhune and Verboom, 1999). The predominant reaction is either neutral or avoidance behavior, rather than attraction behavior. For example, species of delphinids can vary widely in their reaction to vessels. Many exhibit mostly neutral behavior, but there are frequent instances of observed avoidance behaviors (Hewitt 1985, Würsig et al. 1998). In addition, approaches by vessels can elicit changes in behavior, including a decrease in resting behavior or change in travel direction (Bejder et al. 2006). Alternately, some of the delphinid species exhibit behavior indicating attraction to vessels. This can include approaching a vessel (David 2002), and species such as common, rough-toothed and bottlenose dolphins are frequently observed bow riding or jumping in the wake of a vessel (Norris and Prescott 1961, Shane et al. 1986, Würsig et al. 1998, Ritter 2002). These behavioral alterations are short-term and would not result in lasting effects.

Marine vessel traffic related to the SSTC training events would pass near marine mammals only on an incidental basis. Most of the studies mentioned previously examine the reaction of animals to vessels that approach and intend to follow or observe an animal (i.e., whale watching vessels, research vessels, etc.). Reactions to vessels not pursuing the animals, such as those transiting through an area or engaged in training exercises, may be similar but would likely result in less stress to the animal because they would not intentionally approach animals. Large cetacean species generally may pay little attention to transiting vessel traffic as it approaches, although they may engage in last minute avoidance maneuvers especially from larger vessels (Laist et al.

2001). Vessel and small boat movements at the SSTC are not expected to result in additional stress or harassment because, as discussed above, Navy vessel density in the SSTC would remain low. In addition, it is standard Navy practice to employ increased watchstanders on larger vessels as a safety of navigation and marine mammal avoidance protocol. Smaller boats would be expected to avoid marine mammals while in transit except in cases of restricted maneuvering.

There have been no reports of Navy ship strikes to marine mammals within the SSTC area, and small dolphins and pinnipeds, the most likely year round marine mammals within the SSTC, are extremely agile at-sea and likely to either close or avoid ships and boats rather easily. In the event of an admittedly rare case of a large whale ship strike within the SSTC or San Diego Bay, marine mammal ship strikes reporting protocols are already part of existing Navy and NMFS communication procedures within California.

Therefore, disturbance associated with Navy vessel movements at the SSTC is not expected to result in Level A or Level B harassment as defined by the MMPA. Vessel and small boat transits in the SSTC would have no notable effect on marine mammals, and would be highly unlikely to disrupt overall behavior patterns such as migrating, breeding, feeding and sheltering.

Examples of Navy vessel use within the SSTC (small rubber craft, lighterage, and landing craft utilities (LCU) analyzed for in the SSTC Environmental Impact Statement and no considered to result in harassment to marine mammals.

2 DURATION AND LOCATION OF ACTIVITIES

Training events would be conducted at the Silver Strand Training Complex (SSTC) along the appropriate Fleet Response (training) timeline. The location of SSTC is described in Section 1.1.

Nearshore Ocean Environment

The surfside training lanes of SSTC are located in the Silver Strand Littoral Cell, which is an exposed, open subtidal area of the Pacific Ocean extending from south of the international boarder to the Zuniga Jetty at the San Diego Bay for over 17 miles of coastal reach. The Silver Strand Littoral Cell is a coastal eddy system that dominates local ocean movement and generally moves from south to north with periodic reversals. The Silver Strand Littoral Cell causes alternating beach erosion and accretion along the beach front at the SSTC (Hapke et al. 2006). Seasonal fluctuations in wave patterns and currents cause substantial changes in water quality, especially turbidity, in shallow waters. Turbidity may result from natural causes, such as plankton concentrations, as well as from waves, stream discharge, or human actions such as dredging. Nearshore water visibility typically ranges between 5 and 20 feet; however, underwater visibility may be significantly reduced in the surf zone along SSTC due to sediment disturbance from wave action and rip currents (SANDAG 2000).

Surface water temperatures generally are highest from June through September and lowest from November through February. Historical temperatures in the study area range from 52 to 74 °F near the surface and from 49 to 61 °F near the bottom. Water temperatures near the beach tend to be more uniform throughout the water column due to turbulent mixing and shallower depths (SANDAG 2000).

The bathymetry off the surfside training lanes is relatively evenly sloped (shown in 2-meter intervals in Figure 2-1), with a predominantly soft sandy bottom mixed with minor amounts of mud, hard-shale bedrock and small cobble-boulder fields (**Figure 2-1**). It extends from zero to 72 feet over 4,000 yards seaward from the beach, and does not have underwater canyons or significant upwelling conditions. Flora and fauna in the region of the SSTC is dominated by coastal surf zone and some coastal pelagic zone species (Allen et al. 2006).

San Diego Bay

The bayside training lanes of SSTC are located in the San Diego Bay, a naturally-formed, crescent-shaped embayment located along the southern end of the Southern California Bight (SCB) (Largier 1995, DoN and SDUPD 2000). The Bay provides habitat for a number of oceanic and estuarine species as the ebb and flood of tides within the Bay circulate and mix ocean and Bay waters, creating distinct circulation zones within San Diego Bay (Largier et al. 1995, DoN and SDUPD 2000). The San Diego Bay's depth ranges from 59 feet near the mouth to less than 3 feet at the south end. It has an average depth of 21 feet measured from mean sea level. There has always been a narrow, natural channel deepening at the mouth, possibly cut by river floods at a time when sea level was much lower (Peeling 1974). **Figure 2-1** shows the most recently surveyed bathymetry of the bay floor.

Ambient Noise

More detailed discussions on ambient ocean noise are provided in Richardson et al. 1995, Deane 1997, 2000, NRC 2003, Hildebrand 2005, and Hildebrand 2009, which list specific case studies highlighting the sources and frequency content of natural and anthropogenic ocean noise sources. Many of these sources are applicable and contribute to ambient noise within the SSTC. Surf noise, biological noise, large vessel and small boat traffic, and aircraft overflights are likely to be the most dominant ambient noise sources within SSTC (Richardson et al. 1995, Deane 1997, Deane 2000, Hildebrand 2009).

Wenz (1962) provided a generalized portrait of ocean noise used to predict, model, and understand the noise level from unidentifiable sources. These curves provide a noise spectrum level (units are dB re 1μPa²/Hz) that an idealized receiver with omni-directional reception capabilities may experience at a particular moment depending on location. Although ambient noise is always present, the individual sources that contribute to it do not necessarily create sound continuously. For example, rain is periodic, and wind speeds change with weather patterns. Seasonal trends are likely related to changes in average wind speeds with season (McDonald et al. 2006). Given the near shore distribution of the training areas within the SSTC, surf zone noise (breaking waves, etc.) is likely to be a constant ambient noise source. In the northern hemisphere, ambient noise in deep water can be dominated by shipping, particularly at frequencies between 5 and 500 Hz (Richardson et al. 1995, NRC 2003, Hildebrand 2009). By most estimates, there has been an increase of underwater noise associated with increased commercial shipping traffic, especially in areas near major ports. Several studies have documented an approximate equivalent 3 dB per decade increase in ocean noise attributed to commercial shipping (Hildebrand 2005, McDonald et al. 2006, Hildebrand 2009). In terms of logarithmic scaling used in sound measurements, this 3 dB increase is equivalent to a doubling of noise energy levels every 10 years over the last few decades.

Distant and localized shipping traffic approaching San Diego Bay can contribute to the general acoustic environment over a wide frequency range and large geographic area. It should be noted, however, that shallow water noise levels from shipping traffic are highly variable primarily because of differences in local acoustic propagation and seafloor absorption characteristics in shallow water vice deep water (MacDonald et al. 2009). While the distribution and timing of shipping traffic is not uniform, this type of ambient ocean noise is prevalent in and around major ports including San Diego (Heitmeyer et al. 2004).

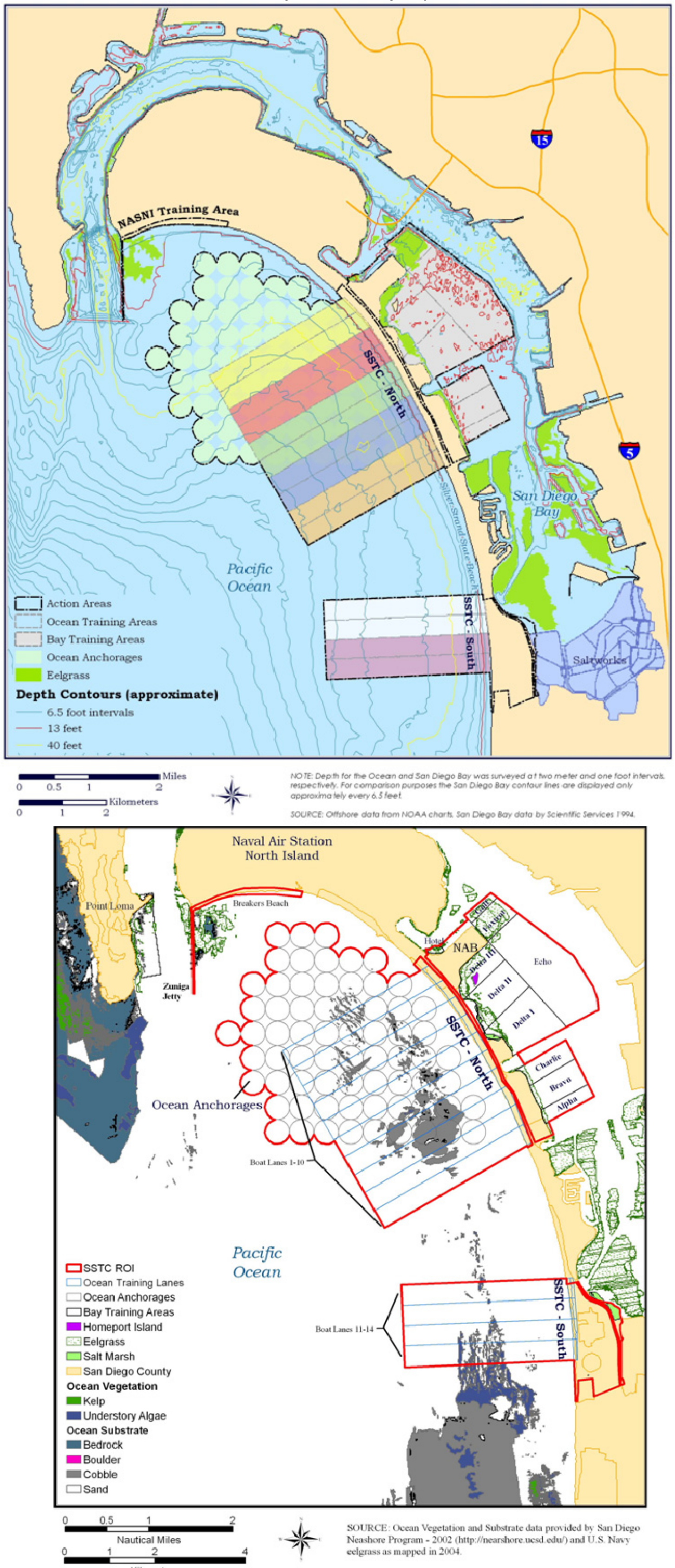

Figure 2-1. Bathymetry (top panel) and substrate (bottom panel) within the SSTC.

Duration and Annual Amount of SSTC Underwater detonations

Table 2-1 shows the underwater detonation training event types described in section 1 along with the net equivalent weight (NEW) for the charges involved, water depth, and number of events per year. NEW is a conversion that allows the comparison of different mixes of explosive formulas. Since different explosive formulas may have different explosive potentials, explosive potentials are often normalized and expressed as compared to the equivalent explosive potential of TNT (trinitrotoluene). TNT is no longer commonly used as a military explosive, but still serves as the base reference for NEW.

While explosive NEW shown in **Table 2-1** range from 0.03 lbs to 29 lbs, it should be noted that approximately 78% of the annual underwater detonation training events at the SSTC would use explosive weights less than 10 lbs (**Figure 2-2**).

Table 2-1. SSTC annual underwater explosive events.

#	Underwater Detonation Training Event Type	NEW (lbs)	# of Sequential Detonations * (#/det)	Water Depth (feet)	Charge Depth	# of Training Events /yr	SSTC Location
N1	Shock wave action generator (SWAG)	0.033	1/det	10–20	Mid-water	74	South San Diego Bay (sub-area "Echo" only)
N1	SWAG	0.033	1/det	10–20	Mid-water	16	Oceanside Boat Lanes 1-10,11-14
5	Mine Counter Measure	10 to 20	1/det	≤ 72	Mid-water	29	Oceanside Boat Lanes 1-10,11-14
5	Mine Counter Measure	10 to 20	1/det	≤ 72	Bottom	29	Oceanside Boat Lanes 1-10,11-14
6	Floating Mine	≤ 5	1/det	≤ 72	Surface (< 5 feet)	53	Oceanside Boat Lanes 1-10,11-14
7	Dive Platoon*	3.5	8/det	30–72	Bottom	8	Oceanside Boat Lanes 1-10,11-14
9	Very Shallow Water Mine Counter Measure	0.1 to 20	1/det	≤ 24	Bottom	60	Oceanside Boat Lanes 1-10,11-14
10	Unmanned Underwater Vehicle	10 to 15	1/det	10 ≤ 72	Bottom to 10 feet from surface	4	Oceanside Boat Lanes 1-10,11-14
11	Marine Mammal System	13 & 29	2/det	10 ≤ 72	Bottom	8	Oceanside Boat Lanes 1-10,11-14
11	Marine Mammal System Operator Course	13 & 29	1/det	24 ≤ 72	Bottom to 20 feet from surface	8	Oceanside Boat Lanes 1-10,11-14
12	Mine Neutralization*	3.5	8/det	30–72	Bottom	4	Oceanside Boat Lanes 1-10,11-14
N2	Surf Zone testing and evaluation	to 20	1/det	≤ 24	Bottom	2	Oceanside Boat Lanes 1-10,11-14
N3	Unmanned Underwater Vehicle Neutralization	3.3 & 3.57	2/det	10–72	Bottom to 10 feet from surface	4	Oceanside Boat Lanes 1-10,11-14
N7	Airborne Mine Neutralization System	3.53	1/det	40–72	Mid-water to Bottom	10	Oceanside Boat Lanes 1-10,11-14
N9	Qualification/ Certification	12.5 to 13.75	2/det	10–72	Bottom	8	Oceanside Boat Lanes 1-10,11-14
N9	Qualification/ Certification	25.5	1/det	40–72	Bottom to 20 feet from surface	4	Oceanside Boat Lanes 1-10,11-14
N11	Naval Special Warfare Demolition Training	≤ 10	1/det	≤ 24	Bottom	4	Oceanside Boat Lanes 1-10,11-14
N11	Naval Special Warfare Demolition Training	≤ 3.6	1/det	≤ 24	Surface	8	Oceanside Boat Lanes 1-10,11-14
37	SEAL Delivery Vehicle\ Advance SEAL Delivery Vehicle	≤ 10	1/det	≤ 24	Bottom to Mid-water	40	Oceanside Boat Lanes 1-10,11-14

* # of training events is the total amount of underwater detonation training involving each particular Training Event Type. Most Training events are a single detonation (i.e., 1/detonation) per event. However, four of these Training Event Types (highlighted above) involve sequential charges during the same training event. Sequential charges are either conducted with a 10 second delay between detonations or 30 minute delay between detonations.

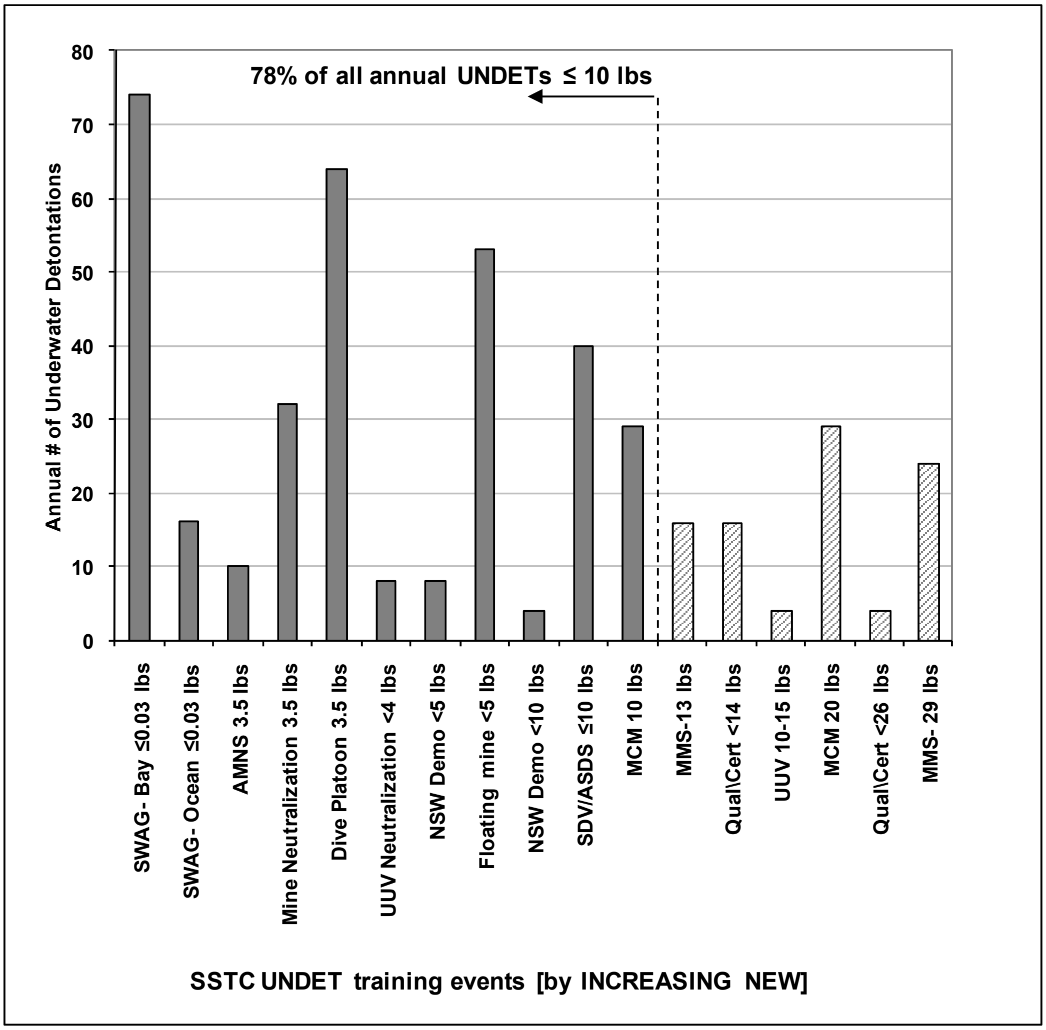

Figure 2-2. SSTC underwater detonations listed by increasing charge weight.

3 MARINE MAMMAL SPECIES AND NUMBERS

Four marine mammal species may inhabit or regularly transit the Silver Strand Training Complex (SSTC). These include the California sea lion, Pacific harbor seal, bottlenose dolphin, and gray whale. **Table 3-1** summarizes the population status and abundance of each of these species, while Section 4 contains detailed life history information.

Extensive natural history information for marine mammal species occurring within Southern California waters has been summarized in previous works (Leatherwood et al. 1982, 1988, Reeves et al. 2002, Barlow and Forney 2007, Carretta et al. 2010). Approximately 41 marine mammal species or stocks are known to occur within southern California waters based on National Marine Fisheries Service (NMFS) Stock Assessment Reports (Carretta et al. 2010). Of these, only three year-round species and one migratory species are expected to be found within the ocean side areas of SSTC. These include the California sea lion (*Zalophus californianus*), Pacific harbor seal (*Phoca vitulina richardii*), bottlenose dolphin (*Tursiops truncatus*), and gray whale (*Eschrichtius robustus*). Both anecdotal accounts and recent Navy funded surveys confirm that there is extremely limited to no marine mammal presence in the San Diego Bay in and adjacent to the bay side of SSTC (USFWS 2006, Merkel & Associates Inc. 2008).

The United States stock of California sea lion and the California stock of Pacific harbor seal can be commonly seen at haul out sites on the mainland, and on buoys and docks within California harbors including San Diego harbor. Both California sea lions and harbor seals do not typically haul-out at the same location at the same time. Within and adjacent to San Diego Bay, California sea lions are the dominant and most numerous pinniped observed. Breeding sites for California sea lion are on islands off the coast of California. Harbor seal breeding sites include the offshore California islands and some mainland sites. The nearest harbor seal breeding site to the SSTC is at La Jolla, CA, approximately 10 nm north of SSTC. While harbor seals are widely distributed from Baja California to Alaska, the stock addressed in this Incidental Harassment Authorization application are assumed to be part of the California stock as assessed by NMFS. In general, the bulk of the harbor seal population occurs north of Southern California (Carretta et al. 2010). California sea lions are also widely distributed from British Columbia to Mexico. While the majority of breeding occurs in California, at sea distribution of California sea lions is somewhat sexually-segregated and varies by season. Males occur north of California during the fall and winter whereas females tend to stay farther south year-round. For both California sea lions and harbor seals, while there are some haul-out areas within San Diego Bay north of SSTC (on piers, buoys, etc.), there are no haul out sites, or rookeries within or adjacent to the SSTC. The California Coastal stock of the Pacific bottlenose dolphin regularly inhabits the nearshore waters of Southern California. This species regularly moves along the California coast and may transit the SSTC area since they generally remain close to shore (within 0.5 nm or 1 km). The Eastern Pacific stock of gray whale occurs off Southern California during their annual migration between summer feeding areas in the Bering and southern Chukchi seas and winter calving areas in Baja California and mainland Mexico. While gray whales may occasionally be found within a kilometer of shore during both their southward and northward migration periods, they are generally found farther offshore than the near shore at SSTC (NMFS, J. Barlow). As such, gray whales would be infrequent transients through or seaward of the outer section of the SSTC.

Table 3-1 provides marine mammal abundance estimates used to analyze effects of SSTC training events. Density is reported for an area, e.g., individuals/km^2. Cetacean density estimates were derived from a combination of the National Marine Fisheries Service (NMFS) 1986-2005 shipboard surveys performed in Southern California south of Point Conception and 1998-1999 aerial survey of San Clemente Island Range (DoN 2008). The density estimate for the gray whale during the cold season was provided by the NMFS Southwest Fisheries Science Center (SWFSC), (NMFS, J. Barlow). The coastal stock of bottlenose dolphins density estimate represents maximum encounter rate derived for the shoreline area adjacent to SSTC based on SWFSC bottlenose dolphin aerial surveys from 1990-2000 (NCCOS 2005). It should be noted that use of Southern California population estimates to quantify densities of marine mammals at the near-shore SSTC environment may over-estimate the density of marine mammals present during training events. Therefore, the predicted exposures discussed in Section 6 also may reflect a proportionate over-estimation. Analyses of survey results using distance sampling techniques include correction factors for marine mammals at the surface but not seen, as well as marine mammals below the surface and not seen. Temporal Variation: Densities are presented for warm (May through October) and cold seasons (November through April) periods based on average oceanographic seasonality within Southern California. Increases or decreases in marine mammal density estimates may reflect seasonal patterns of movement to or from the area, depending on the species. Gray whale densities are only applicable during the cold season when the majority of the whales' migration passes SSTC. The "zero" density estimate for the gray whale during the warm season indicates that this species utilizes coastal waters of the SSTC only during seasonal migrations in the cold season. This artifact carries through later tables that display calculated exposures for the gray whale.

Spatial Distribution- Density assumes that marine mammals are uniformly distributed within a given area, although this is rarely the case. Marine mammals are usually clumped in areas of greater importance, for example, areas of high productivity, lower predation, safe calving, foraging, etc. Density can occasionally be calculated for smaller areas that are used regularly by marine mammals, but more often than not there are insufficient scientific data to calculate density for small regions such as the training areas encompassed by SSTC. Therefore, given lack of availability of SSTC specific marine mammal density, this Incidental Harassment Authorization application assumes an even distribution of marine mammals within SSTC for impact analysis purposes.

Submergence- Cetaceans spend their entire lives in the water and spend most of their time (>90% for most species) entirely submerged below the surface. When at the surface, cetacean bodies are almost entirely below the water's surface, with only the blowhole exposed to allow breathing. This makes cetaceans difficult to locate visually and also exposes them to underwater noise, both natural and anthropogenic, essentially 100% of the time because their ears are nearly always below the water's surface. Seals and sea lions (pinnipeds) spend significant amounts of time out of the water during breeding, molting, and hauling out periods. They do not haul out on SSTC, however. In the water, pinnipeds (seals and sea lions) spend varying amounts of time underwater. California sea lions are known to rest at the surface in large groups for long amounts of time. When not actively diving, pinnipeds at the surface often orient their bodies vertically in the water column and often hold their heads above the water surface. Consequently, pinnipeds may not be exposed to underwater sounds to the same extent as cetaceans. For the purpose of assessing impacts at SSTC, however, the Navy adopted a conservative approach that all four marine mammal species that may be found at SSTC (California sea lion, harbor seal, bottlenose dolphin, and gray whales) were assumed to spend 100% of the time underwater and therefore be potentially exposed to noise.

Depth Distribution (in terms of acoustic impact analysis)- Marine mammals are not distributed evenly within the water column. The ever-expanding database of marine mammal behavioral and physiological parameters obtained through tagging and other technologies has shown that marine mammals use the water column in various ways. Species specific dive profile information is presented in Section 4. Given the relatively shallow bathymetry of SSTC however (**Figure 2-1**), for purposes of this Incidental Harassment Authorization application the Navy conservatively assumed that all marine mammals were at the same water depth as the source, and thus at the maximum acoustical received level for sound in the impact analysis.

Table 3-1. Summary of marine mammal species with highest probability of occurrence in vicinity of the SSTC.

Common Name Species Name Stock	Stock Abundance [1] (Coefficient of Variation)	Annual Population Trend	Occurrence	Warm Season (May-Oct) Presence and Density [2] (individuals/km^2)	Cold Season (Nov-Apr) Presence and Density (individuals/km^2)
Pinnipeds California sea lion *Zalophus californianus* U.S. stock	238,000 [3]	Has been increasing at 6.1%; possibly stabilizing	Most common pinniped, Channel Islands breeding sites in the summer	YES 0.06	YES 0.19
Harbor seal *Phoca vitulina richardii* California stock	All California 34,233 Est. SOCAL only [4] abundance 5,271	Stabilizing	Common; Channel Islands haul outs including San Clemente Island; mainland haul-outs north of Pt Mugu and La Jolla, CA	YES 0.01	YES 0.02
Odontocetes Bottlenose dolphin *Tursiops truncates* California coastal stock	323 (0.13)	Stable	Limited, small population within one km of shore	YES 0.202	YES 0.202
Mysticetes Gray whale *Eschrichtius robustus* Eastern North Pacific stock	19,126 (0.07) Migratory [5]	Increasing >3.2%	Transient, seasonal migrations	NO 0	YES 0.014

1 All abundance estimates from NMFS Stock Assessment Reports (Carretta et al 2010, Allen and Angliss 2010) and reflect estimation of abundance for the entire stock.

2 Densities used for pinnipeds were obtained from Carretta et al. (2000) using the offshore warm and cold season pinniped densities. This publication represents one of the few NMFS at-sea pinniped surveys within Southern California. It is anticipated that while reflective of the more populous offshore numbers of pinnipeds, these values will likely be over predictive of actual at-sea pinniped density within the much smaller spatial extent of the coastal SSTC area (shore to 4000 yards from shore). Densities for the coastal stock of bottlenose dolphins was obtained from the NCCOS 2005 which presents NMFS data for various coastal segments along the California coast, including one adjacent to the SSTC. Densities for gray whales was modified from Carretta et al. (2000) by scientists at the NMFS' Southwest Fisheries Science Center to reflect the limited nature of transitory gray whale presence within the very nearshore habitat of the SSTC. Gray whales migrate through Southern California twice a year. Individual marine mammals likely only present on the order of minutes to hours in transit past SSTC (3 nm/hr travel rate).

3 All pupping occurs in Southern California [CHIP-no change as currently written]

4 Derived by NMFS from the aerial counts of all age classes within Southern California only

4 ASSESSMENT OF MARINE MAMMAL SPECIES OR STOCKS THAT COULD POTENTIALLY BE AFFECTED

There are four marine mammal species within Silver Strand Training Complex (SSTC) marine waters with confirmed or historic occurrence in the study area. These include the California sea lion, Pacific harbor seal, California coastal stock of bottlenose dolphin, and more infrequently gray whale. None are listed as threatened or endangered under the Endangered Species Act.

4.1 California Sea Lions (*Zalophus californianus*), U.S. Stock

Population Status—The California sea lion is not listed under the Endangered Species Act, and the U.S. Stock, some of which occurs in the SSTC, is not considered a strategic stock under the Marine Mammal Protection Act. The entire population cannot be counted because all age and sex classes are never ashore at the same time. In lieu of counting all sea lions, pups are counted during the breeding season (because this is the only age class that is ashore in its entirety), and the number of births is estimated from the pup count (Carretta et al. 2010). The size of the population is then estimated from the number of births and the proportion of pups in the population. Censuses are conducted in July after all pups have been born. Based on these censuses, the U.S. Stock has generally increased from the early 1900s to the present with the exception of four major declines in the number of pups counted occurred during El Niño events in 1983-1984, 1992-93, 1998, and 2003 (Carretta et al. 2010). The NMFS population estimate of the U.S. Stock of California sea lions is 238,000 (Carretta et al. 2010), with a minimum estimate based on a 2005 shore-based survey of all age and sex classes is 141,842 (NMFS, unpublished data, Carretta et al. 2010). Based on data from NMFS and presented in Carretta et al. 2010, there is indication that the California sea lion may have reached or is approaching environmental Carrying Capacity. Carrying Capacity is the environment's ability to support any given animal population based on availability of natural resources such as food and habitat. It is unclear, but possible, that the Optimal Sustainable Population level for sea lions as defined by the Marine Mammal Protection Act may have been reached but more data is needed to ensure the leveling in growth persists (Carretta et al. 2010).

Distribution—Nearly all of the U.S. Stock (more than 95%) breeds and gives birth to pups on San Miguel, San Nicolas, and Santa Barbara islands. Some movement has been documented between the U.S. Stock and Western Baja Mexico Stock, but rookeries in the United States are widely separated from the major rookeries of western Baja California. Males from western Baja California rookeries may spend most of the year in the United States. Smaller numbers of pups are born on the Farallon Islands, and Año Nuevo Island (Lowry et al. 1992). The California sea lion is by far the most commonly-sighted pinniped species at sea or on land in the vicinity of the SSTC. In California waters, sea lions represented 97% (381 of 393) of identified pinniped sightings at sea during the 1998–1999 NMFS surveys (Carretta et al. 2000). They were sighted during all seasons and in all areas with survey coverage from nearshore to offshore areas (Carretta et al. 2000).

Survey data from 1975 to 1978 were analyzed to describe the seasonal shifts in the offshore distribution of California sea lions (Bonnell and Ford 1987). During summer, the highest densities were found immediately west of San Miguel Island. During autumn, peak densities of sea lions were centered on Santa Cruz Island. During winter and spring, peak densities occurred just north of San Clemente Island. The seasonal changes in the center of distribution were attributed to changes in the distribution of the prey species. If California sea lion distribution is determined primarily by prey abundance as influenced by variations in local, seasonal, and inter-annual oceanographic variation, these same areas might not be the center of sea lion distribution every year. Costa et al. (2007) was able to indentify kernel home range contours for foraging female sea lions non-El Nino conditions, although there was some variation over the three years of this tagging study. Melin et al. (2008) showed that foraging female sea lions showed significant variability in individual foraging behavior, and foraged farther offshore and at deeper depths during El Nino years as compared to non-El Nino years.

The distribution and habitat use of California sea lions vary with the sex of the animals and their reproductive phase. Adult males haul out on land to defend territories and breed from mid-to-late May until late July. Individual males remain on territories for 27–45 days without going to sea to feed. During August and September, after the mating season, the adult males migrate northward to feeding areas as far away as Washington (Puget Sound) and British Columbia (Lowry et al. 1992). They remain there until spring (March–May), when they migrate back to the breeding colonies. Thus, adult males are present in offshore areas of the SSTC only briefly as they move to and from rookeries. Distribution of immature California sea lions is less well known, but some make northward migrations that are shorter in length than the migrations of adult males (Huber 1991). However, most immature sea lions are presumed to remain near the rookeries, and thus remain near SSTC for most of the year (Lowry et al. 1992). Adult females remain near the rookeries throughout the year. Most births occur from mid-June to mid-July (peak in late June).

California sea lions feed on a wide variety of prey, including Pacific whiting, northern anchovy, mackerel, squid, sardines, and rockfish (Antonelis et al. 1990, Lowry et al. 1991, Lowry and Carretta 1999, Lowry and Forney 2005, Bearzi 2006). In Santa Monica Bay, California sea lions are known to follow and feed near bottlenose dolphins (Bearzi 2006), and if in the near shore waters of SSTC, may forage on common coastal beach fish species (corbina and barred surfperch) as dolphins (Allen 2006).

There is limited published at-sea density estimates for pinnipeds within Southern California (NMFS, J. Barlow). Higher densities of California sea lions are observed during cold-water months. At-sea densities likely decrease during warm-water months because females spend more time ashore to give birth and attend to their pups. Radio-tagged female California sea lions at San Miguel Island spent approximately 70% of their time at sea during the non-breeding season (cold-water months) and pups spent an average of 67% of their time ashore during their mother's absence (Melin and DeLong 2000). Different age classes of California sea lions are found in the offshore areas of SSTC throughout the year (Lowry et al. 1992). Although adult male California sea lions feed in areas north of SSTC, animals of all other ages and sexes spend most, but not all, of their time feeding at sea during winter, thus, the winter estimates likely are somewhat low. During warm-water months, a high proportion of the adult males and females are hauled out at terrestrial sites during much of the period, so the summer estimates are low to a greater degree.

Reproduction/Breeding —The pupping and mating season for sea lions begins in late May and continues through July (Heath 2002).

Diving Behavior - Over one third of the foraging dives by breeding females are 1–2 minutes in duration; 75% of dives are <3 minutes, and the longest recorded dive was 9.9 minutes (Feldkamp et al. 1989). Approximately 45% of dives were to depths of 66–160 ft (20–50 m) and the maximum depth of a dive was 900 ft (274 m) (Feldkamp et al. 1989). Costa et al. (2007) reported both shallow and deep dives >328 ft (>100 m) by both male and female sea lions. Melin et al. (2008) documented mean dives depths of 62 to 915 feet but that most individuals could make dives to 1,312 feet (400 m). Much of the variation in duration and depth of dives appears to be related to sea lions foraging on vertically-migrating prey. Longer dives to greater depths typically occur during the day, and shorter dives to shallower depths typically occur at night, when prey migrate toward the surface (Feldkamp et al. 1989, Costa et al. 2007, Melin et al. 2008).

Acoustics—In-air, California sea lions make incessant, raucous barking sounds; these have most of their energy at less than 2 kilohertz (kHz) (Schusterman et al. 1967). Males vary both the number and rhythm of their barks depending on the social context; the barks appear to control the movements and other behavior patterns of nearby conspecifics (Schusterman 1977). Females produce barks, squeals, belches, and growls in the frequency range of 0.25 to 5 kHz, while pups make bleating sounds at 0.25 to 6 kHz. California sea lions produce two types of underwater sounds: clicks (or short-duration sound pulses) and barks (Schusterman et al. 1966, 1967, Schusterman and Baillet 1969). All underwater sounds have most of their energy below 4 kHz (Schusterman et al. 1967).

The range of maximal sensitivity underwater is between 1 and 28 kHz (Schusterman et al. 1972). Functional underwater high frequency hearing limits are between 35 and 40 kHz, with peak sensitivities from 15 to 30 kHz (Schusterman et al. 1972). The California sea lion shows relatively poor hearing at frequencies below 1 kHz (Kastak and Schusterman 1998). Peak sensitivities in air are shifted to lower frequencies; the effective upper hearing limit is approximately 36 kHz (Schusterman 1974). The best range of sound detection is from 2 to 16 kHz (Schusterman 1974). Kastak and Schusterman (2002) determined that hearing sensitivity generally worsens with depth—hearing thresholds were lower in shallow water, except at the highest frequency tested (35 kHz), where this trend was reversed. Octave band noise levels of 65 to 70 dB above the animal's threshold produced an average temporary threshold shift (TTS) of 4.9 dB in the California sea lion (Kastak et al. 1999). Center frequencies were 1,000 hertz (Hz) for corresponding threshold testing at 1000 Hz and 2,000 Hz for threshold testing at 2,000 Hz; the duration of exposure was 20 minutes.

4.2 Pacific Harbor Seal (*Phoca vitulina richardii*), California Stock

Population Status—The harbor seal is not listed under the Endangered Species Act, and the California Stock, some of which occurs in the SSTC, is not considered a strategic stock under the Marine Mammal Protection Act. The California population has increased from the mid-1960s to the mid-1990s, although the rate of increase may have slowed during the 1990s as the population has reached and may be stabilizing at carrying capacity (Hanan 1996, Carretta et al. 2010). A complete count of all harbor seals in California is impossible because some are always away from the haul out sites. A complete pup count (as is done for other pinnipeds in California) is also not possible because harbor seals are precocious, with pups entering the water almost immediately after birth (Carretta et al. 2010). Population size is estimated by counting the number of seals ashore during the peak haul out period (May to July) and by multiplying this count by the inverse of the estimated fraction of seals on land.

Based on the most recent harbor seal counts (26,333 in May-July 2004, Lowry et al. 2005) and Hanan's revised correction factor, the harbor seal population in California is estimated by NMFS to number 34,233 (Carretta et al. 2010). The minimum size of the California harbor seal population is 31,600 (Carretta et al. 2010). Of the estimated California population (34,233), less than 30% are thought to reside within Southern California due to lack of suitable haul-our sited because of significant beach urbanization (Lowry et al. 2008).

Distribution—Harbor seals are considered abundant throughout most of their range from Baja California to the eastern Aleutian Islands. An unknown number of harbor seals also occur along the west coast of Baja California, at least as far south as Isla Asuncion, which is about 100 miles south of Punta Eugenia. Animals along Baja California are not considered to be a part of the California stock because it is not known if there is any demographically significant movement of harbor seals between California and Mexico (Carretta et al. 2010). Peak numbers of harbor seals haul out on land during late May to early June, which coincides with the peak of their molt. They generally favor sandy, cobble, and gravel beaches (Stewart and Yochem 1994, 2000), and most haul out on the central California mainland and Santa Cruz Island (Lowry and Carretta 2003, Carretta et al. 2010).

There is limited at-sea density estimates for pinnipeds within Southern California (NMFS, J. Barlow). Harbor seals do not make extensive pelagic migrations, but do travel 300-500 km on occasion to find food or suitable breeding areas (Herder 1986, D. Hanan unpublished data, Carretta et al. 2007). When at sea during May and June (and March to May for breeding females), they generally remain in the vicinity of haul out sites and forage close to shore in relatively shallow waters. Based on likely foraging strategies, Grigg et al. (2009) reported seasonal shifts in harbor seal movements based on prey availability.

Harbor seals are opportunistic feeders that adjust their feeding to take advantage of locally and seasonally abundant prey which can include small crustaceans, rock fish, cusk-eel, octopus, market squid, and surfperch (Bigg, 1981, Payne and Selzer 1989, Stewart and Yochem 1994, Stewart and Yochem 2000, Baird 2001, BjØrge 2002, Oates 2005). If in the near shore waters of SSTC, harbor seals may forage on common coastal beach fish species, corbina and barred surfperch (Allen 2006).

Harbor seals are found in the SSTC throughout the year (Carretta et al. 2000) with local densities estimated at 0.010 animals/km^2 during the warm season and 0.020 animals/km^2 during the cold season.

Reproduction/Breeding— Nursing of pups begins in late February, and pups start to become weaned in May. Breeding occurs between late March and early May on the southern and northern Channel Islands.

Diving Behavior - While feeding, harbor seals dive to depths of 33–130 feet in the case of females with nursing pups, and 260–390 feet in the case of other seals. Dives as deep as 1,463 feet have been recorded, although dives greater than 460 feet are infrequent (Eguchi and Harvey 2005).

Acoustics—Harbor seals produce a variety of airborne vocalizations including snorts, snarls, and belching sounds (Bigg 1981). Adult males produce low frequency vocalizations underwater during the breeding season (Hanggi and Schusterman 1994, Van Parijs et al. 2003, Bjørgesæter et al. 2004, Bodson et al. 2006). Male harbor seals produce communication sounds in the frequency range of 100 to 1,000 Hz (Bodson et al. 2006).

The harbor seal hears almost equally well in air and underwater (Kastak and Schusterman 1998). Harbor seals hear best at frequencies from 1 to 180 kHz; the peak hearing sensitivity is at 32 kHz in water and 12 kHz in air (Terhune and Turnball 1995, Kastak and Schusterman 1998, Wolski et al. 2003, Kastelein et al. 2009). Kastak and Schusterman (1996) observed a TTS of 8 dB at 100 Hz from 6-7 hours of intermittent broadband continuous construction noise (sandblasting; 200-2000 Hz at 95-105 dB sound pressure level unweighted in the seal's enclosure) per day for six days, with complete recovery approximately one week following exposure. Kastak et al. (1999) determined that underwater noise of moderate intensity (65 to 75 dB above the animals hearing threshold at 100, 500 and 1000 Hz) and continuous duration of 20 minutes is sufficient to induce a small TTS of 4.8 dB in harbor seals.

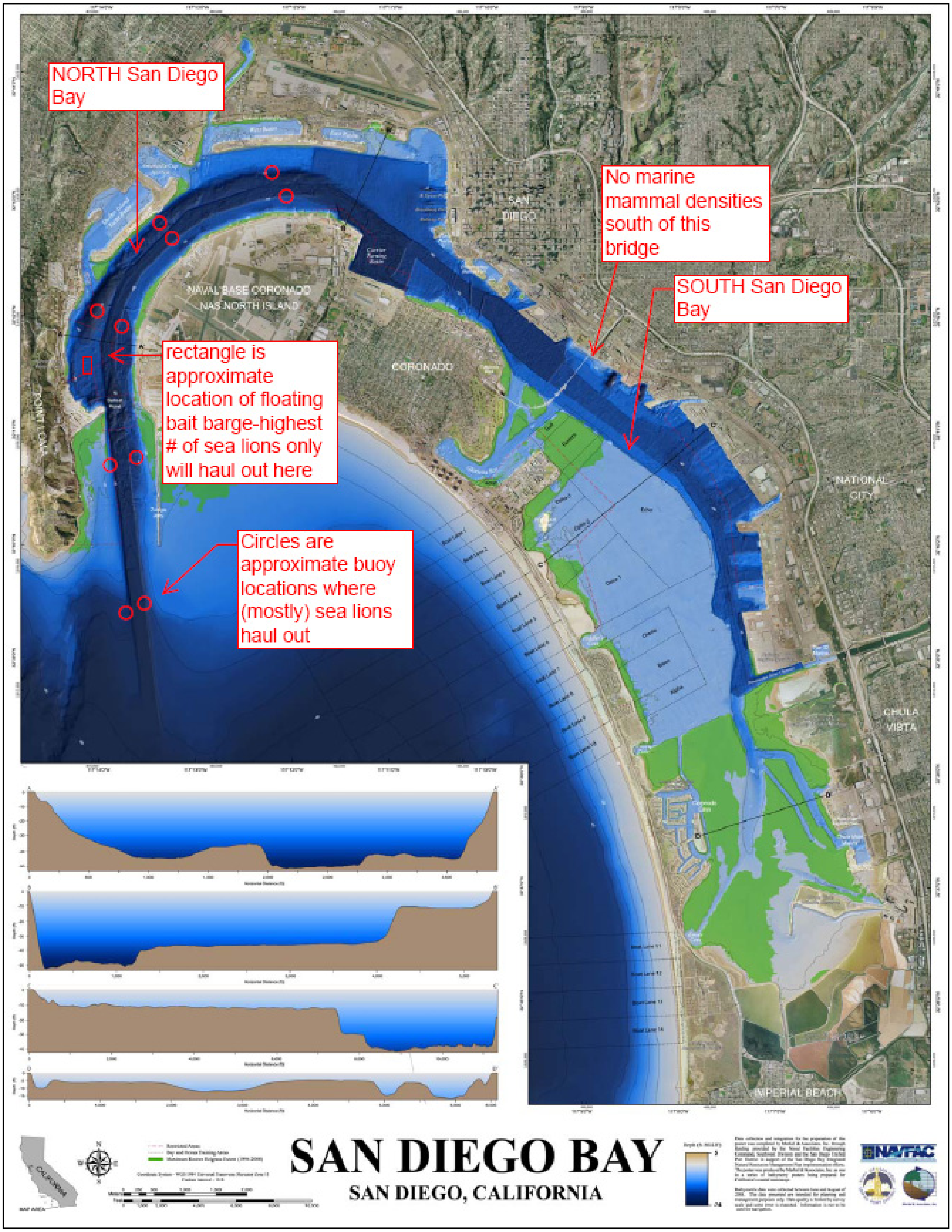

Figure 4-1. Pinniped (typically California sea lions) haul-out locations adjacent to and within north San Diego Bay.

Figure 4-2. Pictures of California sea lions hauled-out on buoy (top) and floating piers (bottom) within San Diego Bay but outside of the SSTC area.

4.3 Bottlenose Dolphin (*Tursiops truncatus*), California Coastal Stock

Population Status—There are two distinct populations of bottlenose dolphins within southern California, a coastal population found within 0.5 nm (0.9 km) of shore and a larger offshore population (Hansen 1990, Bearzi et al. 2009). The California Coastal Stock is the only one of these two stocks likely to occur within the SSTC. The California Coastal Stock of bottlenose dolphins is not listed under the ESA, and is not considered a strategic stock under the Marine Mammal Protection Act. Based on photographic mark-recapture surveys conducted along the San Diego coast in 2004 and 2005, population size for the California Coastal Stock of the bottlenose dolphin is estimated to be 323 individuals (CV = 0.13, 95% CI 259-430; Dudzik et al. 2005, Carretta et al. 2010). This estimate does not reflect that approximately 35% of dolphins encountered lack identifiable dorsal fin marks (Defran and Weller 1999). If 35% of all animals lack distinguishing marks, then the true population size would be closer to 450-500 animals (Carretta et al. 2010).

Distribution— The bottlenose dolphin California Coastal Stock occurs at least from Point Conception south into Mexican waters, at least as far south as San Quintin, Mexico. In southern California, animals are found within 1600 ft (500 m) of the shoreline 99% of the time and within 820 ft (250 m) 90% of the time (Hanson and Defran 1993). Occasionally, during warm-water incursions such as during the 1982–1983 El Niño event, their range extends as far north as Monterey Bay (Wells et al. 1990). Bottlenose dolphins in the Southern California Bight (SCB) appear to be highly mobile within a relatively narrow coastal zone (Defran et al. 1999), and exhibit no seasonal site fidelity to the region (Defran and Weller 1999). There is little site fidelity of coastal bottlenose dolphins along the California coast; over 80% of the dolphins identified in Santa Barbara, Monterey, and Ensenada have also been identified off San Diego (Defran et al. 1999, Maldini-Feinholz 1996, Defran, unpublished data, Carretta et al. 2008, Bearzi et al. 2009). Bottlenose dolphins could occur in the SSTC at variable frequencies and periods throughout the year based on localized prey availability (Defran et al. 1999). The coastal stock utilizes a limited number of fish prey species with up to 74% being various species of surfperch or croakers, a group on non-migratory year-round coastal inhabitant (Defran et al. 1999, Allen et al. 2006). For Southern California, common croaker prey species include spotfin croaker, yellowfin croaker, and California corbina, while common surfperch species include barred surfperch and walleye surfperch (Allen et al. 2006). The corbina and barred surfperch are the most common surf zone fish where bottlenose dolphins have been observed foraging (Allen et al. 2006). Defran et al. (1999) postulated that the coastal stock of bottlenose dolphins showed significant movement within their home range (Central California to Mexico) in search of preferred but patchy concentrations of near shore prey (i.e., croakers and surfperch). After finding concentrations of prey, animals may then forage within a more limited spatial extent to take advantage of this local accumulation until such time that prey abundance is reduced after which the dolphins once again shift location over larger distances (Defran et al. 1999). Bearzi (2005) and Bearzi et al. (2009) also noted little site fidelity from coastal bottlenose dolphins in Santa Monica Bay, California, and that these animals were highly mobile with up to 69% of their time spent in travel and dive-travel mode and only 5% of the time in feeding behaviors.

Group size of the California coastal stock of bottlenose dolphins has been reported to range from 1 to 57 dolphins (Bearzi 2005), although mean pod size were around 19.8 and 10.1 (Defran and Weller 1999, and Bearzi 2005, respectively).

An at-sea density estimate of 0.202 animals/km^2 was used for acoustic impact modeling for both the warm and cold seasons as derived in National Center for Coastal Ocean Science 2005.

Reproduction/Breeding—Newborn calves are seen throughout the year and reproduction may be influenced by productivity and food abundance (Urian et al. 1996).

Diving Behavior—Pacific coast bottlenose dolphins feed primarily on surf perches (Family Embiotocidae) and croakers (Family Sciaendae) (Norris and Prescott 1961, Walker 1981, Schwartz et al. 1992, Hanson and Defran 1993), and also consume squid (*Loligo opalescens*) (Schwartz et al., 1992). Navy bottlenose dolphins have been trained to reach maximum diving depths of about 984 ft (Ridgway et al. 1969). Reeves et al. (2002) noted that the presence of deep-sea fish in the stomachs of some offshore individual bottlenose dolphins suggests that they dive to depths of more than 1,638 ft. Dive durations up to 15 minutes have been recorded for trained individuals (Ridgway et al. 1969). Typical dives expected for the California Coastal stock, however, are more shallow and of a much shorter duration. Bottlenose dolphins utilize the entire water column by feeding on prey that concentrate near the surface, midwater areas and benthic areas (Hastie et al. 2006).

Acoustics—Sounds emitted by bottlenose dolphins have been classified into two broad categories: pulsed sounds (including clicks and burst-pulses) and narrow-band continuous sounds (whistles), which usually are frequency modulated (FM). Generally, whistles range in frequency from 0.8 to 24 kHz but can also go much higher. Clicks and whistles have a dominant frequency range of 110 to 130 kHz and a source level of 218 to 228 dB re 1 μPa at 1 m (peak to peak levels; Au 1993) and 3.5 to 14.5 kHz with a source level of 125 to 173 dB re 1 μPa at 1 m, respectively (Ketten 1998). The bottlenose dolphin has a functional high-frequency hearing limit of 160 kHz (Au 1993) and can hear sounds at frequencies as low as 40 to 125 Hz (Turl 1993). Inner ear anatomy of this species has been described (Ketten 1992). Electrophysiological experiments suggest that the bottlenose dolphin brain has a dual analysis system: one specialized for ultrasonic clicks and the other for lower-frequency sounds, such as whistles (Ridgway 2000). The audiogram of the bottlenose dolphin shows that the lowest thresholds occurred near 50 kHz at a level around 45 dB re 1 μPa (Nachtigall et al. 2000, Finneran and Houser 2006, Houser and Finneran 2007). Below the maximum sensitivity, thresholds increased continuously up to a level of 137 dB re 1 μPa at 75 Hz. Above 50 kHz, thresholds increased slowly up to a level of 55 dB re 1 μPa at 100 kHz, then increased rapidly above this to about 135 dB re 1 μPa at 150 kHz. Scientists have reported a range of best sensitivity between 25 and 70 kHz, with peaks in sensitivity occurring at 25 and 50 kHz at levels of 47 and 46 dB re 1 μPa (Nachtigall et al. 2000). TTS in hearing have been experimentally induced and behavioral responses observed in captive bottlenose dolphins (Ridgway et al. 1997, Schlundt et al. 2000, 2006, Nachtigall et al. 2003, Finneran et al. 2002, 2005, 2007b). Ridgway et al. (1997) observed changes in behavior at the following minimum levels for 1 sec tones: 186 dB re 1 μPa at 3 kHz, 181 dB re 1 μPa at 20 kHz, and 178 dB re 1 μPa at 75 kHz. TTS levels were 194 to 201 dB re 1 μPa at 3 kHz, 193 to 196 dB re 1 μPa at 20 kHz, and 192 to 194 dB re 1 μPa at 75 kHz. Schlundt et al. (2000) exposed bottlenose dolphins to intense tones (0.4, 3, 10, 20, and 75 kHz); the animals demonstrated altered behavior at source levels of 178 to 193 dB re 1 μPa, with TTS after exposures generally between 192 and 201 dB re 1 μPa at 1 m (though one dolphin exhibited TTS after exposure at 182 dB re 1 μPa). Nachtigall et al. (2003) determined threshold for a 7.5 kHz pure tone stimulus. No shifts were observed at 165 or 171 dB re 1 μPa, but when the sound level reached 179 dB re 1 μPa, the animal showed the first sign of TTS. Recovery apparently occurred rapidly, with full recovery apparently within 45 minutes following sound exposure. TTS measured between 8 and 16 kHz (negligible or absent at higher frequencies) after 30 minutes of sound exposure (4 to 11 kHz) at 160 dB re 1 μPa (Nachtigall et al. 2004).

4.4 Gray Whale (*Eschrichtius robustus*), Eastern North Pacific Stock

Population Status— In 1994, due to steady increases in population abundance, the Eastern North Pacific stock of gray whales was removed from the List of Endangered and Threatened Wildlife, as it was no longer considered endangered or threatened under the ESA (Allen and Angliss 2010). The Eastern North Pacific stock of gray whale is not considered a strategic stock under the Marine Mammal Protection Act. Even though the stock is within Optimal Sustainable Population, abundance will rise and fall as the population adjusts to natural and man-caused factors affecting the carrying capacity of the environment (Rugh et al. 2005). In fact, it is expected that a population close to or at the carrying capacity of the environment will be more susceptible to fluctuations in the environment (Moore et al. 2001). Systematic counts of gray whales migrating south along the central California coast have been conducted by shore-based observers at Granite Canyon most years since 1967. The population size of the Eastern North Pacific gray whale stock has been increasing over the past several decades at a rate approximately between 2.5 to 3.3% per year since 1967. The most recent abundance estimates are based the National Marine Fisheries Service's population estimate is 19,126 individuals as reported in Allen and Angliss (2010).

Distribution— The Eastern North Pacific population is found from the upper Gulf of California (Tershy and Breese 1991), south to the tip of Baja California, and up the Pacific coast of North America to the Chukchi and Beaufort seas. There is a pronounced seasonal north-south migration. The eastern North Pacific population summers in the shallow waters of the northern Bering Sea, the Chukchi Sea, and the western Beaufort Sea (Rice and Wolman 1971). The northern Gulf of Alaska (near Kodiak Island) is also considered a feeding area; some gray whales occur there year-round (Moore et al. 2007). Some individuals spend the summer feeding along the Pacific coast from southeastern Alaska to central California (Sumich 1984, Calambokidis et al. 1987, 2002). Photo-identification studies indicate that gray whales move widely along the Pacific coast and are often not sighted in the same area each year (Calambokidis et al. 2002). In October and November, the whales begin to migrate southeast through Unimak Pass and follow the shoreline south to breeding grounds on the west coast of Baja California and the southeastern Gulf of California (Braham 1984, Rugh 1984). The average gray whale migrates 4,050 to 5,000 nm (7,500 to 10,000 km) at a rate of 80 nm (147 km) per day (Rugh et al. 2001, Jones and Swartz 2002). Although some calves are born along the coast of California (Shelden et al. 2004), most are born in the shallow, protected waters on the Pacific coast of Baja California from Morro de Santo Domingo (28°N) south to Isla Creciente (24°N) (Urbán et al. 2003). Main calving sites are Laguna Guerrero Negro, Laguna Ojo de Liebre, Laguna San Ignacio, and Estero Soledad (Rice et al. 1981).

A group of gray whales known as the Pacific Coast Feeding Aggregation (PCFA) feeds along the Pacific coast between southeastern Alaska and northern to central California throughout the summer and fall (NMFS 2001, Calambokidis et al. 2002, Calambokidis et al. 2004b). The gray whales in this feeding aggregation are a relatively small proportion (a few hundred individuals) of the overall eastern North Pacific population and typically arrive and depart from these feeding grounds concurrently with the migration to and from the wintering grounds (Calambokidis et al. 2002, Allen and Angliss 2010). Although some site fidelity is known to occur, there is generally considerable interannual variation since many individuals do not return to the same feeding site in successive years (Calambokidis et al. 2000, Calambokidis et al. 2004).

The Eastern North Pacific stock of gray whale transits through Southern California during its northward and southward migrations between December and June. Gray whales follow three routes from within 15 to 200 km from shore (Bonnell and Dailey 1993). The nearshore route follows the shoreline between Point Conception and Point Vicente but includes a more direct line from Santa Barbara to Ventura and across Santa Monica Bay. Around Point Vicente or Point Fermin, some whales veer south towards Santa Catalina Island and return to the nearshore route near Newport Beach. Others join the inshore route that includes the northern chain of the Channel Islands along Santa Cruz Island and Anacapa Island and east along the Santa Cruz Basin to Santa Barbara Island and the Osborn Bank. From here, gray whales migrate east directly to Santa Catalina Island and then to Point Loma or Punta Descanso or southeast to San Clemente Island and on to the area near Punta Banda. A significant portion of the Eastern North Pacific stock passes by San Clemente Island and its associated offshore waters (Carretta et al. 2000). The offshore route follows the undersea ridge from Santa Rosa Island to the mainland shore of Baja California and includes San Nicolas Island and Tanner and Cortes banks (Bonnell and Dailey 1993).

Peak abundance of gray whales off the coast of San Diego is typically January during the southward migration and in March during the migration north, although females with calves, which depart Mexico later than males or females without calves, can be sighted from March through May or June (Leatherwood 1974, Poole 1984, Rugh et al. 2001, Stevick et al. 2002, Angliss and Outlaw 2008). Gray whales would be expected to be infrequent migratory transients within the out portions of SSTC only during cold-water months (Carretta et al. 2000). Migrating gray whale that might infrequently transit through SSTC would not be expected to forage, and would likely be present for minutes to less than one or two hours at typical travel speeds of 3 knots (approximately 3.5 miles per hour) (Perryman et al. 1999, Mate and Urbán-Ramirez 2003)

A mean group size of 2.9 gray whales was reported for both coastal (16 groups) and non-coastal (15 groups) areas around San Clemente Island (Carretta et al. 2000). The largest group reported was nine animals. The largest group reported by U.S. Navy (1998) was 27 animals. Gray whales would not be expected in the SSTC from July through November (Rice et al. 1981), and are excluded from warm season analysis. Even though gray whale transitory occurrence is infrequent along SSTC a cold season density is estimated at 0.014 animals per km^2 for purposes of conservative analysis.

Reproduction/Breeding—Although some calves are born along the coast of Southern California, most are born in the shallow, protected waters on the Pacific coast of Baja California (Urbán-Ramirez et al. 2003).

Diving Behavior—When foraging, gray whales typically dive to 160 to 200 feet for 5 to 8 minutes. In the breeding lagoons, dives are usually less than 6 minutes (Jones and Swartz, 2002), although dives as long as 26 minutes have been recorded (Harvey and Mate 1984). When migrating, gray whales may remain submerged near the surface for 7 to 10 minutes and travel 1,600 feet or more before resurfacing to breathe. The maximum known dive depth is 560 feet (Jones and Swartz 2002). Migrating gray whales sometimes exhibit a unique “snorkeling” behavior in which they surface cautiously, exposing only the area around the blow hole, exhale quietly without a visible blow, and sink silently beneath the surface (Jones and Swartz 2002). Mate and Urbán-Ramirez (2003) noted that 30 of 36 locations for a migratory gray whale with a satellite tag were in water <330 feet deep, with the deeper water locations all in the Southern California Bight within the Channel Islands. Whales in that study maintained consistent speed indicating directed movement. There has been only one study yielding a gray whale dive profile, and all information was collected from a single animal that was foraging off the west coast of Vancouver Island (Malcolm and Duffus 2000, Malcolm et al. 1996). They noted that the majority of time was spent near the surface on interventilation dives (<10 feet depth) and near the bottom (extremely nearshore in a protected bay with mean dive depth of 60 feet, range 46-72 feet depth). There was very little time spent in the water column between surface and bottom. Foraging depth on summer feeding grounds is generally between 160-200 feet (Jones and Swartz 2002). Based on this very limited information, the following is a rough estimate of depth distribution for gray whales: 50% at <13 feet (surface and interventilation dives) and 50% at 13-59 feet. Of note, however, most gray whales would be expected at shallower depths during transit through Southern California where foraging does not occur due to migration and limited suitable bottom prey habitat.

Acoustics—Au (2000) reviewed the characteristics of gray whale vocalizations. Gray whales produce broadband signals ranging from 100 Hz to 4 kHz (and up to 12 kHz) (Dahlheim et al. 1984, Jones and Swartz 2002). The most common sounds on the breeding and feeding grounds are knocks (Jones and Swartz 2002), which are broadband pulses from about 100 Hz to 2 kHz and most energy at 327 to 825 Hz. The source level for knocks is approximately 142 dB re 1 µPa at 1 m (Cummings et al. 1968). During migration, individuals most often produce low-frequency moans (Crane and Lashkari 1996). The structure of the gray whale ear is evolved for low-frequency hearing (Ketten 1992). The ability of gray whales to hear frequencies below 2 kHz has been demonstrated in playback studies (Cummings and Thompson 1971, Dahlheim and Ljungblad 1990, Moore and Clarke 2002) and in their responsiveness to underwater noise associated with broadband oil and gas activities (Malme et al. 1986, Moore and Clarke 2002). Gray whale responses to noise include changes in swimming speed and direction to move away from the sound source; abrupt behavioral changes from feeding to avoidance, with a resumption of feeding after exposure; changes in calling rates and call structure; and changes in surface behavior, usually from traveling to milling (e.g., Moore and Clarke 2002). Gailey et al. (2007) reported no apparent behavioral disturbance for Western Pacific gray whales in response to low-frequency seismic survey.

5 HARASSMENT AUTHORIZATION REQUESTED

The Navy determined that its underwater detonation events at Silver Strand Training Complex (SSTC) may result in incidental takings of marine mammals by harassment. For that reason, the Navy is applying for authorization from National Marine Fisheries Service (NMFS) for the incidental harassment of marine mammals pursuant to Section 101 (a)(5)(A) of the Marine Mammal Protection Act.

This Incidental Harassment Authorization application is for the incidental harassment of marine mammals under the Marine Mammal Protection Act due to Level B harassment from underwater detonation and pile driving training events at SSTC. It is understood that an Incidental Harassment Authorization is applicable for up to one year, is renewable, and is appropriate where authorization for harassment, but not serious injury or mortality of marine mammals is requested. The training events analyzed are not new and have taken place at SSTC in the past with no reported injuries or mortality to marine mammals. As a result of scientific advances in acoustic exposure effects analysis modeling on marine mammals, the extent of acoustic exposure on marine mammals can be estimated.

The acoustic modeling approach taken in this Incidental Harassment Authorization application attempts to quantify potential exposures to marine mammals resulting from underwater detonations and pile driving. Results from this conservative modeling approach provide an overestimation of exposures and are presented without consideration of mitigation measures employed per Navy standard operating procedures.

Without consideration of mitigation measures, the modeling results from SSTC analysis predicts **267 potential pre-mitigation exposures** from underwater detonations and **348 potential pre-mitigation exposures** from ELCAS pile driving and removal per year that could be classified as Level B harassment as defined under the Marine Mammal Protection Act. For underwater detonations, the models estimated 168 level B exposures to coastal bottlenose dolphins and 99 level B exposures to California sea lions. For ELCAS pile driving and pile removal, the calculations estimated 208 Level B exposures to coastal bottlenose dolphins, 122 Level B exposures to California sea lions, 12 Level B exposures to harbor seals, and 6 Level B exposures to gray whales.

Given Navy's current mitigation procedures presented in Section 11 which include monitoring of mitigation zones prior to detonation, and the increased likelihood that bottlenose dolphins, California sea lions, harbor seals, and gray whales can be readily detected, the potential for Level B exposures is minimized or eliminated. The Navy does not anticipate that 615 (267+348) actual harassment incidents will result from underwater detonations and ELCAS events within SSTC. However, to allow for scientific uncertainty regarding the exact mechanisms of the physical and behavioral effects, and as a conservative approach, the Navy is requesting authorization for take (Level B harassment) of 615 marine mammals per year at SSTC in this Incidental Harassment Authorization application.

The Navy is also requesting a few (e.g., two to five) Level B harassments for harbor seals during underwater detonations. The Navy's model estimated that this species would not be exposed during underwater detonation training events and the Navy does not anticipate Level B harassments. However, there remains a possibility (albeit remote) that the species may be present and undetected during training.

6 NUMBERS AND SPECIES EXPOSED

The National Marine Fisheries Service (NMFS) application for Incidental Harassment Authorizations requires applicants to determine the number of marine mammals that are expected to be incidentally harassed by an action and the nature of the harassment (Level A or Level B). The Proposed Action is a military readiness activity as defined in the Marine Mammal Protection Act. Section 6.1 below defines Marine Mammal Protection Act Level A and Level B as applicable to military readiness activities and presents how these definitions were relied on to develop the quantitative acoustic analysis methodologies used to assess the potential for the proposed action to affect marine mammals.

6.1 Biological and Regulatory Framework

The following discussion outlines the biological framework within which potential impacts can be categorized. This discussion includes an explanation of physiological and behavioral effects, Level A and Level B harassment criteria, harassment zones, indicators of physiological effects, temporary threshold shift (TTS), behavioral effects, and auditory masking. The biological framework can then be combined with the existing regulatory framework of injury (Level A harassment) and behavioral disruption (Level B harassment) to establish appropriate levels of impact.

As summarized by the National Academies of Science, the possibility that human-generated sound could harm marine mammals or significantly interfere with their "normal" activities has been an issue of concern (National Research Council [NRC] 2005). Assessing whether a sound may disturb or injure a marine mammal involves understanding the characteristics of the acoustic sources, the marine mammals that may be present in the vicinity of the sound, and the effects that sound may have on the physiology and behavior of those marine mammals. Although it is known that sound is important for marine mammal communication, navigation, and foraging (NRC 2003, NRC 2005), there are many unknowns in assessing the effects and significance of marine mammal responses to sound exposures related to the context for the exposure and the disposition of the marine mammal (Southall et al. 2007). For this reason, the Navy enlisted the expertise of NMFS as a cooperating agency. Their input assisted the Navy in developing a conceptual analytical framework for evaluating what sound levels marine mammals might receive as a result of Navy training actions, whether marine mammals might respond to these exposures, and whether that response might have a mode of action on the biology or ecology of marine mammals such that the response should be considered a potential harassment. From this framework of evaluating the potential for harassment incidents to occur, an assessment of whether acoustic sources might impact populations, stocks or species of marine mammals can be conducted.

Starting with a sound source, the attenuation of an emitted sound due to propagation loss is determined. Uniform animal distribution is overlaid onto the calculated sound fields to assess if animals are physically present at sufficient received sound levels to be considered "exposed" to the sound. If the animal is determined to be exposed, two possible scenarios must be considered with respect to the animal's physiology – effects on the auditory system and effects on nonauditory system tissues. These are not independent pathways and both must be considered since the same sound could affect both auditory and nonauditory tissues. Note that the model does not account for any animal response; rather the animals are considered stationary, accumulating energy until the threshold is tripped. Potential impacts to the auditory system are assessed by considering the characteristics of the received sound (e.g., amplitude, frequency, duration) and the sensitivity of the exposed animals. Some of these assessments can be numerically based (e.g., TTS, Permanent Threshold Shift [PTS], perception). Others will be necessarily qualitative, due to lack of information, or will need to be extrapolated from other species for which information exists. Potential physiological responses to the sound exposure are ranked in descending order, with the most severe impact (auditory trauma) occurring at the top and the least severe impact occurring at the bottom (the sound is not perceived).

1. Auditory trauma represents direct mechanical injury to hearing related structures, including tympanic membrane rupture, disarticulation of the middle ear ossicles, and trauma to the inner ear structures such as the organ of Corti and the associated hair cells. Auditory trauma is always injurious but could be temporary and not result in PTS. Auditory trauma is always assumed to result in a stress response.

2. Auditory fatigue refers to a loss of hearing sensitivity after sound stimulation. The loss of sensitivity persists after, sometimes long after, the cessation of the sound. The mechanisms responsible for auditory fatigue differ from auditory trauma and would primarily consist of metabolic exhaustion of the hair cells and cochlear tissues. The features of the exposure (e.g., amplitude, frequency, duration, temporal pattern) and the individual animal's susceptibility would determine the severity of fatigue and whether the effects were temporary (TTS) or permanent (PTS). Auditory fatigue (PTS or TTS) is always assumed to result in a stress response.

3. Sounds with sufficient amplitude and duration to be detected among the background ambient noise are considered to be perceived. This category includes sounds from the threshold of audibility through the normal dynamic range of hearing (i.e., not capable of producing fatigue). To determine whether an animal perceives the sound, the received level, frequency, and duration of the sound are compared to what is known of the species' hearing sensitivity.

Since audible sounds may interfere with an animal's ability to detect other sounds at the same time, perceived sounds have the potential to result in auditory masking. Unlike auditory fatigue, which always results in a stress response because the sensory tissues are being stimulated beyond their normal physiological range, masking may or may not result in a stress response, depending on the degree and duration of the masking effect. Masking may also result in a unique circumstance where an animal's ability to detect other sounds is compromised without the animal's knowledge. This could conceivably result in sensory impairment and subsequent behavior change; in this case, the change in behavior is the lack of a response that would normally be made if sensory impairment did not occur. For this reason, masking also may lead directly to behavior change without first causing a stress response. The features of perceived sound (e.g., amplitude, duration, temporal pattern) are also used to judge whether the sound exposure is capable of producing a stress response. Factors to consider in this decision include the probability of the animal being naïve or experienced with the sound (i.e., what are the known/unknown consequences of the exposure).

By extension, this does not result in a stress response (not perceived). Potential impacts to tissues other than those related to the auditory system are assessed by considering the characteristics of the sound (e.g., amplitude, frequency, duration) and the known or estimated response characteristics of nonauditory tissues. Some of these assessments can be numerically based (e.g., exposure required for rectified diffusion). Others will be necessarily qualitative, due to lack of information. Each of the potential responses may or may not result in a stress response.

1. Direct tissue effects – Direct tissue responses to sound stimulation may range from tissue shearing (injury) to mechanical vibration with no resulting injury. Any tissue injury would produce a stress response, whereas noninjurious stimulation may or may not.

2. Indirect tissue effects – Based on the amplitude, frequency, and duration of the sound, it must be assessed whether exposure is sufficient to indirectly affect tissues. For example, the hypothesis that rectified diffusion occurs is based on the idea that bubbles that naturally exist in biological tissues can be stimulated to grow by an acoustic field. Under this hypothesis, one of three things could happen: (1) bubbles grow to the extent that tissue hemorrhage occurs (injury); (2) bubbles develop to the extent that a complement immune response is triggered or nervous tissue is subjected to enough localized pressure that pain or dysfunction occurs (a stress response without injury); or (3) the bubbles are cleared by the lung without negative consequence to the animal. The probability of rectified diffusion, or any other indirect tissue effect, will necessarily be based on what is known about the specific process involved. Given the single point source underwater explosives and broadband impulsive sounds from pile driving, the two main underwater activities with potential to affect marine mammals at SSTC, indirect tissue effects are not a factor. While presented here in context of the framework discussion, indirect tissue effects are not considered in the impact analysis discussed later.

3. No tissue effects – The received sound is insufficient to cause either direct mechanical) or indirect effects to tissues. No stress response occurs.

Stress Response- The acoustic source is considered a potential stressor if, by its action on the animal, via auditory or nonauditory means, it may produce a stress response in the animal. The term "stress" has taken on an ambiguous meaning in the scientific literature, but with respect to the discussions of allostasis and allostatic loading, the stress response will refer to an increase in energetic expenditure that results from exposure to the stressor and which is predominantly characterized by either the stimulation of the sympathetic nervous system (SNS) or the hypothalamic-pituitary-adrenal (HPA) axis (Reeder and Kramer 2005). The presence and magnitude of a stress response in an animal depends on a number of factors. These include the animal's life history stage (e.g., neonate, juvenile, adult), the environmental conditions, reproductive or developmental state, and experience with the stressor. Not only will these factors be subject to individual variation, but they will also vary within an individual over time. Prior experience with a stressor may be of particular importance as repeated experience with a stressor may dull the stress response via acclimation (St. Aubin and Dierauf 2001). In considering potential stress responses of marine mammals to acoustic stressors, each of these should be considered. For example, is the acoustic stressor in an area where animals engage in breeding activity? Are animals in the region resident and likely to have experience with the stressor (i.e., repeated exposures)? Is the region a foraging ground or are the animals passing through as transients? What is the ratio of young (naïve) to old (experienced) animals in the population? It is unlikely that all such questions can be answered from empirical data; however, they should be addressed in any qualitative assessment of a potential stress response as based on the available literature.

Marine mammals naturally experience stressors within their environment and as part of their life histories. Changing weather and ocean conditions, exposure to diseases and naturally occurring toxins, lack of prey availability, social interactions with conspecifics, and interactions with predators all contribute to the stress a marine mammal experiences. In some cases, naturally occurring stressors can have profound impacts on marine mammals; for example, chronic stress, as observed in stranded animals with long-term debilitating conditions (e.g., disease), has been demonstrated to result in an increased size of the adrenal glands and an increase in the number of epinephrine-producing cells (Clark et al. 2006). Anthropogenic activities have the potential to provide additional stressors above and beyond those that occur naturally. Potential stressors resulting from anthropogenic activities must be considered not only as to their direct impact on the animal but also as to their cumulative impact with environmental stressors already experienced by the animal.

Studies on the stress response of odontocete cetaceans to acute acoustic stimuli were previously discussed (Thomas et al., 1990, Miksis et al., 2001, Romano et al. 2004). Other types of stressors include the presence of vessels, fishery interactions, acts of pursuit and capture, the act of stranding, and pollution. In contrast to the limited amount of work performed on stress responses resulting from sound exposure, a considerably larger body of work exists on stress responses associated with pursuit, capture, handling and stranding. Pursuit, capture and short-term holding of belugas has been observed to result in a decrease in thyroid hormones (St. Aubin and Geraci 1988) and increases in epinephrine (St. Aubin and Dierauf 2001). In dolphins, the trend is more complicated with the duration of the handling time potentially contributing to the magnitude of the stress response (St. Aubin et al. 1996, Ortiz and Worthy 2000, St. Aubin 2002). Elephant seals demonstrate an acute cortisol response to handling, but do not demonstrate a chronic response; on the contrary, adult females demonstrate a reduction in the adrenocortical response following repetitive chemical immobilization (Engelhard et al. 2002). With respect to anthropogenic sound as a stressor, the current limited body of knowledge will require extrapolation from species for which information exists to those for which no information exists.

The stress response may or may not result in a behavioral change, depending on the characteristics of the exposed animal. However, provided a stress response occurs, we assume that some contribution is made to the animal's allostatic load. Allostasis is the ability of an animal to maintain stability through change by adjusting its physiology in response to both predictable and unpredictable events (McEwen and Wingfield 2003). The same hormones associated with the stress response vary naturally throughout an animal's life, providing support for particular life history events (e.g., pregnancy) and predictable environmental conditions (e.g., seasonal changes). The allostatic load is the cumulative cost of allostasis incurred by an animal and is generally characterized with respect to an animal's energetic expenditure.

Perturbations to an animal that may occur with the presence of a stressor, either biological (e.g., predator) or anthropogenic (e.g., construction), can contribute to the allostatic load (McEwen and Wingfield 2003). Additional costs are cumulative and additions to the allostatic load over time may contribute to reductions in the probability of achieving ultimate life history functions (e.g., survival, maturation, reproductive effort and success) by producing pathophysiological states. The contribution to the allostatic load from a stressor requires estimating the magnitude and duration of the stress response, as well as any secondary contributions that might result from a change in behavior.

If the acoustic source does not produce tissue effects, is not perceived by the animal, or does not produce a stress response by any other means, it is assumed that the exposure does not contribute to the allostatic load. Additionally, without a stress response or auditory masking, it is assumed that there can be no behavioral change. Conversely, any immediate effect of exposure that produces an injury is assumed to also produce a stress response and contribute to the allostatic load.

Behavior- Acute stress responses may or may not cause a behavioral reaction. However, all changes in behavior are expected to result from an acute stress response. This expectation is based on the idea that some sort of physiological trigger must exist to change any behavior that is already being performed. The exception to this rule is the case of masking. The presence of a masking sound may not produce a stress response, but may interfere with the animal's ability to detect and discriminate biologically relevant signals. The inability to detect and discriminate biologically relevant signals hinders the potential for normal behavioral responses to auditory cues and is thus considered a behavioral change. Numerous behavioral changes can occur as a result of stress response, and lists only those that might be considered the most common types of response for a marine animal. For each potential behavioral change, the magnitude in the change and the severity of the response needs to be estimated. Certain conditions, such as stampeding (i.e., flight response) or a response to a predator, might have a probability of resulting in injury. For example, a flight response, if significant enough, could produce a stranding event. Under the Marine Mammal Protection Act, such an event would be considered a Marine Mammal Protection Act Level A harassment or mortality if the stranding leads to death. Each altered behavior may also have the potential to disrupt biologically significant events (e.g., breeding or nursing) and may need to be qualified as Marine Mammal Protection Act Level B harassment. Exposures to at-sea explosions resulting in sub-TTS behavioral disturbance are quantified as Marine Mammal Protection Act Level B harassment. All behavioral disruptions have the potential to contribute to the allostatic load. This secondary potential is signified by the feedback from the collective behaviors to allostatic loading (physiology block). The response of a marine mammal to an anthropogenic sound source will depend on the frequency content, duration, temporal pattern and amplitude of the sound as well as the animal's prior experience with the sound and the context in which the sound is encountered (i.e., what the animal is doing at the time of the exposure). The direction of the responses can vary, with some changes resulting in either increases or decreases from baseline (e.g., decreased dive times and increased respiration rate). Responses can also overlap; for example, an increased respiration rate is likely to be coupled to a flight response. Differential responses between and within species are expected since hearing ranges vary across species and the behavioral ecology of individual species is unlikely to completely overlap. A review of marine mammal responses to anthropogenic sound was first conducted by Richardson and others in 1995. A more recent review (Nowacek et al. 2007) addresses studies conducted since 1995 and focuses on observations where the received sound level of the exposed marine mammal(s) was known or could be estimated. The following sections provide a very brief overview of the state of knowledge of behavioral responses. The overviews focus on studies conducted since 2000 but are not meant to be comprehensive; rather, they provide an idea of the variability in behavioral responses that would be expected given the differential sensitivities of marine mammal species to sound and the wide range of potential acoustic sources to which a marine mammal may be exposed. Estimates of the types of behavioral responses that could occur for a given sound exposure should be determined from the literature that is available for each species, or extrapolated from closely related species when no information exists.

Behavioral responses to exposure to sound and explosions can range from no observable response to panic, flight and possibly more significant responses as discussed previously (Southall et al. 2007, NMFS 2009). It has been long recognized that the intensity of the behavioral responses exhibited by marine mammals depends on a number of conditions including the age, reproductive condition, experience, behavior (foraging or reproductive), species, received sound level, type of sound (impulse or continuous) and duration of sound

(Reviews by Richardson et al. 1995, Wartzok et al. 2003, Cox et al. 2006, Nowacek et al. 2007, Southall et al. 2007). Many behavioral responses may be short term (seconds to minutes) and of little immediate consequence for the animal such as simply orienting to the sound source. Alternatively, there may be a longer term response over several hours such as moving away from the sound source. In addition, some responses have the potential life function consequences such as leading to a stranding or a mother-offspring separation (Baraff and Weinrich 1993, Gabriele et al. 2001). Generally the louder the sound source the more intense the response although duration, context, and disposition of the animal are also very important (Southall et al. 2007). According to the severity scale response spectrum proposed by Southall et al. (2007), responses classified as from 0-3 are brief and minor, those from 4-6 have a higher potential to affect foraging, reproduction, or survival and those from 7-9 are likely to affect foraging, reproduction and survival. Explosive mitigation measures (exclusion zones) would likely prevent animals from being exposed to the loudest effects that could potentially result in TTS or PTS and more intense behavioral reactions on the response spectrum.

A large body of research on terrestrial animal and human response to airborne sound exists, but results from those studies are not readily extendible to the development of behavioral criteria and thresholds for marine mammals. For example, "annoyance" is one of several criteria used to define impact to humans from exposure to industrial sound sources. Comparable criteria cannot be developed for marine mammals because there is no scientifically acceptable method for determining whether a nonverbal animal is annoyed (NRC 2003). Further, differences in hearing thresholds, dynamic range of the ear, and the typical exposure patterns of interest (e.g., human data tend to focus on eight hour-long exposures) make extrapolation of human sound exposure standards inappropriate. At the present time there is no general scientifically accepted consensus on how to account for behavioral effects on marine mammals exposed to anthropogenic sounds including explosions (NRC 2003, NRC 2005). NRC (2005) acknowledges "there is not one case in which data can be integrated into models to demonstrate that noise is causing adverse affects on a marine mammal population.

Flight Response- A flight response is a dramatic change in normal movement to a directed and rapid movement away from the perceived location of a sound source. Relatively little information on flight responses of marine mammals to anthropogenic signals exists, although observations of flight responses to the presence of predators have occurred (Connor and Heithaus 1996). Flight responses have been speculated as being a component of marine mammal strandings (Evans and England 2001).

Response to Predators- Evidence suggests that at least some marine mammals have the ability to acoustically identify potential predators. For example, harbor seals that reside in the coastal waters off British Columbia are frequently targeted by certain groups of killer whales, but not others. The seals discriminate between the calls of threatening and non-threatening killer whales (Deecke et al. 2002), a capability that should increase survivorship while reducing the energy required for attending to and responding to all killer whale calls. The occurrence of masking or hearing impairment provides a means by which marine mammals may be prevented from responding to the acoustic cues produced by their predators. Whether or not this is a possibility depends on the duration of the masking/hearing impairment and the likelihood of encountering a predator during the time that predator cues are impeded.

Diving- Changes in dive behavior can vary widely. They may consist of increased or decreased dive times and surface intervals as well as changes in the rates of ascent and descent during a dive. Variations in dive behavior may reflect interruptions in biologically significant activities (e.g., foraging) or they may be of little biological significance. Variations in dive behavior may also expose an animal to potentially harmful conditions (e.g., increasing the chance of ship-strike) or may serve as an avoidance response that enhances survivorship. The impact of a variation in diving resulting from an acoustic exposure depends on what the animal is doing at the time of the exposure and the type and magnitude of the response. Nowacek et al. (2004) reported disruptions of dive behaviors in foraging North Atlantic right whales when exposed to an alerting stimulus, an action, they noted, that could lead to an increased likelihood of ship strike. However, the whales did not respond to playbacks of either right whale social sounds or vessel noise, highlighting the importance of the sound characteristics in producing a behavioral reaction. Conversely, Indo-Pacific humpback dolphins have been observed to dive for longer periods of time in areas where vessels were present and/or approaching (Ng and Leung 2003). In both of these studies, the influence of the sound exposure cannot be decoupled from the physical presence of a surface vessel, thus complicating interpretations of the relative contribution of each stimulus to the response. Indeed, the presence of surface vessels, their approach and speed of approach, seemed to be significant factors in the response of the Indo-Pacific humpback dolphins (Ng and Leung 2003). Low frequency signals of the Acoustic Thermometry of Ocean Climate (ATOC) sound source were not found to affect dive times of humpback whales in Hawaiian waters (Frankel and Clark 2000) or to overtly affect elephant seal dives (Costa et al. 2003). They did, however, produce subtle effects that varied in direction and degree among the individual seals, illustrating the equivocal nature of behavioral effects and consequent difficulty in defining and predicting them.

Foraging- Disruption of feeding behavior can be difficult to correlate with anthropogenic sound exposure, so it is usually inferred by observed displacement from known foraging areas, the appearance of secondary indicators (e.g., bubble nets or sediment plumes), or changes in dive behavior. Noise from seismic surveys was not found to impact the feeding behavior in western gray whales off the coast of Russia (Yazvenko et al. 2007) and sperm whales engaged in foraging dives did not abandon dives when exposed to distant signatures of seismic airguns (Madsen et al. 2006). Balaenopterid whales exposed to moderate low-frequency signals similar to the ATOC sound source demonstrated no variation in foraging activity.

Vocalizations- Vocal changes in response to anthropogenic noise can occur across the repertoire of sound production modes used by marine mammals, such as whistling, echolocation click production, calling, and singing. Changes may result in response to a need to compete with an increase in background noise or may reflect an increased vigilance or startle response. A similar compensatory effect for the presence of low frequency vessel noise has been suggested for right whales; right whales have been observed to shift the frequency content of their calls upward while reducing the rate of calling in areas of increased anthropogenic noise (Parks et al. 2007). Killer whales off the northwestern coast of the United States have been observed to increase the duration of primary calls once a threshold in observing vessel density (e.g., whale watching) was reached, which has been suggested as a response to increased masking noise produced by the vessels (Foote et al. 2004). In contrast, both sperm and pilot whales potentially ceased sound production during the Heard Island feasibility test (Bowles et al. 1994), although it cannot be absolutely determined whether the inability to acoustically detect the animals was due to the cessation of sound production or the displacement of animals from the area.

Avoidance- Avoidance is the displacement of an individual from an area as a result of the presence of a sound. It is qualitatively different from the flight response in its magnitude (i.e., directed movement, rate of travel, (Croll et al. 2001), whereas five out of six North Atlantic right whales exposed to an acoustic alarm interrupted their foraging dives (Nowacek et al. 2004). Although the received sound pressure level at the animals was similar in the latter two studies, the frequency, duration, and temporal pattern of signal presentation were different. These factors, as well as differences in species sensitivity, are likely contributing factors to the differential response. A determination of whether foraging disruptions incur fitness consequences will require information on or estimates of the energetic requirements of the individuals and the relationship between prey availability, foraging effort and success, and the life history stage of the animal.

Breathing- Variations in respiration naturally vary with different behaviors and variations in respiration rate as a function of acoustic exposure can be expected to co-occur with other behavioral reactions, such as a flight response or an alteration in diving. However, respiration rates in and of themselves may be representative of annoyance or an acute stress response. Mean exhalation rates of gray whales at rest and while diving were found to be unaffected by seismic surveys conducted adjacent to the whale feeding grounds (Gailey et al., 2007). Studies with captive harbor porpoises showed increased respiration rates upon introduction of acoustic alarms (Kastelein et al. 2000, Kastelein et al. 2006a) and emissions for underwater data transmission (Kastelein et al. 2005). However, exposure of the same acoustic alarm to a striped dolphin under the same conditions did not elicit a response (Kastelein et al. 2006a), again highlighting the importance in understanding species differences in the tolerance of underwater noise when determining the potential for impacts resulting from anthropogenic sound exposure.

Social relationships- Social interactions between mammals can be affected by noise via the disruption of communication signals or by the displacement of individuals. Disruption of social relationships therefore depends on the disruption of other behaviors (e.g., caused avoidance, masking, etc.) and no specific overview is provided here. However, social disruptions must be considered in context of the relationships that are affected). Often times avoidance is temporary, and animals return to the area once the noise has ceased. Longer term displacement is possible, however, which can lead to changes in abundance or distribution patterns of the species in the affected region if they do not become acclimated to the presence of the sound (Blackwell et al. 2004, Bejder et al. 2006, Teilmann et al. 2006). Acute avoidance responses have been observed in captive porpoises and pinnipeds exposed to a number of different sound sources (Kastelein et al. 2000, Finneran et al. 2003, Kastelein et al. 2006a, Kastelein et al. 2006b). Short term avoidance of seismic surveys, low frequency emissions, and acoustic deterrents has also been noted in wild populations of odontocetes (Bowles et al. 1994, Goold 1996, 1998, Stone et al. 2000, Morton and Symonds 2002) and to some extent in mysticetes (Gailey et al. 2007), while longer term or repetitive/chronic displacement for some dolphin groups and for manatees has been suggested to be due to the presence of chronic vessel noise (Haviland-Howell et al. 2007, Miksis-Olds et al. 2007).

Orientation- A shift in an animal's resting state or an intentional change via an orienting response represent behaviors that would be considered mild disruptions if occurring alone, and thus are placed at the bottom of the framework behavior list. As previously mentioned, the responses may co-occur with other behaviors; for instance, an animal may initially orient toward a sound source, and then move away from it. Thus, any orienting response should be considered in context of other reactions that may occur.

Proximate Life Functions- Proximate life history functions are the functions that the animal is engaged in at the time of acoustic exposure. The disruption of these functions, and the magnitude of the disruption, is something that must be considered in determining how the ultimate life history functions are affected. Consideration of the magnitude of the effect to each of the proximate life history functions is dependent upon the life stage of the animal. For example, an animal on a breeding ground which is sexually immature will suffer relatively little consequence to disruption of breeding behavior when compared to an actively displaying adult of prime reproductive age.

Ultimate Life Functions- The ultimate life functions are those that enable an animal to contribute to the population (or stock, or species, etc.). The impact to ultimate life functions will depend on the nature and magnitude of the perturbation to proximate life history functions. Depending on the severity of the response to the stressor, acute perturbations may have nominal to profound impacts on ultimate life functions. For example, underwater detonations in an area that is utilized for foraging, but not for breeding, may disrupt feeding by exposed animals for a brief period of time. Because of the brevity of the perturbation, the impact to ultimate life functions may be negligible. By contrast, weekly training over a period of years may have a more substantial impact because the stressor is chronic. Assessment of the magnitude of the stress response from the chronic perturbation would require an understanding of how and whether animals acclimate to a specific, repeated stressor and whether chronic elevations in the stress response (e.g., cortisol levels) produce fitness deficits. The proximate life functions are loosely ordered in decreasing severity of impact. Mortality (survival) has an immediate effect, in that no future reproductive success is feasible and there is no further addition to the population resulting from reproduction. Severe injuries may also lead to reduced survivorship (longevity) and prolonged alterations in behavior. The latter may affect an animal's overall reproductive success and reproductive effort. Disruptions of breeding have an immediate impact on reproductive effort and may impact reproductive success. The magnitude of the effect will depend on the duration of the disruption and the type of behavior change that was provoked. Disruptions to feeding and migration can affect all of the ultimate life functions; however, the impacts to reproductive effort and success are not likely to be as severe or immediate as those incurred by mortality and breeding disruptions. Taking into account these considerations, it was determined if there were population and species effects.

6.1.1 Integration of Physiological and Behavioral Effects

This section integrates the biological framework within which potential effects can be categorized and then related to the existing regulatory framework of injury (Marine Mammal Protection Act Level A harassment) and behavioral disruption (Marine Mammal Protection Act Level B harassment). The information presented in the previous sections is used to develop specific numerical exposure thresholds. Exposure thresholds are combined with underwater detonation and sound propagation models and species distribution data to estimate the potential exposures.

Sound exposure may affect multiple biological traits of a marine animal; however, existing protective regulations (i.e., Marine Mammal Protection Act) provide guidance as to which traits should be used when determining impacts. Specifically, impacts that qualify as Level A harassment should address injury and impacts that qualify as Level B harassment should address behavioral disruption. This guidance reduces the number of traits that must be considered in establishing a biological framework of impact assessment.

The biological framework outlined in this Incidental Harassment Authorization application is structured according to physiological and behavioral effects resulting from received pressure waveform, or total exposure. The range of effects may then be assessed to determine which qualify as harassment under Marine Mammal Protection Act regulations. Physiology and behavior are chosen over other biological traits for several reasons, including the fact that: (1) they are consistent with regulatory statements defining harassment; (2) they are components of other biological traits that may be relevant; and (3) they are a more sensitive and immediate indicator of effect. For example, ecology is not used as the basis of the framework because the ecology of a marine mammal is dependent upon the interaction of a marine mammal with the environment. The marine mammal's interaction with the environment is driven both by its physiological function and its behavior, and an ecological impact may not be observable over short periods of observation. Anatomy is not used because disruption of a marine mammal's anatomy would necessarily result in a change in physiological function.

The definitions of "physiological effect" and "behavioral effect" described within this document are specific to this Incidental Harassment Authorization application and based upon a NMFS approved approach.

A "*physiological effect*" is defined within the context of this Incidental Harassment Authorization application as one in which the "normal" physiological function of the marine mammal is altered in response to sound exposure. Physiological function is any of a collection of processes ranging from biochemical reactions to mechanical interaction and operation of organs and tissues within a marine mammal. A physiological effect may range from the most significant of impacts (e.g., mortality, serious injury) to lesser impacts that would define the lower end of the physiological impact range (e.g., non-injurious distortion of auditory tissues). This latter physiological effect is important to the integration of the biological and regulatory frameworks and is described in later sections.

A "*behavioral effect*" is one in which the "normal" behavior of an animal, or patterns of behavior, are overtly disrupted in response to an acoustic exposure. Examples of behaviors of concern can be derived from the harassment definitions of the Marine Mammal Protection Act.

In this Incidental Harassment Authorization application, the term "normal" is used to qualify distinctions between physiological and behavioral effects. Its use follows the convention of normal daily variation in physiological and behavioral function without the influence of anthropogenic acoustic sources. As a result, this Incidental Harassment Authorization application uses the following definitions:

A physiological effect is a variation in an animal's physiology that results from an anthropogenic sound exposure and exceeds the normal daily variation in physiological function.

A behavioral effect is a variation in an animal's behavior or behavior patterns that results from an anthropogenic sound exposure and exceeds the normal daily variation in behavior, but which arises through normal physiological process (it occurs without an accompanying physiological effect).

It is reasonable to expect some physiological effects to result in subsequent behavioral effects. For example, a marine mammal that suffers a severe injury may be expected to alter diving or foraging such that variation in these behaviors is outside that which is considered normal for the species. If a physiological effect is accompanied by a behavioral effect, the overall effect is characterized as a physiological effect; physiological effects take precedence over behavioral effects with regard to their ordering. This approach provides the most conservative evaluation of effects with respect to severity, provides a rational approach to dealing with the overlap of the definitions, and avoids circular arguments. The severity of physiological effects generally decreases with decreasing exposure (acoustic or blast-wave) and/or increasing distance from the sound source. The same generalization does not consistently hold for behavioral effects because they do not depend solely on received sound levels. Behavioral responses also depend on an animal's learned responses, innate response tendencies, motivational state, the pattern of the sound exposure, and the context in which sounds are presented. However, to provide a tractable approach to predicting acoustic impacts that is relevant to the terms of behavioral disruption described in the Marine Mammal Protection Act; it is assumed herein that the severity of behavioral effects also decreases with decreasing sound exposure and/or increasing distance from the sound source.

6.1.2 Level A and Level B Harassment

Categorizing potential effects as either physiological or behavioral effects allows them to be related to the harassment definitions. For military readiness activities, Marine Mammal Protection Act Level A harassment includes any act that injures or has the significant potential to injure a marine mammal or marine mammal stock in the wild. Injury, as defined in this Incidental Harassment Authorization request and previous rulings (NMFS 2001, 2002, 2008a, 2008b), is the destruction or loss of biological tissue from a species. The destruction or loss of biological tissue will result in an alteration of physiological function that exceeds the normal daily physiological variation of the intact tissue. For example, increased localized histamine production, edema, production of scar tissue, activation of clotting factors, white blood cell response, etc., may be expected following injury.

Therefore, this Incidental Harassment Authorization application assumes that all injury is qualified as a physiological effect and, to be consistent with prior actions and rulings (NMFS 2001, 2008a, 2008b), all injuries (slight to severe) are considered Marine Mammal Protection Act Level A harassment. Public Law 108-136 (2004) amended the Marine Mammal Protection Act definitions of Level B harassment for military readiness activities, which applies to this action. For military readiness activities, Marine Mammal Protection Act Level B harassment is defined as "any act that disturbs or is likely to disturb a marine mammal or marine mammal stock by causing disruption of natural behavioral patterns including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering to a point where such behaviors are abandoned or significantly altered." Unlike Marine Mammal Protection Act Level A harassment, which is solely associated with physiological effects, both physiological and behavioral effects may cause Marine Mammal Protection Act Level B harassment.

For example, some physiological effects (such as TTS) can occur that are non-injurious but that can potentially disrupt the behavior of a marine mammal. These include temporary distortions in sensory tissue that alter physiological function, but that are fully recoverable without the requirement for tissue replacement or regeneration. For example, an animal that experiences a temporary reduction in hearing sensitivity suffers no injury to its auditory system, but may not perceive some sounds due to the reduction in sensitivity. As a result, the animal may not respond to sounds that would normally produce a behavioral reaction. This lack of response qualifies as a temporary disruption of normal behavioral patterns – the animal is impeded from responding in a normal manner to an acoustic stimulus. The harassment status of slight behavior disruption has been addressed in workshops, previous actions, and rulings (NMFS 2001, 2008a, 2008b, DoN 2001a). The conclusion is that a momentary behavioral reaction of an animal to a brief, time-isolated acoustic event does not qualify as Marine Mammal Protection Act Level B harassment. A more general conclusion, that Marine Mammal Protection Act Level B harassment occurs only when there is "a potential for a significant behavioral change or response in a biologically important behavior or activity," is found in recent rulings (NMFS 2002a, 2008a, 2008b). Public Law 108-136 (2004) amended the definition of Marine Mammal Protection Act Level B harassment for military readiness activities.,

Although the temporary lack of response discussed above may not result in abandonment or significant alteration of natural behavioral patterns, the acoustic effect inputs used in the acoustic model assume that temporary hearing impairment (slight to severe) is considered Marine Mammal Protection Act Level B harassment. Although modes of action are appropriately considered, the conservative assumption used here is to consider all hearing impairment as harassment from TTS. As a result, the actual incidental harassment of marine mammals associated with this action may be less than predicted via the analytical framework.

To assess the potential for harassment, two quantities are of interest:

- The number of animals with probability of being present in the zone of influence (ZOI) for injury but not detected.
- The expected number of marine mammals within various radii of the detonation point or pile driving (i.e., ZOI ranges for mortality, injury, and behavioral disruption) is included in the considerations. This quantity is ordinarily referred to as "incidental take."

For this Incidental Harassment Authorization application, estimates of the numbers of species within the harassment zones and exposed to the various underwater detonation and ELCAS training sound sources were calculated assuming that none of the current mitigation measures routinely used for SSTC training events were implemented. Harassment that may result from Navy events described in this Incidental Harassment Authorization application is unintentional and incidental to those events.

6.1.3 Harassment and Mortality Zones

The volumes of ocean in which Level A and B harassment are predicted to occur are described as harassment zones. All animals predicted to be in a zone are considered "exposed" within the applicable harassment category.

The Level A harassment zone extends from the source out to the distance and exposure where slight injury is predicted to occur. The acoustic exposure that produces slight injury is therefore the threshold value defining the outermost limit of the Level A harassment zone. A dual criterion approach was used to determine potential impact ranges for Level A. Criterion included 1% mortality, which could occur from either maximum shock wave pressure or bulk cavitation, and slight injury. Slight injury included onset gastro-intestinal tract injury, which could occur from maximum shock wave pressure, and onset permanent threshold shift (PTS) which could occur from either maximum shock wave pressure or weighted energy flux density. Use of the threshold associated with the onset of slight injury (onset PTS) as the most distant point and least injurious exposures account of all more serious injuries by inclusion within the Level A harassment zone.

The Level B harassment zone begins just beyond the point of slightest injury and extends outward from that point. It includes all animals that may potentially experience Level B harassment. Physiological effects extend beyond the range of slightest injury to a point where slight temporary distortion of the most sensitive tissue occurs, but without destruction or loss of that tissue. The animals predicted to be in this zone experience Level B harassment by virtue of temporary impairment of sensory function (i.e., altered physiological function) that can disrupt behavior. Beyond that distance, the Level B harassment zone continues to the point at which no biologically significant behavioral disruption is expected to occur. Onset of temporary impact criterion included onset TTS which could occur from either maximum shock wave pressure or weighted energy flux density.

6.1.4 Auditory Tissues as Indicators of Physiological Effects

The mammalian auditory system consists of the outer ear, middle ear, inner ear, and central nervous system. Sound waves are transmitted through the outer and middle ears to fluids within the inner ear. The inner ear contains delicate electromechanical hair cells that convert the fluid motions into neural impulses that are sent to the brain. The hair cells within the inner ear are the most vulnerable to overstimulation by noise exposure (Yost 1994). Very high sound levels may rupture the eardrum or damage the small bones in the middle ear (Yost 1994). Lower level exposures may cause permanent or temporary hearing loss—called a noise-induced threshold shift (NITS) or simply threshold shift (TS) (Miller 1974, Ward 1997). A TS may be permanent, called a permanent threshold shift (PTS), or temporary, called a temporary threshold shift (TTS). Still lower exposures may result in auditory masking interfering with a marine mammal's ability to hear other concurrent sounds.

A TTS is a result of auditory system fatigue following stimulation. Collectively, these qualify as physiological changes that would exceed the normal daily variation in physiological function specific to those components of the auditory system. A PTS results from injury, which may occur at multiple levels of the auditory system. Tissue destruction can produce both localized and distributed variations in physiology depending on the type, location, and magnitude of the injury. With respect to auditory tissues, destruction of tissues associated with PTS would, at a minimum, result in localized changes in the physiology of the tissue that exceeds its normal daily variation in physiological function. Therefore, both TTS and PTS are physiological effects.

The amount of TS depends on the amplitude, duration, frequency, and temporal pattern of the sound exposure. Threshold shifts generally increase with the amplitude and duration of sound exposure. For continuous sounds, exposures of equal energy would lead to approximately equal effects (Ward 1997). For intermittent sounds, less TS occurs from continuous exposure with the same energy; further, some recovery occurs between exposures (Kryter et al. 1966, Ward 1997). The relationships between sound exposure parameters and resulting TS are not well understood for impulsive sounds. The TSs from impulsive sounds are generally more difficult to characterize than TSs from continuous-type sounds, in part because of the wide variety of impulsive sound waveforms that may be encountered (Hamernik et al. 1991). The magnitude of TS normally decreases with the amount of time post-exposure (Miller 1974). The amount of TS just after exposure is called the initial TS. If the TS eventually returns to zero (i.e., the threshold returns to the pre-exposure value), the TS is a TTS. Because the amount of TTS depends on the time post-exposure, it is common to use a subscript to indicate the time in minutes after exposure (Quaranta et al. 1998). For example, TTS_2 means a TTS measured two minutes after exposure. If the TS does not return to zero but leaves some finite amount of TS, that remaining TS is a PTS. The distinction between PTS and TTS is based on whether there is a complete recovery of TS following a sound exposure.

Because the tissues of the ear appear to be the most susceptible to the physiological effects of sound, this Incidental Harassment Authorization application uses physiological effects on the auditory system to define harassment zone boundaries. Table 6-1. outlines the selecting criteria for physiological effects leading to injury—the outer limits of the Level A harassment zone, and the criteria and thresholds for physiological effects leading to behavioral disturbance—the outer limits of the Level B harassment zone.

6.1.5 Mortality Zone

Marine mammals can be killed by underwater explosions due to the response of air cavities, such as the lungs and bubbles in the intestines, to the shock wave (Elsayed 1997, Elsayed and Gorbunov 2007). The criterion for mortality used in this Incidental Harassment Authorization application is the onset of extensive lung hemorrhage. Extensive lung hemorrhage is considered debilitating and potentially fatal as a result of air embolism or suffocation. In this Incidental Harassment Authorization application, all marine mammals within the calculated radius for 1% probability of onset of extensive lung injury (i.e., onset of mortality) are counted as lethal exposures. The range at which 1% probability of onset of extensive lung hemorrhage is expected to occur is greater than the ranges at which 50% to 100% lethality would occur from closest proximity to the charge or from presence within the bulk cavitation region. (The region of bulk cavitation is an area near the surface above the detonation point in which the reflected shock wave creates a region of cavitation within which smaller animals would not be expected to survive). Because the range for onset of extensive lung hemorrhage for smaller animals exceeds the range for bulk cavitation and all more serious injuries, all smaller animals within the region of cavitation and all animals (regardless of body mass) with more serious injuries than onset of extensive lung hemorrhage are accounted for in the lethal exposures estimate. The calculated maximum ranges for onset of extensive lung hemorrhage depend upon animal body mass, with smaller animals having the greatest potential for impact, as well as water column temperature and density.

6.1.6 Injury and the Level A Harassment Zone

The Level A harassment zone encompasses all non-lethal injuries that could potentially occur to marine mammals as a result of blast exposure. The criteria used to define the outer edge of the Level A harassment zone is the range at which PTS begins to occur (onset PTS). The auditory system consists of delicate tissues (e.g., hair cells) that are sensitive to pressure changes and responsive to sound exposures that are well below levels likely to cause trauma to non-auditory, air containing structures. PTS is non-recoverable and must result from the destruction of tissues within the auditory system (e.g., tympanic membrane rupture, disarticulation of the middle ear ossicles, and hair-cell damage).

PTS therefore qualifies as an injury and is classified as Level A harassment under the wording of the Marine Mammal Protection Act. Onset PTS is indicative of the minimum level of injury that can occur due to sound exposure. All other forms of trauma would occur closer to the sound source than the range at which onset PTS occurs.

6.1.7 TTS and the Level B Harassment Zone

The Level A harassment zone extends from the detonation/pile driving point outward to that point where the slightest injury may occur. Therefore, the Level B TTS harassment zone begins just beyond the point at which the slightest amount of injury occurs and extends outward to the distance and exposure where the onset of TTS is expected to occur. Consistent with previous NMFS rulings, single, time-isolated impulsive events such as that described in this Incidental Harassment Authorization application are considered incapable of causing significant behavioral disruption at levels below those causing TTS. Because of the transient nature of the sources used in this action, the limited number of detonations and pile driving events, and temporal spacing of detonations, no significant behavioral effects that qualify as Level B TTS harassment would occur in this action (NMFS 2001, NMFS 2009a, NMFS 2009b). As a result, only physiological effects need be considered in the development of harassment criteria..TTS is recoverable and, as in recent rules (NMFS 2009a, 2009b), is considered to result from the temporary, non-injurious distortion of hearing-related tissues. In this Incidental Harassment Authorization application, the smallest measurable amount of TTS (onset TTS) is taken as the best indicator for slight temporary sensory impairment. The acoustic exposure associated with onset TTS is used to define the outer limit of the portion of the Level B harassment zone attributable to physiological effects. This follows from the concept that hearing loss potentially affects a marine mammal's ability to react normally to the sounds around it; it potentially disrupts normal behavior by preventing it from occurring. Therefore, the potential for TTS qualifies as a Level B harassment that is mediated by physiological effects upon the auditory system.

6.1.8 Behavioral Effects and the Level B Harassment Zone

This Incidental Harassment Authorization application defines behavioral effects as variations in a marine mammal's behavior that exceed the normal daily variation in behavior, do not meet the definition of a physiological effect, and which follow an anthropogenic sound exposure. Level B harassment includes only those acts which disturb or are likely to disturb by causing disruption of behavioral patterns to the point where those patterns are abandoned or significantly altered. Previous actions and rules (NMFS 2001, 2009a, 2009b, DoN , 2008a, 2008b) have concluded that a momentary behavioral reaction of a marine mammal to a brief, time-isolated acoustic event does not qualify as Level B harassment. That Level B harassment occurs only when there is "a potential for a significant behavioral change or response in a biologically important behavior or activity" was found in recent rules (2009a, 2009b). This conclusion is further supported by the National Defense Authorization Act of 2004 (Public Law 108-136) for actions involving military readiness, as defined in Section 11.

The short-duration underwater detonations and pile driving events proposed in this Incidental Harassment Authorization application are brief and time-isolated. In this Incidental Harassment Authorization application and consistent with prior rules (e.g., NMFS, 2001, 2009a, 2009b), they are considered incapable of causing behavioral effects beyond slight, momentary disruption and are unlikely to have any significant biological impact upon exposed animals. Furthermore, the transient nature of impulsive sources proposed for this action, the limited number of detonations required for the completion of the action, the temporal spacing of detonations and pier construction events (on the order of days to months), and the dynamic and patchy nature of offshore animal distributions makes it unlikely that any animal would be exposed to more than one acoustic event. These conclusions are considered as limiting factors in the development of harassment zones for this proposed action. Behavioral disruption that is not due to a physiological effect (i.e., behavioral disruption at levels below those causing TTS) is considered to have a negligible impact and to not rise to the significance of Level B harassment.

6.1.9 Auditory Masking

Natural and artificial sounds can disrupt behavior by masking, or interfering with a marine mammal's ability to hear other sounds. Masking occurs when the receipt of a sound is interfered with by another coincident sound at similar frequencies and at similar or higher levels. If the second sound were man-made, it could be potentially harassing (according to the Marine Mammal Protection Act) if it disrupted hearing-related behavior such as communications or echolocation. It is important to distinguish TTS and PTS, which persist after the sound exposure, from masking, which occurs during the sound exposure. Because masking (without a resulting threshold shift) is not associated with abnormal physiological function, it is not considered a physiological effect in this Incidental Harassment Authorization application, but rather a potential behavioral effect.

The most intense underwater sounds in the proposed action are those produced by underwater detonations and pile driving. Given that the energy distribution of an underwater explosion and pile driving covers a broad frequency spectrum, sound from the SSTC these sources would likely be within the audible range of California sea lions, harbor seals, bottlenose dolphins, and gray whales. However, the time scale of the explosive shots is very limited; the pulse lengths are short, the repetitions of the shots are few (in some cases no repetition), and the total time per year during which detonations occur is small. Pile driving activity is relatively short-term, with rapid pulses occurring for approximately 10 minutes every 2 hours over a period of approximately 10 days. The probability for any detonation or pile driving resulting from this proposed action masking acoustic signals important to the behavior and survival of marine mammal species is therefore negligible. Additionally, for reasons outlined above, any masking event that did occur would be considered transient and insignificant and would not qualify as Level B harassment. Masking effects are not considered as contributing to exposure estimates in this Incidental Harassment Authorization application.

6.2 Impact Criteria and Thresholds

The effects of an at-sea explosion or pile driving on a marine mammal depends on many factors, including the size, type, and depth of both the animal and the explosive charge/pile being driven; the depth of the water column; the standoff distance between the charge/pile and the animal; and the sound propagation properties of the environment. Potential impacts can range from brief acoustic effects (such as behavioral disturbance), tactile perception, physical discomfort, slight injury of the internal organs and the auditory system, to death of the animal (Yelverton et al. 1973, O'Keeffe and Young 1984, DoN 2001). Non-lethal injury includes slight injury to internal organs and the auditory system; however, delayed lethality can be a result of individual or cumulative sublethal injuries (DoN 2001a). Short-term or immediate lethal injury would result from massive combined trauma to internal organs as a direct result of proximity to the point of detonation or pile driving (DoN 2001a).

This section summarizes the marine mammal impact criteria used for the subsequent modeled calculations. The following terminology is used:

In this Incidental Harassment Authorization application, several standard acoustic metrics (Urick 1983) are used to describe the thresholds for predicting potential physical impacts from underwater pressure waves:

• Total energy flux density or Sound Exposure Level (SEL). For plane waves (as assumed here), SEL is the time integral of the instantaneous intensity, where the instantaneous intensity is defined as the squared pressure divided by the impedance of sea water. Thus, SEL is the instantaneous pressure amplitude squared, summed over the duration of the signal and has dB units referenced to 1 re μPa^2-s.

• 1/3-octave SEL. This is the SEL in a 1/3-octave frequency band. A 1/3-octave band has upper and lower frequency limits with a ratio of 21:3, creating bandwidth limits of about 23 percent of center frequency.

• Positive impulse. This is the time integral of the initial positive pressure pulse of an explosion or explosive-like wave form. Standard units are Pa-sec, but psi-ms also are used.

• Peak pressure. This is the maximum positive amplitude of a pressure wave, dependent on charge mass and range. Units used here are psi, but other units of pressure, such as μPa and Bar, also are used.

• Criterion. Specific impact that could be used to represent a broad type of impacts (mortality, injury, harassment). For example, 1% probability of onset of severe lung injury (extensive lung hemorrhage) is used in this Incidental Harassment Authorization application as a criterion for the onset of mortality.

• Threshold. The specific level of sound pressure, impulse, or energy needed to cause the specific impact stated in a criterion.

• Range. The maximum horizontal distance from a detonation point where the threshold level is predicted to occur.

To assess the effects of underwater explosions at SSTC, three types of criteria are necessary, those for mortality, those for injury (i.e., Level A harassment) and those for non-injurious physiological and/or behavioral disruption (i.e., Level B harassment).

6.2.1 Harassment Threshold for Sequential Underwater Detonations

There may be rare occasions when sequential underwater detonations are part of a static location event. Sequential detonations are more than one detonation within a 24-hour period in a geographic location where harassment zones overlap. For sequential underwater detonations, accumulated energy over the entire training time is the natural extension for energy thresholds since energy accumulates with each subsequent shot.

For sequential underwater detonations, the acoustic criterion for behavioral harassment is used to account for behavioral effects significant enough to be judged as harassment, but occurring at lower sound energy levels than those that may cause TTS. The behavioral harassment threshold is based on recent rulemaking from NMFS (NMFS 2009a, 2009b) for the energy-based TTS threshold. The research on pure tone exposures reported in Schlundt et al. (2000) and Finneran and Schlundt (2004) provided the pure-tone threshold of 192 dB as the lowest TTS value. This value is modified for explosives by (a) interpreting it as an energy metric, (b) reducing it by 10 dB to account for the time constant of the mammal ear, and (c) measuring the energy in 1/3 octave bands, the natural filter band of the ear. The resulting TTS threshold for explosives is 182 dB re 1 μPa^2-s in any 1/3 octave band. As reported by Schlundt et al. (2000) and Finneran and Schlundt (2004), instances of altered behavior in the pure tone research generally began 5 dB lower than those causing TTS. The behavioral harassment threshold is therefore derived by subtracting 5 dB from the 182 dB re 1 μPa^2-s in any 1/3 octave band threshold, resulting in a 177 dB re 1 μPa^2-s behavioral disturbance harassment threshold for multiple successive explosives (**Table 6-1**).

6.2.2 Criteria for ELCAS pile driving and removal

Since 1997, NMFS has been using generic sound exposure thresholds to determine when an activity in the ocean that produces impact sound (i.e., pile driving) result in potential take of marine mammals by harassment (70 CFR 1871). NMFS is developing new science-based thresholds to improve and replace the current generic exposure level thresholds, but the criteria have not been finalized (Southall et al. 2007). Current NMFS criteria (70 FR 1871) regarding exposure of marine mammals to underwater impulsive sounds (e.g., impact pile driving) is that cetaceans exposed to sound levels of 180 dB root mean squared (RMS in units of dB re 1 μPa) or higher and pinnipeds exposed to 190 dB RMS or higher are considered to have been taken by Level A (i.e., injurious) harassment. Marine mammals (cetaceans and pinnipeds) exposed to impulse sounds of 160 dB RMS but below injurious thresholds (i.e., 180 or 190 dB) are considered to have been taken by Level B behavioral harassment. Marine mammals (cetaceans and pinnipeds) exposed to continuous noise of 120 dB RMS (e.g., vibratory pile driving) or above are considered to have been taken by Level B behavioral harassment (**Table 6-1**).

6.2.3 Criteria Summary

Criteria and thresholds mortality, Level A injury harassment, and Level B harassment from underwater detonations and pile driving are summarized in **Table 6-1**. For underwater detonations, criteria used in the Hawaii Range Complex and Southern California Range Complex Final Environmental Impact Statement/Overseas Environmental Impact Statements (DoN 2008a, 2008b), and approved by NMFS through subsequent rulemaking (NMFS 2009a, 2009b) was used for the SSTC Incidental Harassment Authorization application. For pile driving, NMFS developed criteria provided in the Notice of Intent to prepare an Environmental Impact Statement to analyze impacts of applying new criteria to guidelines under the Marine Mammal Protection Act and Endangered Species Act (70 FR 1871) was used.

Table 6-1. Effects criteria for underwater detonations and ELCAS pile driving\removal

Underwater Explosive Criteria		
Criterion	**Criterion Definition**	**Threshold**
Mortality	**Onset of severe lung injury (1% probability of mortality)**	**31 psi-ms (positive impulse)**
Level A Harassment (Injury)	**Slight lung injury; or**	**13.0 psi-ms (positive impulse)**
	50% of marine mammals would experience ear drum rupture; and 30% exposed sustain PTS	**205 dB re $1\mu Pa^2$-sec (full spectrum energy)**
Level B Behavioral Harassment	**TTS (dual criteria)**	**23 psi (peak pressure; explosives <2,000 lbs), or**
		182 dB re$1\mu Pa^2$-sec (peak 1/3 octave band)
	(sequential detonations only)	**177 dB re $1\mu Pa^2$-sec**
Pile Driving\ Removal Criteria		
Criterion	**Criterion Definition**	**Threshold**
Level A Harassment	**Pinnipeds only Impulsive sound (i.e., pile driving)**	**190 dB RMS (dB re 1 μPa)**
Level A Harassment	**Cetaceans only Impulsive sound (i.e., pile driving)**	**180 dB RMS (dB re 1 μPa)**
Level B Harassment	**Cetaceans and pinnipeds Impulsive sound (i.e., pile driving)**	**160 dB RMS (dB re 1 μPa)**
Level B Harassment	**Cetaceans and pinnipeds Continuous noise (i.e., vibratory pile removal)**	**120 dB RMS (dB re 1 μPa)**

6.3 Assessing for Explosive Effects of Underwater Detonations

6.3.1 Predictive Modeling for Underwater Detonations- Overview

Underwater detonations produced during SSTC training events represent a single, known source. Chemical explosives create a bubble of expanding gases as the material burns. The bubble can oscillate underwater or, depending on charge-size and depth, be vented to the surface in which case there is no bubble-oscillation with its associated low-frequency energy. Explosions produce very brief, broadband pulses characterized by rapid rise-time, great zero-to-peak pressures, and intense sound, sometimes described as impulse. Close to the explosion, there is a very brief, great-pressure acoustic wave-front. The signal's rapid onset time, in addition to great peak pressure, can cause auditory impacts, although the brevity of the signal can include less SEL than expected to cause impacts. The transient signal gradually decays in magnitude as it broadens in duration with range from the source. The waveform transforms to approximate a low-frequency, broadband signal with a continuous sound energy distribution across the spectrum. In addition, underwater explosions are relatively brief, transitory events when compared to the existing ambient noise within the San Diego Bay and at the SSTC. Ambient noise can be composed of natural sources such as wind, surf, and biological activity (ex., snapping shrimp, fish calls, and marine mammal vocalizations), as well as generalized distance sound from human activities of which shipping is the dominant component (Richardson et al. 1995, NRC 2003, 2005).

The impacts of an underwater explosion to a marine mammal are dependent upon multiple factors including the size, type, and depth of both the animal and the explosive. Depth of the water column and the distance from the charge to the animal also are determining factors as are boundary conditions that influence reflections and refraction of energy radiated from the source. The severity of physiological effects generally decreases with decreasing exposure (impulse, sound exposure level, or peak pressure) and/or increasing distance from the sound source. The same generalization consistently is not applicable for behavioral effects, because they solely do not depend on sound exposure level. Behavioral responses also depend on an animal's learned responses, innate response tendencies, motivational state, pattern of the sound exposure, and context in which sounds are presented. Potential impacts can range from brief acoustic effects, tactile perception, and physical discomfort to both lethal and non-lethal injuries. Disturbance of ongoing behaviors could occur as a result of noninjurious physiological responses to both the acoustic signature and shock wave from the underwater explosion. Nonlethal injury includes slight injury to internal organs and auditory system. The severity of physiological effects generally decreases with decreasing sound exposure and/or increasing distance from the sound source. Injuries to internal organs and the auditory system from shock waves and intense impulsive noise associated with explosions can be exacerbated by strong bottom-reflected pressure pulses in reverberant environments (Gaspin 1983, Ahroon et al. 1996). The same generalization applies to behavioral effects, but is complicated by the fact that behavioral responses also depend on an animal's learned responses, innate response tendencies, motivational state, pattern of the sound exposure, and the context in which the sound is presented. While there are little data on the consequences of sound exposure from underwater detonations on behavioral or vital rates of marine mammals, exposure to sounds resulting from Navy underwater explosive training would be brief as each event is relatively discrete and separate in time and space from other similar events. In addition, the overall size of the explosives used at the SSTC is much smaller than those used during larger Fleet ship and aircraft training events.

6.3.2 Predictive Modeling for Underwater Detonations- Modeling Framework

All underwater detonations proposed for SSTC were modeled as if they will be conducted in shallow water of 24 to 72 feet, including those that would normally be conducted in very shallow water (VSW) depths of zero to 24 feet. Modeling in deeper than actual water depths causes the modeled results to be more conservative (i.e., over prediction of propagation and potential exposures) than if the underwater detonations were modeled at their actual, representative depths when water depth is less than 24 feet. As will be discussed later and in Section 11, in deeper water, there is less sound and energy propagation interference associated with the sea bottom and water surface.

The effects that underwater detonations have on a marine mammals is dependent upon multiple factors including size of the detonation, type of detonation, species of marine mammal, and depth of both the mammal and detonation. Depth of the water column and distance from the charge to the marine mammal also are determining factors. To quantify impacts, the U.S. Navy has developed simulations that determine exposures of protected species during training operations.

The Navy's underwater explosive effects simulation requires six major process components:

- a training event description including explosive type;
- physical oceanographic and geoacoustic data for input into the acoustic propagation model representing seasonality of the planned operation;
- biological data for the area including density (and multidimensional animal movement for those training events with multiple detonations);
- an acoustic propagation model suitable for the source type to predict impulse, energy, and peak pressure at ranges and depths from the source;
- the ability to collect acoustic and animal movement information to predict exposures for all animals during a training event (dosimeter record [1]); and
- the ability for post-operation processing to evaluate the dosimeter exposure record and calculate exposure statistics for each species based on applicable thresholds (Section 6.2.3).

An impact model, such as the one used for the SSTC analysis, simulates the conditions present based on location(s), source(s), and species parameters by using combinations of embedded models (Mitchell et al. 2008). The software package used for SSTC consists of two main parts: an underwater noise model and bioacoustic impact model (Lazauski et al. 1999; Lazauski and Mitchell 2006; Lazauski and Mitchell 2008).

1 A virtual dosimeter is a time-step log of received impulse, energy, pressures, or other explosion characteristics that are collected during the simulated training exercise.

Location-specific data characterize the physical and biological environments while exercise-specific data construct the training operations. The quantification process involves employment of modeling tools that yield numbers of exposures for each training operation (**Figure 6-1).**

During modeling, the exposures are logged in a time-step manner by virtual dosimeters linked to each simulated animal. After the operation simulation, the logs are compared to exposure thresholds to produce raw exposure statistics. It is important to note that dosimeters only were used to determine exposures based on energy thresholds, not impulse or peak pressure thresholds. The analysis process uses quantitative methods and identifies immediate short-term impacts of the explosions based on assumptions inherent in modeling processes, criteria and thresholds used, and input data. The estimations should be viewed with caution, keeping in mind that they do not reflect measures taken to avoid these impacts (i.e., mitigations). Ultimately, the goals of this acoustic impact model were to predict acoustic propagation, estimate exposure levels, and reliably predict impacts.

Figure 6-1 shows the conceptual model framework used for the SSTC impact analysis.

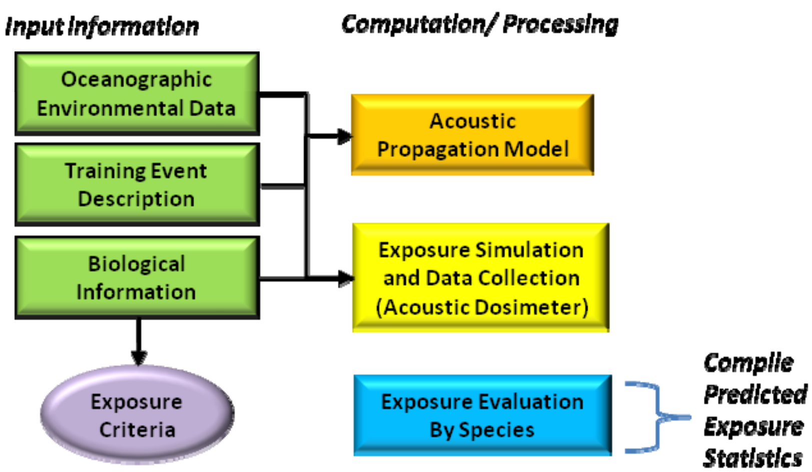

Figure 6-1. Generalized modeling process for estimating exposures from SSTC underwater detonations.

Predicting Impulse, Energy, and Peak Pressure- Predictive sound analysis software incorporates specific bathymetric and oceanographic data to create accurate sound field models for each source type. Oceanographic data such as the sound speed profiles, bathymetry, and seafloor properties directly affect the acoustic propagation model. Depending on location, seasonal variations, and the oceanic current flow, dynamic oceanographic attributes (e.g., sound speed profile) dramatically can change with time. The sound field model is embedded in the impact model as a core feature used to analyze sound and pressure fields associated with SSTC underwater detonations.

The sound field model for SSTC detonations was the Reflection and Refraction in Multilayered Ocean/Ocean Bottoms with Shear Wave Effects (REFMS) model (version 6.03). The REFMS model calculates the combined reflected and refracted shock wave environment for underwater detonations using a single, generalized model based on linear wave propagation theory (Cagniard 1962, Britt 1986, Britt et al. 1991). The Cagniard model used in REFMS sometimes is referred to as Generalized Ray Theory in seismology.

The required inputs for the REFMS model include:

- representation of the layered water and sediment environment including compressional wave speed, sediment and water density, and layer depth;
- explosive weight, type, and depth; and
- receiver depth and range from the source

Similitude equations calculate constants for each explosive type in terms of trinitrotoluene (TNT) equivalents referred to as similarity parameters for explosives. Britt et al. (1991) indicated that care should be taken in using similitude for small charges. REFMS models the variation of physical properties (i.e., sound speed, shear wave speed, and density) with depth in the ocean water column and at the seafloor. The water column and seafloor are represented with up to 300 homogeneous layers depending on the environment where detonations occur.

The model outputs include positive impulse, sound exposure level (Sound exposure level; total and in 1/3-octave bands) at specific ranges and depths of receivers (i.e., marine mammals), and peak pressure. The shock wave consists of two parts, a very rapid onset "impulsive" rise to positive peak over-pressure followed by a reflected negative under-pressure rarefaction wave (**Figure 6-2**). Propagation of shock waves and sound energy in the shallow-water environment is constrained by boundary conditions at the surface and seafloor (**Figure 6-3**). In Figure 6-3, a hypothetical source is shown below the sea surface and above the seabed, indicating energy from the explosion reaches a subsurface receiver via multi-paths. An iso-speed water column was used for illustrative purposes, because it resembles the simplified SSTC situation. The iso-speed condition indicates no refraction of paths from changes in sound speed.

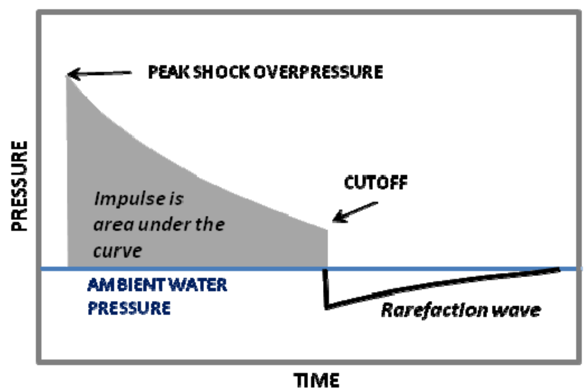

Figure 6-2. Generalized shock wave.

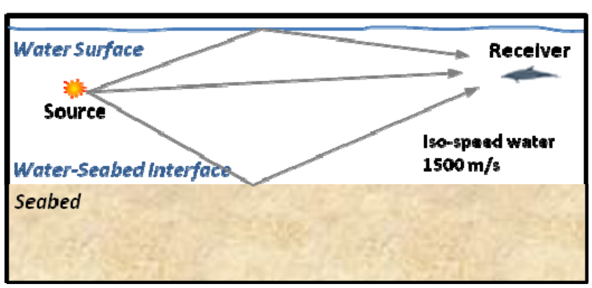

Figure 6-3. Generalized underwater pathways of shock waves and sound energy **(adapted from Siderius and Porter 2006).**

Estimating Exposures- Multiple locations (in Boat Lanes and Echo area) and charge depths were used to determine the most realistic spatial and temporal distribution of detonation types associated with each training operation for a representative year. Additionally, the effect of sound on an animal depends on many factors including:

- properties of the acoustic source(s): source level (SL), spectrum, duration, and duty cycle;
- sound propagation loss from source to animal, as well as, reflection and refraction;
- received sound exposure measured using well-defined metrics;
- specific hearing;
- exposure duration; and
- masking effects of background and ambient noise.

To estimate exposures sufficient to be considered injury or significantly disrupt behavior by affecting the ability of an individual animal to grow (e.g., feeding and energetics), survive (e.g., behavioral reactions leading to injury or death, such as stranding), reproduce (e.g., mating behaviors), and/or degrade habitat quality resulting in abandonment or avoidance of those areas, dosimeters were attached to the virtual animals during the simulation process. Propagation and received impulse, SEL, and peak pressure are a function of depth, as well as, range depending on the location of an animal in the simulation space. As stated previously, dosimeters were used to collect and retain exposure logs for SEL with associated time stamps.

Predicting Impacts- Predicting impacts to marine mammals from underwater detonations required knowledge regarding the criteria levels associated with mortality, injury, and physiological and behavioral disruption (see Section 6.2.3). Criteria and thresholds associated with impulse, SEL, and peak pressure are used to determine impact to internal organs and sensitive auditory tissues. In addition, disruption of behaviors from MSEs was considered. Exposures were quantified based on exceeding the associated thresholds. Note, efforts to minimize exposure to impacts (i.e., mitigation proposed in Section 11) are not quantified or applied to these estimated exposures.

6.3.3 Predictive Modeling for Underwater Detonations- Modeling Specifics

The exposure quantities calculated by modeling were based on input data and processes described in Section 6.3.2. While many modeling parameters and associated process are provided, with greater technical detail in Jordan (2008), the following descriptions elaborate on the generalized process flow as applicable to the SSTC.

Explosive weight, water depth, and charge depth- Charge weights used at SSTC vary in size from 0.03 lbs of PETN to 29 lbs NEW of plastic bonded explosives with additives (PBXN) (see Table 2-1). REFMS requires conversion of explosive types to equivalent weights calculated from similitude equations. Standard similitude formulas facilitate explosive propagation modeling using the free-field source properties close to the source, starting at a nominal source-level range of 3.3 ft. Weak shock theory is used to estimate the waveform and levels to ranges beyond a few meters for all ranges because the amplitudes of explosive waveforms are small. Corresponding simulated parameters for the REFMS model for each explosive type, including their discrete NEW; as referenced to TNT), sequence, and position depths below the water surface were chosen to represent each training type. Additionally, four discrete water depths and location within the SSTC training areas were used [i.e., Echo sub-area and oceanside Boat Lanes (Figure 2-1)].

Charge depths within the water column were not fixed but relative to the surface and seafloor at the locations within the Boat Lanes (Table 2-1). Relative charge depth was calculated as the surface to 5 ft below the surface for surface charge depth, depth divided by two for the "mid" charge depth (e.g., mid-depth within a 56-ft water column was 28 ft), and seafloor depth plus 1 or 2 ft for bottom charge depth.

Sound Speed Profiles- Sound speed profiles to use in the SSTC analysis for all 12 months were acquired from a classified web site maintained by the Naval Oceanographic Office. Unfortunately, these profiles did not specifically cover the near shore region represented by the oceanside Boat Lanes or Echo sub-area of the SSTC. The closest Naval Oceanographic Office sound speed profile site was approximately five nautical miles west of the western side of the oceanside Boat Lanes. While this area has a deeper water column and slightly different profiles, when compared to empirically measured profiles during SSTC underwater explosive testing, sound speed measurements from the shallower location were only slight less than the deeper Naval Oceanographic Office location by approximately 100 ft per sec (~2%).

To reconcile this discrepancy, several sensitivity tests were performed to quantify the relative influence of the sound speed profiles on the final Zone of Influence (ZOI) calculations, as well as subsequent marine mammal exposure estimates. Essentially, a 2% increase in sound speed statistically yielded the same 2% increase in ZOI, which was not threshold independent because of the differences in sound speed from month to month. Given this low percentage, the REFMS model was modified to allow uniform adjustments in the sound speed profiles within the water column. This adjustment was applied to all Naval Oceanographic Office sound speed profiles (one for each month). After each sound speed profile was adjusted, the corresponding ZOIs were computed by the modified REFMS model and tabulated for each given threshold. To report representative values for the warm and cold seasons, mean and standard deviation statistics were calculated for May–October, and November–April, respectively.

Sediment Properties- The bottom sediment was assumed to be consistent throughout the site and was equivalent to the much greater area encompassing southern California. Based on a previous experience in modeling for this region, the bottom sediment for the entire region was considered sandy-silt (Hamilton 1980). The sound-speed ratio for sandy-silt was 1.145 grams per cubic centimeter (g/cm^3) with a wet density of 1.941 g/cm^3 (Hamilton 1980).

Charge Depths and Ranges- The limits of each ZOI and threshold were defined as the distance to the onset of the impact based on each specific threshold. ZOIs were determined for each threshold using REFMS, which concurrently supplied multiple two-dimensional computational points (depth and range). At simulated SSTC sites where the water depths are between 24 and 72 ft, the selected discrete computational points of depth and range were consistent for all thresholds. This two dimensional (range and depth) distribution yielded more than 60 discrete points of REFMS results for evaluating the ZOIs for marine mammal thresholds [impulse (psi-msec), total SEL and SEL in 1/3-octave bands (dB re 1μPa2-sec), and peak pressure (psi)].

Animal Movement- Animal movement was used for modeling Multiple Successive Explosive events (i.e., sequential charges, see Table 2-1). Movement of animals within the virtual SSTC environment was two dimensional in nature, because the shallow water depth placed a constraint on diving. Only lateral movement (changes in x-y position) based on expected species specific swim speeds was considered between Multiple Successive Explosive events (**Table 6-1**). Therefore, it was not necessary to establish a depth restriction for the range points above, because the water depths at SSTC were shallow. These maximum SEL ranges then were used to form concentric circles to determine the area affected at or above the exposure thresholds. The number of mammals within this area whose levels are greater than the thresholds for single detonations were summed, scaled by the species densities to quantify the total exposures, and then reported in 1/100ths. By reporting potential exposures to 0.01 of an individual, no error was included by the simulation, only that of the density estimates. One exposure occurred at 0.5 < exposure < 1.49 for Marine Mammal Protection Act determination. Inasmuch as their placement and movement (Multiple Successive Explosive events only) randomly were initialized, 1,000 separate simulations usually are necessary to determine a statistical mean of mammal exposures with standard deviations less than 2% for underwater detonations.

When Multiple Successive Explosive events were modeled, the statistical computation became time-dependent. Each mammal swam within the rectangular plane or simulated range space. Mammal movements were initialized by using a random compass heading, swim speed with a random 10% variation of the species mean, and a straight path across the range (Jordan 2008). The animals did not react to the acoustic operations or avoid them in any way. Mammals that exit the defined range space before the next detonation randomly were replaced along the range boundary with a new random swim speed and heading towards the inside of the range space with its dosimeter set to an SEL of zero. Those mammals outside the range space with SELs greater than the thresholds normally are counted towards the final exposure level. This approach kept the population constant throughout the training operation. However, the recorded received levels on the dosimeters were below the explosive thresholds. Thus, exposures reported herein only represent those animals found inside the range space for all training operations (Jordan 2008).

Table 6-2. Estimated marine mammal swim speeds used in SSTC Multiple Successive Explosive events modeling.

Species	Swim Speeds (meters/second)
California sea lion	2.00
Pacific harbor seal	1.00
Bottlenose dolphin	3.08
Gray whale	1.86

Zones of Influence (ZOI)- The outer boundary of the ZOI is defined by the maximum radius (i.e., range) at which the exposure threshold occurs (Table 6-1). For the SSTC determination of the ZOI, improvements concurrently were made to the REFMS tool to allow multiple depths and range points given each threshold (Jordan 2008). In the ZOI determinations, single detonations were considered separate events. Multiple Successive Explosive events were handled differently in terms of ZOIs based on the total and 1/3-octave band SEL thresholds. The spatial and temporal distribution of the detonations, as well as, the incoherent accumulation of the resultant SELs were needed to model Multiple Successive Explosive events.

Computational Process- The schematic of the computational sequence shows five processing steps as a sequence of calculations (**Figure 6-4**). Software processing modules (red font) are stated for each step with two ultimate outcomes, ZOIs and marine mammal exposures.

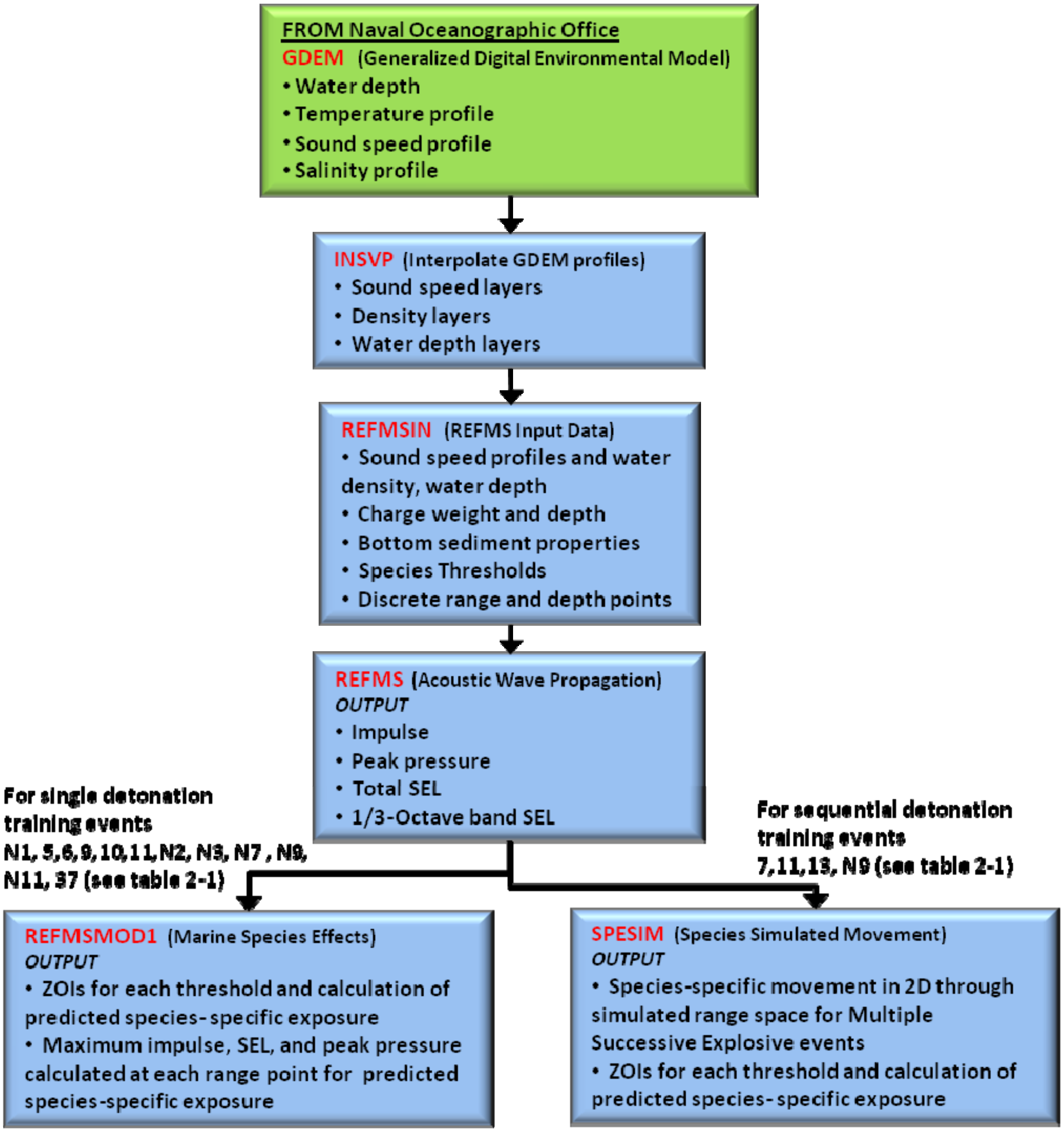

Figure 6-4. Computational sequence for determining effects of underwater detonations at SSTC.

The monthly in-situ sound speed profiles were acquired from the Generalized Digital Environmental Model (GDEM) database. Two preprocessing routines (Interpolate Generalized Digital Environmental Model Profiles [INSVP] and Reflection and Refraction Multi-Layered Ocean/Ocean Bottoms with Shear Wave Effects Input Data [REFMSIN]) were executed to process the environmental conditions and create the initial REFMS input dataset. The explosive characteristics, detonation location, position in the water column, bottom sediment properties, and local sound speed profiles were used to determine wave propagation characteristics of the detonations at the SSTC with the REFMS model. REFMS resolved the traveling explosive compression wave using applicable spreading rules. REFMS was the basis for the two core computation phases (REFMS Modification 1 Marine Species Effects [REFMSMOD1] and Species Simulation Movement [SPESIM]). Static (REFMSMOD1) and dynamic (SPESIM) routines sequentially were executed to determine estimated exposures for cases of single detonations and Multiple Successive Explosive events. REFMSMOD1 is an enhanced version of the original REFMS software that explicitly evaluated the ZOIs using specific NMFS criteria and thresholds. SPESIM tracked the individual received SELs with the virtual dosimeter, when an operation included Multiple Successive Explosive events. This tool includes species movement and uses the acoustic property predictions of REFMS to dynamically evaluate the exposures. Exposure values were not retained for multiple training operations because all were considered independent of one another.

For very shallow water (VSW where water depth is less than 24 ft), in-situ empirical data regarding propagation of sources was available and used to assess impacts in a separate report (unpublished Naval Special Warfare Command (NSWC)/Anteon Corporation 2005). In their analysis REMFS and in-situ data for small charges were compared. One of the major findings was that REFMS predictions made for VSW were unreliable because of the strong influence of boundary conditions. REFMS was not designed to model impulsive sources at boundaries where bottom sediments and surface conditions, such as in the surf zone. Test data and model estimations indicated good predictability when water depth was near 24 ft, therefore, propagation modeling was deemed suitable and performed where empirical data were unavailable (water depth of 24–72 ft). (A further discussion of the empirical VSW measurements is contained in Section 11).

Therefore, all marine mammal exposures presented in this Incidental Harassment application are modeled conservatively to have occurred between 24-72 feet. Likely propagation and associated exposure for any underwater detonation event in water less than 24 feet is likely to be much less.

6.3.4 Key SSTC Modeling Caveats and Assumptions

The exposure quantities predicted from modeling of training events rely on many factors but are influenced greatly by assumptions, methods, and criteria used during the process.

In general, the SSTC impact assessment is a conservative approach (i.e., over predicts likely exposures) based on some generalities that have to be assumed because of training event parameters, criteria application, or model limitations.

Therefore, The caveats and modeling assumptions described below should be considered when evaluating the marine mammal predicted exposures within the context of this Incidental Harassment Authorization application

Of note, these assumptions and resulting model estimations do not account for the protective nature of the Navy's proposed mitigations detailed in Section 11, which in reality would eliminate or reduce any potential exposures.

Modeling Assumptions- *Operational Assumptions*

- Oceanographically, there are two seasons at SSTC, a warm season from May–October and a cold seasons from November–April.
- Underwater training events shown in Table 2-1 represent SSTC range schedule maximums with range time fully booked. In other words, with the full quantity of events * (311 annually) scheduled to occur and sought in this Incidental Harassment Authorization.

  * This authorization does not account for training schedule change, event cancelations due to weather or other unforeseen factors, unit deployments which would mean fewer personnel needing training, and other real-world and exercise conditions that may result in fewer annual underwater detonations.

- All training operations were evenly distributed across months with 50% of the events occurring during each season (50% during warm season, 50% during cold season).
- No two training operations were assumed to occur during the same day, and each training event was treated as an isolated event.
- Each training activity for single detonations (Table 2-1) was treated as an isolated event; therefore, exposures represent short-term and immediate impacts. Events with single explosions did not take into account animal movement.
- Events with Multiple Successive Explosive events (Table 2-1) were treated as training events requiring the accumulation of received energy (SEL) with consideration of mammal movement. Movement within the virtual SSTC environment was two-dimensional and did not take into account depth as a dimension; therefore, marine mammals were assumed to be in the water column where the effect of the detonations was greatest
- Sequential charges are either conducted with a 10 second delay between detonations or 30 minute delay between detonations. However, the actual temporal relationships between explosions can be longer depending on conditions (set-up, operator experience, weather, marine mammal sighting, etc).
- All underwater detonations proposed for SSTC were modeled as if they will be conducted in shallow water of 24 to 72 feet, including those that would normally be conducted in very shallow water (VSW) depths of zero to 24 feet

Modeling Assumptions- *Biological Assumptions*

- Marine mammals and associated densities are considered to always be present within SSTC and densities are spread evenly through all of the oceanside SSTC Boat Lanes. [In fact, marine mammal presence within SSTC is variable, dynamic, and very patchy, but REFMS currently does not have algorithms to address this complexity, nor is the state of science adequate for predicting patchy marine mammal occurrence at small spatial scales]
- Percentage of time pinnipeds haul out was not factored into the modeling, although California sea lions and harbor seals may not be exposed during the time they are out of the water.
- Mean marine mammal densities were used during exposure calculations and took into account the worst-case water depth, animal depth, and sound speed profile to conservatively (i.e., over predict) the greatest amount of potential exposures.
- All estimated exposures are seasonal averages (mean) plus one standard deviation.

6.3.5 Zones of Influence From Underwater Detonations

Severity of an effect often is related to the distance between the sound source and a marine mammal and is influenced by source characteristics (Richardson and Malme 1995). For SSTC, zones of influence were estimated for the different charge weights, charge depths, water depths, and seasons using the REFMS model as described previously.

Zones of influence (ZOI) for SSTC underwater detonations by training event are shown in **Table 6-3** and conceptually illustrated in **Figure 6-5**.

For single detonations, the ZOI were calculated using the range associated with **onset TTS** based on the Navy REFMS model predictions.

For Multiple Successive Explosive events (i.e., sequential detonations) ZOI calculation was based on the range to non-TTS behavior disruption. Calculating the zones of influence in terms of total SEL, 1/3-octave bands SEL, impulse, and peak pressure for sequential (10 sec timed) and multiple controlled detonations (> 30 minutes) were slightly different than the single detonations. For the sequential detonations, ZOI calculations considered spatial and temporal distribution of the detonations, as well as the effective accumulation of the resultant acoustic energy. To calculate the ZOI, sequential detonations were modeled such that explosion SEL were summed incoherently to predict zones while peak pressure was not.

In summary, all ZOI radii were strongly influenced by charge size and placement in the water column, and only slightly by the environment variables.

Table 6-3. Maximum Zone of Influence for underwater detonation events at SSTC.

Activity #, Underwater Detonation Activity, NEW Charge Weight Used, And Annual Activity Amount	Season Warm (May-Oct) Cold (Nov-Apr)	Maximum ZOI (yards)					
		Sub-TTS	TTS		Injury		Mortality
		177 dB re 1μPa²-sec	23 psi	182 dB re 1μPa²-sec	Onset of slight lung injury (13.0 psi-msec)	50% TM rupture (205 dB re 1μPa²-sec)	Onset of extensive lung injury (30.5 psi-msec)
N1) SWAG (San Diego Bay- Echo sub-area) 0.033 NEW (74/yr)	Warm	n/a	60	20	0	0	0
	Cold	n/a	40	20	0	0	0
N1) SWAG (SSTC-North and South oceanside) 0.033 NEW (16/yr)	Warm	n/a	60	20	0	0	0
	Cold	n/a	40	20	0	0	0
5, 9) Mine Countermeasures 20 lbs NEW (29/yr)	Warm	n/a	470	300	360	80	80
	Cold	n/a	450	340	160	80	80
6) Floating Mine 5 lbs NEW (53/yr)	Warm	n/a	240	160	80	40	20
	Cold	n/a	260	180	80	40	20
7) Dive Platoon 3.5 lb NEW (sequential) (8/yr)	Warm	470	210	330	80	90	50
	Cold	560	220	370	90	90	50
10) Unmanned Underwater Vehicle 15 lb NEW (4/yr)	Warm	n/a	440	280	360	80	80
	Cold	n/a	400	320	150	80	80
11) Marine Mammal Systems 29 lb NEW (sequential) (8/yr)	Warm	740	380	420	360	140	90
	Cold	650	450	470	170	140	90
11) Marine Mammal Systems 29 lb NEW (8/yr)	Warm	n/a	400	330	360	100	90
	Cold	n/a	490 *	370	170	100	90
12) Mine Neutral 3.5 lb NEW (sequential) (4/yr)	Warm	470	210	330	80	90	50
	Cold	560	230	370	90	90	50
N2) Surf Zone Training and Evaluation <20 lb NEW (2/yr)	Warm	n/a	470	300	160	80	80
	Cold	n/a	450	340	160	80	80
N3) UUV Neutral 3.6 lb NEW (sequential) (4/yr)	Warm	260	220	180	80	60	50
	Cold	280	230	180	90	60	50
N7) AMNS 3.5 lb NEW (10/yr)	Warm	n/a	220	170	80	40	40
	Cold	n/a	230	180	80	40	40
N9) Qual./Cert. 13.8 lb NEW (sequential) (8/yr)	Warm	470	330	330	140	100	80
	Cold	530	360	370	140	100	80
N9) Qual./Cert. 25.5 lb NEW (4/yr)	Warm	n/a	420	330	300	90	90
	Cold	n/a	470	360	170	90	90
N11) Naval Special Warfare Demolition Training 10 lb NEW (4/yr)	Warm	n/a	360	240	160	80	40
	Cold	n/a	360	250	160	80	40
N11) Naval Special Warfare Demolition Training 3.6 lb NEW (4/yr)	Warm	n/a	220	180	80	60	50
	Cold	n/a	230	180	90	60	50
37) Naval Special Warfare SEAL Delivery Vehicle 10 lb NEW (40/yr)	Warm	n/a	360	240	160	80	40
	Cold	n/a	360	250	160	80	40
Naval Special Warfare SEAL Delivery Vehicle 10 lb NEW (40/yr)	Warm	n/a	360	240	160	80	40
	Cold	n/a	360	250	160	80	40

*** Although revising max. ZIO to 490 yards from 400 yards, with only 8 detonations/year (4 warm season, 4 cold season), this max. ZOI of 490 yards would only likely occur < 1.3% (4/311) of all annual SSTC underwater detonations.**

Figure 6-5 summarizes the relationship between zones of influence and ranges to mortality and NMFS Level A and Level B Harassment.

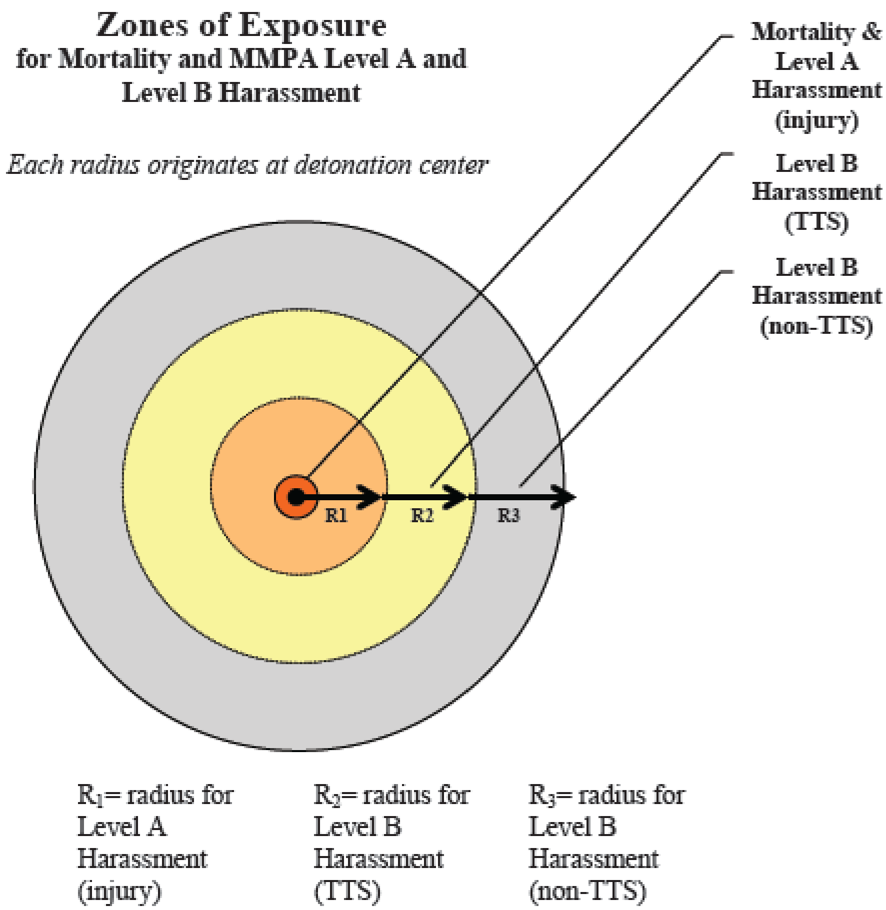

Figure 6-5. Zones of Influence and radii associated with mortality, Level A Harassment, and Level B Harassment.

6.3.6 Very Shallow Water (VSW) Underwater Detonations Live-Fire Tests (0-24 Feet) and Determination of Zones of Influence

Empirical field measurement of underwater detonations at the SSTC was conducted by the Navy in 2002. Results from these tests were used to determine potential Zones of Influence (ZOI) and application of these ZOIs for mitigation zones in the VSW zone at the SSTC. **Figure 11-1** shows the general VSW zone within the overall oceanside area of the SSTC Boat Lanes.

Measurements of the propagated pressures during single-charge underwater detonation exercises in VSW (0 to 24 feet water depth) at SSTC (and San Clemente Island) were conducted in 2002 as part of a study to evaluate existing underwater explosive propagation models for application to VSW conditions (unpublished, Naval Special Warfare Center/Anteon Corporation 2005). The direct measurements made in those tests provided an in-place characterization of pressure propagation for the training exercises as they are actually conducted at the SSTC. During the tests, 2 and 15 lbs charges of NEW explosives were detonated in 6 and 15 feet of water with charges laying on the bottom or two feet off the bottom at SSTC and San Clemente Island. At SSTC, swell conditions precluded detonations at the 6-foot depth. Peak-pressures (unfiltered) and energies – between 100 Hz and 41 kHz - in 1/3-octave bands of highest energies from each detonation were measured in three locations relative to the charges: 1) 5-10 feet seaward of the charge, 2) 280 to 540 feet seaward, and 3) at about 1,000 feet seaward. Underwater detonations of small 2 lb charges at SSTC were measured at a "near range" location within feet of the charge and at a "single far range" of 525 feet from the charge (unpublished, Naval Special Warfare Center/Anteon Corporation 2005). In the tests, the position of single charges - on and 2 feet off the bottom – affected the propagated peak-pressures. Off-bottom charges produced consistently greater peak-pressures than on-bottom charges as measured at about 200, 500, and 1,000 feet distances. Off-bottom 15 lb charges in 15 feet of water produced between 43 – 67 % greater peak-pressures than on-bottom charges. Greater differences were found when detonations occurred in extremely shallow depths of 6 feet at San Clemente Island (unpublished, Naval Special Warfare Center/Anteon Corporation 2005). Generally, measurements during single-charge exercises produced empirical data that were predicted by the propagation models. At about 1,000 feet seaward, peak-pressure varied from 11-17 pounds per square inch (psi) at different depths, and energies between 100 Hz and 41 kHz in the 1/3-octave bands of highest energies varied from about 175-186 dB re 1 μPa^2·sec at different depths. From the measurements, it was determined that the range at which the criterion for onset-TTS would be expected to occur in small odontocetes matched the range predicted by a conservative model of propagation that assumed a boundary-less medium and equal sound velocity at all depths in the range – i.e., an "iso-velocity" model. Bottom and water-column conditions also influence pressure-wave propagation and dissipation of blast residues. The study conducted during exercises at SSTC and Northwest Harbor on San Clemente Island during 2002 and 2003 revealed considerable differences in pressure-wave propagation between the two sites - differences that are attributable to the different bottom and water-column conditions at those sites. The SSTC range is composed of clean sand along an open coast with, presumably, a hard substrate. There, recorded propagation characteristics of VSW bottom-laid and off-bottom charges closely matched propagation-model predictions. The SSTC range is completely open to the ocean and, as such, undergoes substantial, frequent water exchange with the ocean as a result of tidal volume flux and coastal circulation patterns. Further, water mixing is substantial as evidenced by the absence of thermal and salinity layering in the sound-velocity measurements taken during empirical data collection. That water mixing reduces layering effects and facilitates the rapid dilution of explosive by-products.

In comparison, predictions made by the Navy's REFMS model (see previous Section 6 text) were found to be unstable across the distances considered under the conditions of VSW with bottom or near bottom charge placement, reflective bottom, and a non-refractive water column (i.e., equal sound velocity at all depths). The source of instability in the REFMS predictions is most likely due to the nature of the VSW zone wherein the ratio of depth to range is very small – a known problem for the REFMS' predictive ray-tracing. Reflective and placement conditions within the model may contribute as well. REFMS was developed for large explosives in deep water and has been validated there, but is in need of added development for reliable application in VSW conditions. The Navy is continuing this REFMS refinement, but this model improvement was not available at the time of this Incidental Harassment Authorization application. As mentioned, the peak-pressures and 1/3-octave band energies for the VSW bottom at SSTC were just as well predicted by the simpler iso-velocity model. In iso-velocity conditions, peak pressure follows a power law over distance as do the dominant frequency and energy at that frequency.

Establishment of VSW mitigation Zone- The VSW mitigation zone is the maximum range to the Level B harassment (on-set TTS dual criteria in Table 6-1) calculated via the iso-model prediction.

For SSTC this range was determined to be a **1,200 foot or 400 yard** radius out from the site of the detonation with the shoreward half of the implied circle being truncated by the shoreline and extremely shallow water immediately off shore.

Determination of this range was based on based on the empirical propagation data and iso-velocity model predictions discussed above for charge-weights of 20 lbs or less of NEW explosive on the bottom and for charge-weights of 3.6 lbs or less off the bottom.

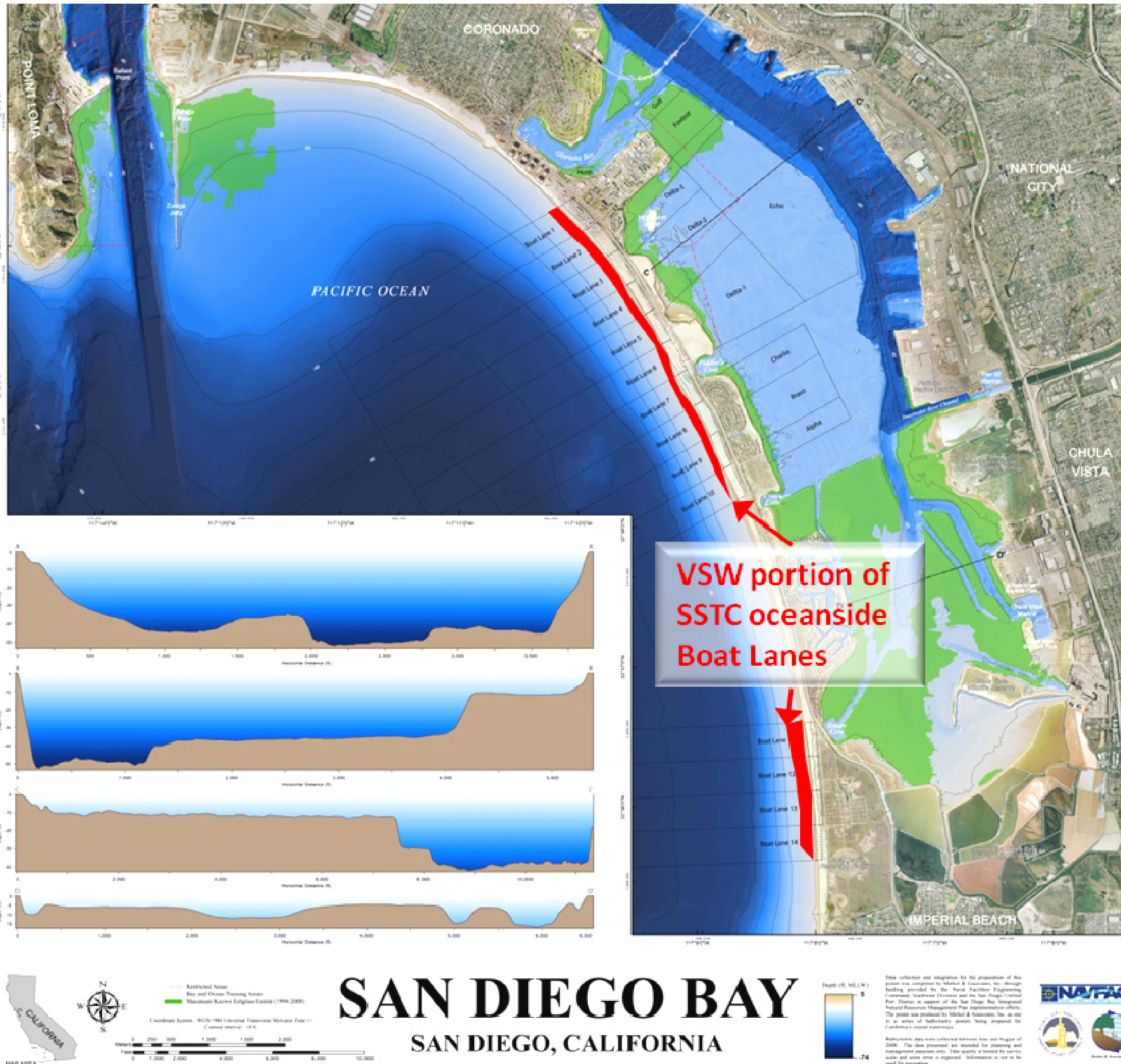

Figure 6-6. VSW zone within the oceanside Boat Lanes at the SSTC.

6.4 Estimated Marine Mammal Exposures From SSTC Underwater Detonations

The quantitative exposure modeling methodology estimated numbers of individuals exposed to the effects of underwater detonations exceeding the thresholds used, as if no mitigation measures were employed (see Section 6.3).

All estimated exposures are seasonal averages (mean) plus one standard deviation using 1/2 of the yearly training tempo to represent each season. Taking this approach was an effort to be conservative (i.e., allow for an over prediction of exposure) when estimating exposures typical of training during a single year.

Table 6-4 shows number of annual predicted exposures by species for all underwater detonation training within the SSTC. As stated previously, only events with sequential detonations were examined for non-TTS behavior disruption.

The Navy currently employs and proposes to continue mitigation measures that include visual monitoring of the area for marine mammals prior to detonations. These mitigation measures, discussed in Section 11, will minimize the number of marine mammal exposures shown in **Table 6-4**, and does not account for the beneficial effects of these mitigation measures in avoiding exposures.

For all underwater detonations, the Navy's impact model predicted:

- No marine mammal mortality to any species
- No Level A Injury to any species

For non-sequential (i.e., single detonation) training events, the Navy's impact model predicted

- 153 annual exposures that could result in Level B harassment (TTS)
    - 98 annual exposures to bottlenose dolphins
    - 55 annual California sea lion exposures
    - 0 annual exposures to gray whales
    - 0 annual exposures to harbor seals

For sequential (Multiple Successive Explosive events) training events, the Navy's impact model predicted:

- 114 annual exposures that could results in Level B harassment
    - 70 annual exposures to bottlenose dolphins
    - 44 annual exposures to California sea lions
    - 0 annual exposures to gray whales
    - 0 annual exposures to harbor seals

Table 6-4. SSTC modeled estimates of species exposed to underwater detonations without implementation of mitigation measures.

Species			Annual Mammals Exposure (All Sources)			
			Level B Behavior (Multiple Successive Explosive events only)	Level B TTS	Level A Injury	Mortality
			177 dB	182 dB / 23 psi	205 dB / 13.0 psi-ms	30.5 psi-ms
Cetaceans	Gray Whale	Warm	-	-	-	-
		Cold	0	0	0	0
	Coastal Bottlenose Dolphin	Warm	30	43	0	0
		Cold	40	55	0	0
Pinnipeds	California Sea Lion	Warm	4	4	0	0
		Cold	40	51	0	0
	Harbor Seal	Warm	0	0	0	0
		Cold	0	0	0	0
Total Annual Exposures			114	153	0	0

6.4.1 Limitations To and Conservative Nature of the Exposure Results

For purposes of predicting potential explosive effects on marine mammals, the Navy used an acoustic impact model process and numeric criteria agreed upon with NMFS. However, the limitations of this process should be noted to put the predicted exposure numbers into context.

For instance, 1) significant scientific uncertainties are implied and carried forward in any analysis using marine mammal density data as a predictor for marine mammal occurrence within a given geographic area; 2) there are limitations to the actual model process based on information available (marine mammal densities, marine mammal depth distributions, marine mammal motion data, impact thresholds, and supporting statistical model); and 3) determination and understanding of what constitutes a significant behavioral effect is still unresolved.

In addition, throughout the modeling and assessment process, the Navy made many conservative assumptions (listed and described above), which also make the results of the model that are shown in Table 6-4 conservative (i.e., likely over predictive of potential exposures).

While numbers generated allow establishment of predicted marine mammal exposures for permitting purposes with NMFS, the short duration and limited geographic extent of explosive events does not necessarily mean that these exposures would occur even if mitigation measures were not implemented.

In addition as discussed below, REFMS has computational limitations in predicting propagation in water depths less than 24 feet. Navy has empirical data from measured underwater detonations that illustrate this issue.

6.5 Assessing ELCAS Pile Driving and Removal Impacts

Noise associated with ELCAS training includes loud impulsive sounds derived from driving piles into the soft sandy substrate of the SSTC waters to temporarily support a causeway of linked pontoons. Two hammer-based methods will be used to install/remove ELCAS piles: impact pile driving for installation and vibratory driving for removal. The impact hammer is a large metal ram attached to a crane (see Figure 1-3). A vertical support holds the pile in place and the ram is dropped or forced downward. The energy is then transferred to the pile which is driven into the seabed. The ram is typically lifted by a diesel power source.

ELCAS events would occur up to four times a year at either the dedicated training lane with bayside Bravo Beach, or in the oceanside training lanes at SSTC-North. Pile installation occurs over a period of approximately 10 days and pile removal over approximately three days. Approximately 101 piles are driven in a typical ELCAS training event, with around 250 to 300 impacts per pile, and each pile taking on average 10 minutes to install.

The ELCAS is then used for a period of time, usually < two weeks to transfer cargo back and forth from sea to shore.

At the end of the all ELCAS training, a vibratory hammer attached to the pile head will be used to remove piles by applying a rapidly alternating force to the pile by rotating eccentric weights about shafts, resulting in an upward vibratory force on the pile. The vertical vibration in the pile disturbs or "liquefies" the sediment next to the pile causing the sediment particles to lose their frictional grip on the pile. This also allows sediment to fill back into the hole that is left after the pile is removed.

The available scientific literature suggest that introduction of pile driving into the marine environment could result in short term behavioral and/or physiological marine mammal impacts such as: altered headings; increased swimming rates; changes in dive, surfacing, respiration, feeding, and vocalization patterns; masking, and hormonal stress production (Southall et al., 2007); however some field studies also suggest marine mammals do not observably respond to construction type sounds such as drilling (e.g., Richardson et al., 1990, 1991; Moulton et al., 2005). Individual animal responses are likely to be highly variable depending on situational state, and prior experience or habituation. Southall et al. 2007 point out that careful distinction must be made of brief minor, biologically unimportant reactions as compared to profound, sustained or biologically meaningful responses related to growth, survival, and reproduction. Populations of bottlenose dolphins, California sea lions, and harbor seals in and adjacent to San Diego Bay and SSTC have likely been historically exposed and potentially habituated to multiple regional anthropogenic underwater noise sources (i.e., commercial shipping, recreational boating, in-water construction, aircraft overflights, etc.).

6.5.1 Predictive Modeling for ELCAS Events (Pile Driving and Removal)

The methodology for analyzing potential impacts from ELCAS events is similar to that of analyzing explosives. The ELCAS analysis includes three steps used to calculate potential exposures:

1. Estimate the zone of influence for Level A injurious and Level B behavioral exposures for both impact pile driving and vibratory pile removal using the practical spreading loss equation (CADOT 2009).
2. Estimate the number of species exposed using species density estimates and estimated zones of influence.

The practical spreading loss equation is typically used to estimate the attenuation of underwater sound over distance. NOAA and USFWS have accepted the use of the practical spreading loss equation to estimate transmission loss of sound through water for past pile driving calculations (CADOT 2009).

The formula for this propagation loss can be expressed as:

$$TL = F * \log (D1/D2)$$

Where:

TL = transmission loss (the sound pressure level at D1 minus the sound pressure level at D2, in RMS, dB re 1μPa)

F = attenuation constant

D1 = distance at which the targeted transmission loss occurs

D2 = distance from which the transmission loss is calculated

The attenuation constant (F) is site-specific factor based on several conditions, including water depth, pile type, pile length, substrate type, and other factors. Measurements conducted by the California Department of Transportation (CADOT) and other consultants (Greeneridge Science) indicate that the attenuation constant (F) can vary from 5 to 30. For pile driving sounds, large piles produce lower frequency sounds that can propagate further than smaller piles which produce higher frequency sound. Small-diameter steel H-type piles have been found to have high F values in the range of 20 to 30 near the pile (i.e., between 30-60 feet) (CADOT 2009). In the absence of empirically measured values at SSTC, the Navy originally set the F value for SSTC to be on the low (conservative, and more predictive) end of the small-diameter steel piles (F=20). In subsequent consultation with the NMFS Office of Protected Resources, it was requested[2] that the Navy take a still more conservative approach and use a F value of F=15.

2 The calculations in this Supplement are done with the change of F=20 to F=15. As discussed in Section 6.5.2 and 6.5.3, this resulted in a change of ZOI and subsequent marine mammal exposures.

6.5.2 Zones of Influence for ELCAS Events

Actual noise levels of ELCAS pile driving at SSTC depend on the type of hammer used, the size and material of the pile, and the substrate the piles are being driven into. Using known equipment, installation procedures, and applying certain constants derived from other west coast measured pile driving, predicted underwater sound levels from ELCAS pile driving can be calculated. The ELCAS uses 24-inch diameter hollow steel piles, installed using a diesel impact hammer to drive the piles into the sandy on-shore and near-shore substrate at SSTC. For a dock repair project in Rodeo, California in San Francisco Bay, RMS underwater sound level for a 24 inch steel pipe pile driven with a diesel impact hammer in less than 15 ft of water depth was measured at 189 dB re 1uPa from approximately 33 ft (11 yards) away. RMS sound level for the same type and size pile also driven with a diesel impact hammer, but in greater than 36 ft of water depth, was measured to be 190 to 194 dB RMS during the Amoco Wharf repair project in Carquinez Straits, Martinez, California (CADOT 2009). The areas where these projects were conducted have a silty sand bottom with an underlying hard clay layer, which because of the extra effort required to drive into clay, would make these measured pile driving sound levels louder (more conservative) than they would if driving into SSTC's sandy substrate. Given the local bathymetry and smooth sloping sandy bottom at SSTC, ELCAS piles will be generally be driven in water depths of 36 ft or less.

Therefore, for the purposes of the Navy's SSTC ELCAS analysis, both the Rodeo repair project (189 RMS) and the low end of the measured values of the Amoco Wharf repair projects (190 RMS) are considered to be reasonably representative of sound levels that would be expected during ELCAS pile driving at SSTC. For hollow steel piles of similar size as those proposed for the ELCAS (<24-in diameter) used in Washington State and California pile driving projects, the broadband frequency range of underwater sound was measured between 50 Hz to 10.5 kHz with highest energy at frequencies <1 to 3 kHz (CADOT 2009). Although frequencies over 10.5 kHz are likely present during these pile driving projects, they are generally not typically measured since field data has shown a decrease in RMS to less than 120 dB at frequencies greater than 10.5 kHz (Laughlin 2005, 2007). It is anticipated that ELCAS pile driving would generate a similar sound spectra.

The use of previously derived non-region data to generate "F" values for the SSTC will be reviewed and compared to empirically measure ELCAS pile driving at the next oceanside ELCAS training event within the SSTC (see Section 11.3 ELCAS mitigation).

ELCAS Pile Driving- For ELCAS training events, using an estimated RMS measurement of 190 dB re 1uPa at 11 yards as describe above, the circular zone of influence (ZOI) surrounding a 24-inch steel diesel-driven ELCAS pile can be estimated via the practical spreading loss equation to have a radius of:

- 11 yards for Level A injurious harassment for pinnipeds (190 dB RMS);
- 46 yards for Level A injurious harassment for cetaceans (180 dB RMS), and
- 1,094 yards for the Level B behavioral harassment (160 dB RMS).

The above values reflect the NMFS' recommendation to change the F factor in the practical spreading loss equation from 20 to 15. It should be noted that ELCAS pier construction starts with piles being driven near the shore and extends offshore. Near the shore, the area of influence would be a semi-circle and towards the end of the ELCAS (approximately 1,200 feet or 400 yards from the shore) would be a full circle.

The above calculated area of influence conservatively assumes that all ELCAS piles driven are all driven offshore at SSTC, producing a circular zone of influence, and discounts the limited propagation from piles driven closer to shore.

ELCAS pile removal- Noise levels derived from piles removed via vibratory extractor are different than those driven with an impact hammer. Steel pilings and a vibratory driver were used for pile driving at the Port of Oakland (CADOT 2009). Underwater sound levels during this project for a 24-inch steel pile in 36 ft of water depth was field measured to be 160 dB RMS.

The area where this project was conducted (Oakland) has a harder substrate, which because of the extra effort required to drive and remove the pile, would make these measured pile driving sound levels louder (more conservative) than they would if driving and removing into and from SSTC's sandy substrate. Conservatively using this RMS measurement for SSTC, the ZOI for a 24-inch steel pile removed via a vibratory extractor out to the 120 dB RMS Level B behavioral harassment threshold can be estimated via the practical spreading loss equation to be:

- < 1 yard yards for Level A injurious harassment for pinnipeds (190 dB RMS);
- One (1) yard for Level A injurious harassment for cetaceans (180 dB RMS), and
- 5,076 yards for the Level B behavioral harassment (120 dB RMS).

The above values reflect the NMFS' recommendation to change the F factor in the practical spreading loss equation from 20 to 15. As discussed above, the above calculated area of influence conservatively assumes that all ELCAS piles are driven and subsequently removed offshore at SSTC, producing a circular zone of influence.

Table 6-5. Maximum Zones of Influence for ELCAS pile driving and removal.

	Level B (Continuous noise)	Level B (Impulse)	Level A (Cetaceans)	Level A (Pinnipeds)
	120 dB RMS	160 dB RMS	180 dB RMS	190 dB RMS
Installation (Pile Driving)	N/A	1,094 yards	46 yards	11 yards
Removal (Vibratory)	5,076 yards	N/A	1 yard	< 1 yard

6.5.3 Estimated Marine Mammal Exposures From ELCAS pile driving\removal

ELCAS Pile Driving

Using the marine mammal densities presented in Table 3-1, the number of animals exposed to annual Level B harassment from ELCAS pile driving can be estimated. A couple of conservative business rules and assumptions are used in this determination:

1. Pile driving is estimated to occur 10 days per ELCAS training event, with up to four training exercises being conducted per year (40 days per year). Given likely variable training schedules, an assumption was made that approximately 20 of these 40 days would occur during the warm water season, and 20 of the 40 days would occur during the cold water season.
2. To be more conservative even to the point of over predicting likely exposures, the Navy asserts that during the calculation there can be no "fractional" exposures of marine mammals on a daily basis. In other words, there is no exposure to 0.3, 0.5, 0.6, etc. of an animal, but that each instance of exposure gets rounded up during the calculation to "1".

Pile Driving Potential Exposure Formula

The Navy used the expression below to estimate potential ELCAS pile driving exposures:

(Area of Influence ($pi*ZOI^2$) x warm season mm density x warm season pile driving days) +
(Area of Influence ($pi*ZOI^2$) x cold season mm density x cold season pile driving days) = annual exposures

with:

area of influence = 3.14 km^2 (1,094 yds Level B impact ZOI as described in Section 6.5.1 x 0.000914 km/yd = 0.9999 km. Since pi=3.14, then the term $pi*ZOI^2$ = 3.14 x 0.9999 km x 0.9999 km = 3.14 km^2)

mm= marine mammal

Taking bottlenose dolphins in a non-rounded example, the calculation would look like:

(3.14 x 0.202 x 20) + (3.14 x 0.202 x 20) = 13+13 = 26 potential exposures

However, in using the conservative "daily rounding up" business rule (#2 above), the Navy's final calculation looks like:

(3.14 x 0.202) = 0.6 which is then rounded to "1". 1 x 20 = 20
and 20 + 20 (warm season plus cold season) = 40 potential exposures

Based on the assessments conducted, using the methodology discussed previously, applying the business rules and limitations described in this section and in 6.5.4 , and without consideration of current mitigation measures, the Navy's estimate (Table 6-6) is that ELCAS pile driving could result in:

- 0 Level A injury harassments to any marine mammal (190 and 180 dB RMS)
- 60 Level B harassments (40 bottlenose dolphins, 20 California sea lions)

ELCAS Pile Removal

Using the marine mammal densities presented in Table 3-1, the number of animals exposed to annual Level B harassment from ELCAS pile driving can be estimated. A couple of conservative business rules and assumptions are used in this determination:

1. Pile removal is estimated to occur an average of 3 days per training exercise, up to four training exercises being conducted per year (12 days per year). Given likely variable training schedules, an assumption was made that approximately 6 of these 12 days would occur during the warm water season, and 6 of the 12 days would occur during the cold water season.
2. To be more conservative even to the point of over predicting likely exposures, the Navy asserts that during the calculation there can be no "fractional" exposures of marine mammals on a daily basis. In other words, there is no exposure to 0.3, 0.5, 0.6, etc. of an animal, but that each instance of exposure gets rounded up during the calculation to "1".

Pile Removal Potential Exposure Formula

The Navy used the expression below to estimate potential ELCAS pile removal exposures:

(Area of Influence (pi*ZOI^2) x warm season mm density x warm season pile driving days) +
(Area of Influence (pi*ZOI^2) x cold season mm density x cold season pile driving days) = annual exposures

with:

area of influence = 67.7 km^2)

mm= marine mammal

Taking bottlenose dolphins in a non-rounded example, the calculation would look like:

(67.7 x 0.202 x 6) + (67.7 x 0.202 x 6) = 82 + 82 = 164 potential exposures

However, in using the conservative "daily rounding up" business rule (#2 above), the Navy's final calculation looks like:

(67.7 x 0.202) = 13.7 which is rounded to "14". 14 x 6 = 84
and 84 + 84 (warm season plus cold season) = 168 potential exposures

Based on the assessments conducted, using the methodology discussed previously, applying the business rules and limitations described in this section and in 6.5.4 , and without consideration of current mitigation measures, the Navy's estimate (Table 6-6) is that ELCAS pile removal could result in:

- 0 Level A injury harassments to any marine mammal (190 and 180 dB RMS)
- 288 Level B harassments (168 bottlenose dolphins, 102 California sea lions, 12 harbor seals, 6 gray whales)

Table 6-6. Exposure estimates from ELCAS pile driving\removal prior to implementation of mitigation measures.

Species			Annual Estimated Mammals Exposure			
			Level B (Continuous)	Level B (Impulse)	Level A (Cetaceans)	Level A (Pinnipeds)
			120 dB RMS	160 dB RMS	180 dB RMS	190 dB RMS
Cetaceans	Gray Whale	Installation	N/A	0	0	0
		Removal	6	N/A	0	0
	Bottlenose Dolphin	Installation	N/A	40	0	0
		Removal	168	N/A	0	0
Pinnipeds	California Sea Lion	Installation	N/A	20	0	0
		Removal	102	N/A	0	0
	Harbor Seal	Installation	N/A	0	0	0
		Removal	12	N/A	0	0
Total Annual Exposures			288	60	0	0

6.5.4 Limitations To and Conservative Nature of the Model Results

The exposures predicted from ELCAS assessment rely on many factors but are influenced greatly by assumptions, methods, and criteria used. The following list of assumptions, caveats, and limitations is not exhaustive but reveals several features of the technical approach that influence exposure prediction:

- Significant scientific uncertainties are implied and carried forward in any analysis using marine mammal density data as a predictor for animal occurrence within a given geographic area.
- The assessment conservatively assumed(i.e., over predicts) that all ELCAS training would occur along the oceanside of SSTC. In actuality, some ELCAS training may be conducted in the Bravo Beach training area on the south San Diego Bay side of SSTC-North. Marine mammals are rarely encountered within this southern portion of San Diego Bay, and given this lack of occurrence, exposures to marine mammals during ELCAS training in the Bay is not expected. By assuming that all ELCAS training would occur on the oceanside of SSTC-North, exposure estimates may over represent actual potential exposures. For example, the estimates may be double of what they might actually be if half of the ELCAS training was to occur on the Bay.
- Marine mammal are assumed to be uniformly distributed within the ocean waters adjacent SSTC, when as discussed previously, marine mammal distribution is patchy and occasional at the small scales represented by the SSTC area.
- The tempo of training events was divided evenly throughout the year with two oceanographic seasons, defined as warm and cold at this location, each having ½ total events for simulated purposes.
- There are data limitations. Some of the data supporting the analysis was derived from other projects with different environmental and project conditions (pile driving source levels, and transmission loss parameters).
- The NMFS recommendation of a change in F factor from 20 to 15 resulted in more a larger calculated ZOI and slight increase in potential Level B harassments. These changes are reflected in Supplement #1 to the Navy's original application.
- The ELCAS exposure assessment methodology is an estimate of the numbers of individuals potentially exposed to the effects of ELCAS pile driving and removal exceeding NMFS established thresholds. Of significant note in these exposure estimates, mitigation methods were not quantified within the assessment and successful implementation of mitigation is not reflected in exposure estimates. While the numbers generated from the ELCAS exposure calculations provide conservative overestimates of marine mammal exposures for consultation with NMFS, the short duration and limited geographic extent of ELCAS training would further limit actual exposures.

7 IMPACTS TO MARINE MAMMAL SPECIES OR STOCKS

Overall, the conclusions in this analysis find that impacts to marine mammal species and stocks would be negligible, especially when mitigation measures outlined in Section 11 are implemented.

The predicted annual exposures from impact analysis conducted for this Incidental Harassment Authorization include:

- No Level A injury or mortality to gray whales, the coastal stock of bottle nose dolphins, California sea lions, or harbor seals from SSTC underwater detonations and ELCAS training events.
- 267 Level B harassment exposures to bottlenose dolphins (168) and California sea lions (99) from underwater detonations.
- 348 Level B harassment exposures to bottlenose dolphins (208), California sea lions (122), harbor seals (12), and gray whales (6) from ELCAS pile driving and removal.

Bottlenose dolphin- There were no predicted mortality or Level A injury for bottlenose dolphins. Modeling predicted there would be 168 potential Level B harassment exposures from underwater explosions and only 208 Level B harassments from ELCAS pile driving and removal. Within SSTC, given the relatively shallow water (**Figure 2-1**), and the high travel mode, low site fidelity aspect of bottlenose dolphin behavior in California (Defran et al. 1999, Defran and Weller 1999, Bearzi 2005, Bearzi et al. 2009), there is a high likelihood that pre-detonation mitigation would detect bottlenose dolphins and therefore reduce exposures such that potential effects would be minimal.

California sea lion- There were no predicted mortality or Level A injury to California sea lions, and modeling only predicted 99 potential Level B harassment exposures from underwater detonations and 122 potential Level B harassment exposures from ELCAS pile driving and removal. Within SSTC, given the relatively shallow water (**Figure 2-1**), lack of significant foraging areas and haul out/breeding sites within the ocean areas of SSTC, and the fact that California sea lions make short duration dives and may rest at the surface (Feldkamp et al. 1989), there is a high likelihood that pre-detonation mitigation would detect sea lions and therefore reduce exposures such that potential effects would be minimal.

Harbor seal- There were no predicted mortality or Level A injury to harbor seals, and modeling only 12 predicted Level B harassment exposures from ELCAS pile removal. Within SSTC, given the relatively shallow water (**Figure 2-1**), lack of significant foraging areas and haul out/breeding sites within the ocean areas of SSTC, harbor seal occurrence would be low near the surf zone where the majority of ELCAS pile removal would happen. With low occurrence and applied mitigation, the probability of actual exposures would be minimal.

Gray whale- There were no predicted mortality or Level A injury to harbor seals, and modeling only 6 predicted Level B harassment exposures from ELCAS pile removal. Within SSTC, given the relatively shallow water (**Figure 2-1**), seasonal transitory nature of gray whale migrations, lack of significant foraging areas within the shallow coastal ocean areas of SSTC, gray whale occurrence would be low near the surf zone where the majority of ELCAS pile removal would happen. With low occurrence and applied mitigation, the probability of actual exposures would be minimal.

The exposure numbers presented in **Table 6-4 and 6-6** for the bottlenose dolphin, California sea lion, and Pacific harbor seal, and gray whale are overly conservative estimates of harassment as discussed in Section 6, due to a range of conservative assumptions made throughout the modeling and estimation process. For example, density data used in the assessment represents relatively greater density offshore areas of southern California than the nearshore areas of SSTC (e.g., sea lions). Operational data represents a maximum underwater detonation and ELCAS training tempo rather than an average. Marine mammals were assumed to be in the location of the water column where acoustic exposure is the greatest without entering or leaving the area, when in reality, SSTC while within bottlenose dolphin's, sea lion's, and harbor seal's natural distribution, does not represent a significant breeding or foraging area. Gray whales are only transitory through Southern California during the cold season.

Further, the assessment calculates harassment without taking into consideration standard mitigation measures, and is not indicative of a likelihood of harm. The mitigation measures described in Section 11 are designed to reduce sound exposure of marine mammals to achieve the least practicable adverse effect on marine mammal species or stocks.

This Incidental Harassment Authorization application assumes that short-term non-injurious sound exposure levels predicted to cause onset-temporary threshold shift (TTS) or temporary behavioral disruptions (non-TTS) qualify as Level B harassment. This overestimates reactions qualifying as harassment under Marine Mammal Protection Act because there is no established scientific correlation between short term underwater detonations and long term abandonment or significant alteration of behavioral patterns in marine mammals.

Consideration of negligible impact is required for NMFS to authorize incidental take of marine mammals. By definition, an activity has a "negligible impact" on a species or stock when it is determined that the total taking is not likely to reduce annual rates of adult survival or recruitment (i.e., offspring survival, birth rates).

Behavioral reactions of marine mammals to sound are known to occur but are difficult to predict. Reactions to sounds, if any, depend on the species, past exposure history and experience, current activity, reproductive state, time of day, and other factors. In general, marine mammals often change their activity when exposed to disruptive levels of sound. When sound becomes potentially disruptive, cetaceans at rest become active, feeding or socializing cetaceans or pinnipeds often interrupt these events by diving or swimming away. If the sound disturbance occurs around a haul out site, pinnipeds may move back and forth between water and land or eventually abandon the haul out. When attempting to understand behavioral disruption by anthropogenic sound, a key question to ask is whether the exposures have biologically significant consequences for the individual or population (NRC 2005).

If a marine mammal does react to an underwater sound by changing its behavior or moving a small distance, the impacts of the change may not be important to the individual. On the other hand, if a sound source displaces marine mammals from an important feeding or breeding area for a prolonged period, impacts to the marine mammal could be negative because the disruption has biological consequences. There are no significant breeding or foraging areas identified within SSTC.

Biological parameters or key elements having greatest importance to a marine mammal relate to its ability to mature, reproduce, and survive. These key elements could be defined as follows:

- Growth: adverse effects on ability to feed;
- Reproduction: the range at which reproductive displays can be heard and the quality of mating/calving grounds (e.g., gray whales); and
- Survival: sound exposure may directly affect survival.

The importance of the disruption and degree of consequence for individual marine mammals often has much to do with the frequency, intensity, and duration of the disturbance. Isolated acoustic disturbances such as underwater detonation and pile driving events at SSTC usually have minimal consequences or no lasting effects for marine mammals. Marine mammals regularly cope with occasional disruption of their activities by predators, adverse weather, and other natural phenomena. It is reasonable to assume that they can tolerate occasional or brief disturbances by anthropogenic sound without significant consequences. However, prolonged disturbance, as might occur if a stationary and noisy activity were established near a concentrated area, is a more important concern. The long-term implications would depend on the degree of habituation within the population. If the marine mammals fail to habituate or become sensitized to disturbance and, as a consequence, are excluded from an important area or are subject to stress while at the important area, long-term effects could occur to individuals or the population. Again, however, SSTC does not represent significant habitat, breeding area, or foraging hot spots for marine mammals likely to be found there (bottlenose dolphin, California sea lion, Pacific harbor seal)

The Context of Behavioral Disruption and TTS - Biological Significance To Populations

The exposure estimates calculated by predictive models currently available reliably predict propagation of sound and received levels and measure a short-term, immediate response of an individual using applicable criteria. Consequences to populations are much more difficult to predict and empirical measurement of population effects from anthropogenic stressors is limited (NRC 2005). To predict indirect, long-term, and cumulative effects, the processes must be well understood and the underlying data available for models..

Relevancy To Marine Mammals at SSTC

In terms of SSTC, however, proposed events occur over a small spatial and temporal extent (i.e., relatively small ocean area and limited duration events). Put in context of the biological distribution for the coastal stock of bottlenose dolphins, California sea lions, and harbor seals, SSTC represents a very small part of their overall distribution, and contains limited haul out areas (for pinnipeds) or significant habitat for any of these species.

In a study of California sea lion reaction to human activity, Holcomb et al. (2009) showed that in general sea lions are rather resilient to human disturbance. Sea lions within the context of the distribution near and within San Diego Bay north of SSTC are exposed to a variety of human generated airborne and underwater noise associated with a busy commercial and recreation port, and are likely habituated to a wide range of sounds. No impacts to gray whales or harbor seals are predicted.

As discussed in Section 4, bottlenose dolphins forage on very patchy distributions of surf zone and coastal pelagic fish species and display little site-specific fidelity over a broad range of Central and Southern California, and parts of Baja Mexico. Temporary impacts and disturbance to prey (i.e., fish) are not expected to be significant in terms of impacts to these forage species also with a wide distribution throughout coastal California, and with known high recruitment and biomass (Allen 2006).

Any potential effects on individuals would be temporary and short-term as predicted from the acoustic impact modeling. This assumes that individual marine mammals are exposed at all, when in fact no detonations and hence no exposures would occur when marine mammals are observed within mitigation zones. In addition, while scaling from limited potential individual impacts to population impacts is uncertain, even accounting for marine mammals inadvertently exposed, population level impacts, in particular would likely be insignificant as detailed in **Table 7-1**.

Based on each species' life history information, expected behavioral patterns in SSTC training locations, an analysis of the temporary disturbance levels showing no overall mortality (just temporary behavior and TTS), and the application of robust mitigation procedures, SSTC training is anticipated to have a negligible impact on marine mammals.

Table 7-1. Qualitative assessment of impacts at SSTC from underwater detonations and ELCAS pile driving\removal.

Individual and Population Condition	Species			
FUNCTION IMMEDIATELY AFFECTED	**Bottlenose dolphin California coastal stock**	**California sea lion U.S. stock**	**Pacific harbor seal California stock**	**Gray whale Eastern Pacific stock**
Survival	No impacts (no mortality, injury predicted from modeling)	No impacts (no mortality, injury predicted from modeling)	No impacts (no mortality, injury predicted from modeling)	No impacts (no mortality, injury predicted from modeling)
Migration	No impacts predicted; SSTC represents only small area over entire species range; While foraging likely, dolphins present would be episodic and transient depending on patchy prey availability.	No impacts predicted; SSTC not within normal breeding or typical at-sea forage areas for bulk of population. Animals present would be transient.	No impacts predicted; SSTC not within normal breeding or typical at-sea forage areas for bulk of population. Animals present would be transient.	No impacts predicted; SSTC shoreline not within expected travel route for ELCAS pile removal effects; any disruption would be small scale, temporary and transitory.
Feeding	Temporary impacts IF dolphin are not observed within mitigation zone and are exposed which might interrupt feeding. More likely enhanced feeding if fish within immediate blast zone are stunned or injured and easier to catch.	Temporary impacts IF sea lions are not observed within mitigation zone and are exposed which might interrupt feeding. More likely enhanced feeding if fish within immediate blast zone are stunned or injured and easier to catch.	Temporary impacts IF sea lions are not observed within mitigation zone and are exposed which might interrupt feeding. More likely enhanced feeding if fish within immediate blast zone are stunned or injured and easier to catch.	Not applicable; gray whale generally do not feed, or feed significantly while in transit past Southern California; limited bottom food resources
Breeding	Breeding is likely not site specific (Section 4); SSTC represents only small area over entire species range.	No impacts; SSTC has no haul out or rookeries which occur on the offshore Channel Islands.	No impacts; SSTC has no haul out or rookeries.	Not applicable; SSTC is not part of gray whale breeding area
Response to predator	Temporary impacts IF dolphin is not observed within mitigation zone and exposed AND if temporarily disoriented AND if predator (white shark; killer whales not common near shore) is present before effects wear off. Combination of all conditions would have to be meet in order for any assessment of predation. Predation, however, would be insignificant relative to normal natural mortality.	Temporary impacts IF sea lion is not observed within the mitigation zone and exposed AND if temporarily disoriented AND if predator (white shark; killer whales not common near shore is present before effects wear off. Combination of all conditions would have to be meet in order for any assessment of predation. Predation, however, would be insignificant relative to normal natural mortality.	Temporary impacts IF sea lion is not observed within the mitigation zone and exposed AND if temporarily disoriented AND if predator (killer whales not common near shore is present before effects wear off. Combination of all conditions would have to be meet in order for any assessment of predation. Predation, however, would be insignificant relative to normal natural mortality.	Temporary impacts IF sea lion is not observed within the mitigation zone and exposed AND if temporarily disoriented AND if predator (killer whales not common near shore is present before effects wear off. Combination of all conditions would have to be meet in order for any assessment of predation. Predation, however, would be insignificant relative to normal natural mortality.

8 IMPACT ON SUBSISTENCE USE

Potential impacts resulting from the Proposed Action will be limited to individuals of marine mammal species located in the Silver Strand Training Complex (SSTC) that have no subsistence requirements. Therefore, no impacts on the availability of species or stocks for subsistence use are considered.

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

The proposed events at Silver Strand Training Complex (SSTC) will not result in any permanent impact on habitats used by marine mammals, and potentially short-term to minimum impact to the food sources such as forage fish. There are no known haul-out sites, foraging hotspots, or other ocean bottom structure of significant biological importance to harbor seals, California sea lions, or bottlenose dolphins within SSTC. Therefore, the main impact issue associated with the proposed activity will be temporarily elevated noise levels and the associated direct effects on marine mammals, as discussed in Sections 6 and 7.

The primary source of effects to marine mammal habitat is exposures resulting from underwater detonation training and Elevated Causeway System (ELCAS) pile driving and removal training events.

Other sources that may affect marine mammal habitat include changes in transiting vessels, vessel strike, turbidity, and introduction of fuel, debris, ordnance, and chemical residues. However, each of these components was addressed in the SSTC Environmental Impact Statement and it is the Navy's assertion that there would be no likely impacts to marine mammal habitats from these training events.

The most likely impact to marine mammal habitat occurs from underwater detonation and pile driving and removal effects on likely marine mammal prey (i.e., fish) within SSTC.

9.1 Explosive Effects On Potential Prey (Fish)

A number of studies have examined the effects of explosives on fish. These are reviewed in detail in Hastings and Popper (2005). One of the real problems with these studies is that they are highly variable and so extrapolation from one study to another, or to other sources, such as those used at SSTC, is not really possible. While many of these studies show that fish are killed if they are near the source, and there are some suggestions that there is a correlation between size of the fish and death (Yelverton et al. 1975), little is known about the very important issues of non-mortality damage in the short- and long-term, and nothing is known about effects on behavior of fish.

9.1.1 Physiological Effects

Key variables that appear to control the physical interaction of sound with fishes include the size of the fish relative to the wavelength of sound, mass of the fish, anatomical variation, and location of the fish in the water column relative to the sound source (e.g., Yelverton et al. 1975, Govoni et al. 2003).

The major issue in explosives is that the gas oscillations induced in the swim bladder or other air bubble in fishes caused by high sound pressure levels can potentially result in tearing or rupturing of the chamber. This has been suggested to occur in some (but not all) species in several gray literature unpublished reports on effects of explosives (e.g., Aplin 1947; Coker and Hollis 1950, Yelverton et al. 1975, Gaspin 1975, Goertner et al. 1994,), whereas other published studies do not show such rupture (e.g., the very well done peer reviewed study by Govoni et al. 2003).

Explosive blast pressure waves consist of an extremely high peak pressure with very rapid rise times (< 1 ms). Yelverton et al. (1975) exposed eight different species of freshwater fish to blasts of 1-lb spheres of Pentolite in an artificial pond. The test specimens ranged from 0.02 g (guppy) to 744 g (large carp) body mass and included small and large animals from each species. The fish were exposed to blasts having extremely high peak overpressures with varying impulse lengths. The investigators found what appears to be a direct correlation between body mass and the magnitude of the “impulse,” characterized by the product of peak overpressure and the time it took the overpressure to rise and fall back to zero (units in psi-ms), which caused 50% mortality (see Hastings and Popper, 2005 for detailed analysis).

One issue raised by Yelverton et al. (1975) was whether there was a difference in lethality between fish which have their swim bladders connected by a duct to the gut and fish which do not have such an opening. The issue is that it is potentially possible that a fish with such a connection could rapidly release gas from the swim bladder on compression, thereby not increasing its internal pressure. However, Yelverton et al. (1975) found no correlation between lethal effects on fish and the presence or lack of connection to the gut.

While these data suggest that fishes with both types of swim bladders are affected in the same way by explosive blasts, this may not be the case for other types of sounds, and especially those with longer rise or fall times that would allow time for a biomechanical response of the swim bladder (Hastings and Popper 2005). Moreover, there is some evidence that the effects of explosives on fishes without a swim bladder are less than those on fishes with a swim bladder (e.g., Gaspin 1975, Geortner et al. 1994, Keevin et al., 1997). Thus, if internal damage is, even in part, an indirect result of swim bladder (or other air bubble) damage, fishes without this organ may show very different secondary effects after exposure to high sound pressure levels. Still, it must be understood that the data on effects of impulsive sources and explosives on fish are limited in number and quality of the studies, and in the diversity of fish species studied. Thus, extrapolation from the few studies available to other species or other devices must be done with the utmost caution.

In a more recent published report, Govoni et al. (2003) found damage to a number of organs in juvenile pinfish (*Lagodon rhomboids*) and spot (*Leiostomus xanthurus*) when they were exposed to underwater detonations at a distance of 3.6 m, and most of the effects, according to the authors, were sublethal. Effects on other organ systems that would be considered irreversible (and presumably lethal) only occurred in a small percentage of fish exposed to the explosives. Moreover, there was virtually no effect on the same sized animals when they were at a distance of 7.5 m, and more pinfish than spot were affected.

9.1.2 Behavioral Effects

Behavioral effects include changes in the distribution, migration, mating, and catchability of fish populations. While it is possible to suggest behavioral effects on fish, there have been few laboratory, and no field, studies to show the nature of any effects of increased background noise (including underwater detonations) on fish behavior.

9.2 ELCAS Pile Driving Effects On Potential Prey (Fish)

During pile driving, pile driving\removal noise levels may exclude fish from the vicinity of ELCAS installation site. Hastings and Popper (2005, 2009) identified several studies that suggest fish may relocate to avoid certain areas of noise energy. Additional studies have documented effects of pile driving on file, although several are based on studies in support of large, multiyear bridge construction projects (Scholik and Yan 2001, 2002, Govoni et al. 2003, Hawkins 2005, Hastings 1990, 2007, Popper et al. 2006, 2007, Popper and Hastings 2009). The area likely impacted by ELCAS pile driving is relatively small compared to the overall ocean area within SSTC. Potentially up to 0.8 acres (0.003 km^2) of marine mammal foraging habitat may have decreased foraging value as each pile is driven. The duration of fish avoidance of this area after pile driving stops is unknown, but a rapid return to normal recruitment, distribution and behavior is anticipated. Of note, the potentially affected area from ELCAS pile driving\removal is less than 0.2 percent of the total area within SSTC's 321 acres (1.3 km^2) of boat lanes (Figure 1-1). Any behavioral avoidance by fish of the disturbed area would still leave significantly large areas of fish and marine mammal foraging habitat. Given the short daily duration of noise associated with individual ELCAS pile driving\removal, short duration of the entire ELCAS construction (10-days), the relatively small areas being affected, ELCAS events are not likely to have a permanent, adverse effect on any EFH, or population of fish species. Therefore ELCAS pile driving\removal is not likely to have a permanent, adverse effect on marine mammal foraging habitat at SSTC.

9.3 Summary

Based upon currently available data, it is not possible to quantitatively predict specific effects of SSTC underwater detonations and pile driving on fish. At the same time, there are several results that are at least suggestive of potential effects that result in death or damage. First, there are data from impulsive sources such as pile driving and seismic airguns that indicate that any mortality declines with distance, presumably because of lower signal levels. Second, there is also evidence from studies of explosives (Yelverton et al. 1975) that smaller animals are more affected than larger animals. Finally, there is also some evidence that fish without an air bubble, such as flatfish and sharks and rays, are less likely to be affected by explosives or pile driving and other sources than are fish with a swim bladder or other air bubble. The evidence of short- and long-term behavioral effects, as defined by changes in fish movement, etc., is limited. Thus, we still do not know if the presence of an explosion or an impulsive source at some distance, while not physically harming a fish, will alter its behavior in any significant way. In general, any adverse effects on fish behavior attributable to SSTC underwater detonations and pile driving may depend on the species in question, the age of the fish, its motivational state, its size, and numerous other factors that are difficult, if not impossible, to quantify at this point. However, given that the most likely response would be a brief startle followed by return to normal behavior, it is likely that any behavioral effects would be transitory in nature given:

- episodic, limited duration of SSTC underwater detonation and pile driving events;
- small geographic scale over which training occurs within SSTC

Therefore, temporary impacts and disturbance to marine mammal prey (i.e., fish) are not expected to be significant in terms of impacts to forage species with a wide distribution throughout coastal California, and with known high recruitment and biomass (Allen 2006). Fish prey availability for bottlenose dolphins, California sea lions, and harbor seals would not be negatively affected.

10 IMPACTS TO MARINE MAMMALS FROM LOSS OR MODIFICATION OF HABITAT

The proposed events at Silver Strand Training Complex (SSTC) is not expected to have any habitat-related effects that could cause significant or long-term consequences for individual marine mammals or their populations. Based on the discussions in Section 9, there will be no impacts to marine mammals resulting from loss or modification of marine mammal habitat.

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

The exposures outlined in Section 6 represent the maximum expected number of marine mammals that could be exposed to acoustic sources reaching Level B harassment levels (dual criteria TTS from Table 6-3).

None of the previous assessment takes into consideration measures that will be employed by the Navy to minimize impacts to marine mammals.

The Navy currently conducts and proposes to continue employing a number of mitigation measures in this Section to minimize the number of marine mammals potentially affected from training events at the Silver Strand Training Complex (SSTC).

There are three broad sets of training events for which the Navy proposes additional mitigation. These events are:

- Very shallow water (VSW, <24 feet) underwater detonation mitigation

  With a 1,200 foot or 400 yard mitigation zone. This mitigation zone is based on the maximum range of on-set TTS as predicted by the iso-velocity analysis of empirically measured very shallow water detonations <20 lbs NEW (see Section 11.1.1 for description).

- Shallow water (24-73 feet) underwater detonation mitigation

  With a **1,500** foot or **500** yard mitigation zone. This mitigation zone is based on the maximum range to onset-TTS (either 23 psi or 182 dB) predicted using the Navy's REFMS model (490 yards) plus a slight additional buffer (see Section 6 and Table 6-3).

- ELCAS pile driving and removal mitigation

  With 150 foot or 50 yard mitigation zone. This mitigation zone is based on the maximum range estimated to the Level A Cetacean Harassment criteria (180 dB RMS) (See Table 6-5).

In terms of differences between Very Shallow Water (VSW, < 24 feet depth) and shallow water (24-72 feet depth) detonation mitigations, bathymetric conditions and the proximity of the shoreline called for different measures to monitor for marine mammals during training events. These differences are presented below.

In consideration of other protected species, in addition to marine mammals, although not always stated, whenever mitigation calls for monitoring in a particular mitigation zone for marine mammals, it is also the Navy's intent to include monitoring and pause detonation events, if required, for sea turtles within established mitigation zones, as well.

As discussed earlier, Level A take is not anticipated for the proposed underwater detonations, or Elevated Causeway pile driving and removal events. Mitigation measures are anticipated to prevent Level B harassment from underwater detonations in the VSW zone, and minimize, if not eliminate Level B harassment from underwater detonations in shallow water and ELCAS pile driving and removal.

11.1 Mitigation for Underwater Detonations in Very Shallow Water (0-24 feet)

The following mitigation procedures formalizes practices that are currently in effect at SSTC for detonations conducted in the VSW zone.

1. Easily visible anchored floats will be positioned on a **1,200 foot or 400 yard radius** of a roughly semi-circular zone (the shoreward half being bounded by shoreline and immediate off-shore water) around the detonation location for small explosive exercises at the SSTC. These mark the outer limits of the mitigation zone. The 1,200 foot or 400 yard radius is the mitigation zone for VSW as determined from empirical measurements as discussed in Section 6.3.6.

2. For each VSW underwater detonation event, a safety-boat with a minimum of one observer is launched **30 or more minutes prior** to detonation and moves through the area around the detonation site. The task of the safety observer is to exclude humans from coming into the area and to augment a shore observer's visual search of the mitigation zone for marine mammals. The safety-boat observer is in constant radio communication with the exercise coordinator and shore observer discussed below.

3. A shore-based observer will also be deployed for VSW detonations in addition to boat based observers. The shore observer will indicate that the area is clear of marine mammals after 10 or more minutes of continuous observation with no marine mammals having been seen in the mitigation zone (1,200 feet or 400 yards) or moving toward it.

4. At least **10 minutes prior** to the planned initiation of the detonation event-sequence, the shore observer, on an elevated on-shore position, begins a continuous visual search with binoculars of the mitigation zone. At this time, the safety-boat observer informs the shore observer if any marine mammal has been seen in the zone and, together, both search the surface within and beyond the mitigation zone for marine mammals (and other protected species such as sea turtles).

5. The observers (boat and shore based) will indicate that the area is not clear any time a marine mammal is sited in the mitigation zone or moving toward it and, subsequently, indicate that the area is clear of marine mammals when the animal is out and moving away and no other marine mammals have been sited.

6. Initiation of the detonation sequence will only began on final receipt of an indication from the shore observer that the area is clear of marine mammals and will be postponed on receipt of an indication from that any observer that the area is not clear of marine mammals.

7. Following the detonation, visual monitoring of the mitigation zone continues **for 30 minutes** for the appearance of any marine mammal in the zone. Any marine mammal appearing in the area will be observed for signs of possible injury.

8. Any marine mammal observed after an VSW underwater detonation either injured or exhibiting signs of distress will be reported to Navy environmental representatives from the regional Navy shore commander (Commander, Navy Region Southwest) and U.S. Pacific Fleet, Environmental Office, San Diego Detachment. Using Marine Mammal Stranding communication trees and contact procedures established for the Southern California Range Complex, the Navy will report these events to the Stranding Coordinator

of NMFS' Southwest Regional Office. These voice or email reports will contain the date and time of the sighting, location (or if precise latitude and longitude is not currently available, then the approximate location in reference to an established SSTC beach feature), species description (if known), and indication of the animals status.

Additional Justification- The shallow water features and near-shore proximity of the VSW zone at the SSTC and the mitigation procedures listed in this section are expected to provide for reliable and effective mitigation of harm to marine mammals from VSW underwater. The physical topography of the VSW zone, low numbers of marine mammal anticipated within the SSTC, and training routines at SSTC allow for exceptionally reliable and effective mitigation procedures. Unlike typical circular pressure wave propagation, pressure-wave propagation in VSW (and thus mitigation zones), is restricted to a relatively small area and volume due to the nearby shoreline and shallow water depth. The shoreline limits the zone to a rough semi-circle extending seaward about the point of detonation - i.e., the site has a field-of-search with a visual angle from the shore of less than 180 degrees. The beach slopes up from the waterline with an elevated on-shore position that provides a stable – i.e., unmoving - elevated height-of-eye for complete binocular-aided observation of the detonation area and sea-surface throughout the 1,200 foot mitigation zone. The semi-circular shaped zones employed in VSW have only 50% of the surface area typical of deeper mitigation zones for underwater detonations. In addition, shallow bottom-bounded volumes are less than 3% as large as deeper-water hemispheric or cylindrical volumes. The semi-circular mitigation zone extends out from detonations in VSW depths of only 10-24 feet.

Visual observation from the shore is combined with the observations of a safety boat operator moving through and beyond the mitigation area.

In addition, for personnel safety reasons, VSW underwater detonations are conducted during daylight hours and not conducted if sea states get higher than Beaufort 3, meaning that in general, there will be less surface chop and smoother seas thus enhancing marine mammal detection.

Mysticetes such as gray whales are rarely, if ever, present in the VSW portion of the SSTC. The VSW area of SSTC on the ocean side is not known to be a preferred feeding site for small marine mammals. The principle mitigation concern during underwater detonations is for protection of small odontocetes (dolphins) and pinnipeds, most likely California sea lions, that may occasionally transit through. Were marine mammals to approach the VSW zone, even at a distance beyond the 1,200 foot mitigation zone, it is likely they would be detectable to the shore or safety-boat observers. The very shallow depths maximizes the probability of marine mammals being on the surface and increases probability of visual detection. When combined with the low numbers of marine mammals typically in these zones, the few marine mammals in or transiting through these shallow areas are not diving deeply or for extended periods of time.

Given effective VSW mitigation measured adopted by the Navy, low number of protected species, very shallow depth of water, restricted zone of influence, and easier detection potential of marine mammals, VSW underwater detonations are unlikely to result in marine mammal mortality; and risk of Level-A harassment by injury and Level-B harassment associated with TTS are likely to be minimized if not eliminated (Sequential underwater detonations are not conducted in the VSW zone, so Level-B non-TTS harassment discussion do not apply).

11.2 Mitigation for Underwater Detonations in Shallow Water

Modeling results for ZOIs discussed in Section 6 were used to develop mitigation zones applicable to the mitigation measures for underwater detonations in water between 24-72 feet at the SSTC.

The ZOIs effectively represent the mitigation zone that would be established around each detonation point to prevent Level B harassment to marine mammals. While the ZOIs vary between the different types of underwater detonation training, the Navy is proposing to establish a **500 yard** mitigation zone for the maximum zone of influence from all underwater detonations except Shock Wave Generator (SWAG) detonations conducted on the oceanside of SSTC (see Table 6-3). This large a mitigation zone is not necessary for any underwater detonations other than the Marine Mammal System operations (see Table 6-3), but it is proposed as a conservative (i.e., over protective) measure. SWAGs have smaller, more directional charges and subsequent a small ZOI, so a smaller mitigation zone of 60 yards is proposed.

The mitigation measures for underwater detonation events on the oceanside of SSTC (except for SWAG events) are listed as follows:

Underwater Detonation Mitigation (24-72 feet) (All except SWAG)

1. A mitigation zone of **1,500 feet or 500 yards** will be established around each underwater detonation point. This mitigation zone is based on the maximum range to onset-TTS (either 23 psi or 182 dB).
2. A minimum of two boats, including but not limited to small zodiacs and 11-meter Rigid Hulled Inflatable Boats (RHIB) will be deployed. One boat will act as an observer platform, while the other boat is typically the diver support boat.
3. Two observers with binoculars on one small craft\boat will survey the detonation area and the mitigation zone for marine mammals from at least **30 minutes prior** to commencement of the scheduled explosive event and until at least **30 minutes after** detonation.
4. In addition to the dedicated observers, all divers and boat operators engaged in detonation events can potentially monitor the area immediately surrounding the point of detonation for marine mammals (and other protected species such as sea turtles).
5. If a marine mammal is sighted within the **1,500** foot or **500** yard mitigation zone or moving towards it, underwater detonation events will be suspended until the marine mammal has voluntarily left the area and the area is clear of marine mammals **for at least 30 minutes**.
6. Immediately following the detonation, visual monitoring for marine mammals within the mitigation zone will continue for **30 minutes**. Any marine mammal observed after an underwater detonation either injured or exhibiting signs of distress will be reported to Navy environmental representatives from the regional Navy shore commander (Commander, Navy Region Southwest) and U.S. Pacific Fleet, Environmental Office, San Diego Detachment. Using Marine Mammal Stranding communication trees and contact procedures established for the Southern California Range Complex, the Navy will report these events to the Stranding Coordinator of NMFS' Southwest Regional Office. These voice or email reports will contain the date and time of the sighting, location (or if precise latitude and longitude is not currently available, then the approximate location in reference to an established SSTC beach feature), species description (if known), and indication of the animals status.

Underwater Detonation Mitigation (SWAG events only)

A modified set of mitigation measures would be implemented for SWAG detonations, which involve much smaller charges of 0.03 lbs NEW.

1. A mitigation zone of **180 feet or 60 yards** will be established around each SWAG detonation site.

2. A minimum of two boats, including but not limited to small zodiacs and 11-meter Rigid Hulled Inflatable Boats (RHIB) will be deployed. One boat will act as an observer platform, while the other boat is typically the diver support boat.

3. Two observers with binoculars on one small craft\boat will survey the detonation area and the mitigation zone for marine mammals (and other protected species such as sea turtles) from at least **10 minutes prior** to commencement of the scheduled explosive event and until at least **10 minutes after detonation**.

4. In addition to the dedicated observers, all divers and boat operators engaged in detonation events can potentially monitor the area immediately surrounding the point of detonation for marine mammals.

5. Divers and personnel in support boats would monitor for marine mammals out to the 180 feet or 60 yards mitigation zone for 10 minutes prior to any detonation.

6. After the detonation, visual monitoring for marine mammals would continue for **10 minutes**. Any marine mammal observed after an underwater SWAG detonation either injured or exhibiting signs of distress will be reported to Navy environmental representatives from the regional Navy shore commander (Commander, Navy Region Southwest) and U.S. Pacific Fleet, Environmental Office, San Diego Detachment. Using Marine Mammal Stranding communication trees and contact procedures established for the Southern California Range Complex, the Navy will report these events to the Stranding Coordinator of NMFS' Southwest Regional Office. These voice or email reports will contain the date and time of the sighting, location (or if precise latitude and longitude is not currently available, then the approximate location in reference to an established SSTC beach feature), species description (if known), and indication of the animals status.

11.3 Mitigation For ELCAS Training At SSTC

11.3.1 ELCAS Mitigation Measures

The Navy proposes the below mitigation procedures for ELCAS pile driving and removal events along the oceanside Boat Lanes at the SSTC for protected species (and sea turtles with the Bay).

1. Mitigation Zone- A mitigation zone will be established **at 150 feet or 50 yards** from ELCAS pile driving and pile removal events. This mitigation zone is base on the predicted range to Level A harassment (180 dB RMS) for cetaceans, and is being applied conservatively to both cetaceans and pinnipeds.

2. Monitoring will be conducted within the **150 foot or 50 yard mitigation zone** for the presence of marine mammals (and other protected species such as sea turtles) during ELCAS pile driving and pile removal events. Monitoring will begin **30 minutes before** any ELCAS pile driving or removal event, continue during pile driving or removal events, and be conducted for **30 minutes after** completion of any pile driving or removal event. A minimum of one trained observer will be placed on shore, on the ELCAS, or in a boat at the best vantage point(s) to monitor for marine mammals (or sea turtles)

3. If marine mammals (or sea turtles) are found within the 150 foot or 50 yard mitigation zone, pile removal events **will be halted** until the marine mammals (or sea turtles) have voluntarily left the mitigation zone. If the animal remains in the zone, pile driving/removal will remain stopped. If the animal is observed leaving the mitigation zone (> 50 yards), then pile driving/removal can be resumed. If the animal is lost from sight while within the mitigation zone, then pile driving/removal will remain stopped **until at least a minimum of five minutes** have elapsed without further sighting of the animal. After five minutes, pile driving/removal can be resumed. In five minutes, a marine mammal even traveling at a minimal pace of one knot (nm/hr), would travel over 0.08 nm or 169 yards which is over three times the mitigation zone distance (169 yards as compared to 50 yards).

4. Monitoring observer(s) will implement shut–down/delay procedures when applicable by calling for shut–down to the hammer operator when marine mammals (or sea turtles) are sighted within the mitigation zone.

5. Soft Start - Providing additional protection for marine mammals (and sea turtles), ELCAS pile driving includes a soft start as part of normal construction procedures. The pile driver increases impact strength as resistance goes up. At first, the pile driver piston drops a few inches. As resistance goes up, the pile driver piston will drop from a higher distance thus providing more impact due to gravity. This will allow marine mammals in the project area to vacate or begin vacating the area minimizing potential harassment. The ELCAS soft start is not the traditional soft-start used in bigger civilian construction projects, and doesn't include a waiting period (an initial set of several strikes from the impact hammer at 40-60 percent energy levels, followed by a one minute waiting period, then two subsequent 3 strike sets), but does provide additional time for marine mammals to vacate the area. Including waiting periods as part of training would be inconsistent with Navy training objectives that requires the ELCAS to be constructed as quickly as possible in real world conditions to ensure rapid supply of equipment and materials to shore in a hostile territory during wartime, or during humanitarian assistance operations.

6. ELCAS Acoustic Monitoring- The Navy proposes, under the associated SSTC marine mammal monitoring plan, to conduct underwater acoustic propagation monitoring during the first available ELCAS deployment at the SSTC under this Incidental Harassment Authorization application. This acoustic monitoring would provide empirical field data on ELCAS pile driving and removal underwater source levels, and propagation specific to ELCAS training at the SSTC. These results will be used to either confirm or refine the Navy's exposure predictions (source level, F value, exposures) described in Section 6.

11.3.2 ELCAS mitigations considered but rejected

As discussed in Section 11.3.1, the Navy will monitor an ELCAS mitigation zone for the presence of marine mammals (and sea turtles) before, during and after pile driving and removal events. If marine mammals (or sea turtles) are found in the mitigation zone, pile driving and removal will be halted until the marine mammals have voluntarily left the zone.

Mitigation measures that other, generally longer term and much larger pier and bridge construction projects have implemented in the past are listed as follows, with an explanation of why the Navy is not proposing to implement them.

A significant reason for not considering these mitigations is that the engineering needed to both develop, and more importantly field deploy, these mitigations is often not available under the remote expeditionary nature that characterizes field training with the ELCAS. There is generally a lack of facility based infrastructure to support the mitigation deployment. In addition, these measures are part of a much longer term (sometime several years) projects where deployment time of the mitigation can be factored into a given construction project over several months. By contrast, an entire ELCAS training event from construction, to use, to disassembly usually is only scheduled to occur for periods of up to two to three weeks or shorter. Deploying of additional significant hardware-based mitigations would be impractical, nor meet the Navy's Title 10 requirements for training.

The range of additional ELCAS mitigations considered but rejected fall into two classes. One is deploying various engineering solutions such as sound dampening measure or material change, and the other is seasonal or daily restrictions.

ELCAS mitigation measures considered, but rejected

1. Adding sound dampening measures- Following are a list of sound dampening measures that other pier construction and repair projects have considered or used in the past that help to attenuate some sound from pile driving, but for which the Navy asserts are not practical for ELCAS training These measures are not used in actual ELCAS operations overseas or easily adaptable for ELCAS training at SSTC. In addition, the purpose of ELCAS training is to teach personnel to construct an ELCAS as they would overseas in as quick a manner as possible. Adding in sound dampening measures that are not used in real world conditions would not only confuse personnel trying to learn and recertify their capabilities in ELCAS construction, but divert the limited amount of Navy personnel available to ELCAS support units away from necessary training while they implement these measures.

   a. Bubble curtain: Air bubble curtains infuse the area surrounding the pile with air bubbles, creating a bubble screen that inhibits the propagation of some sound from pile driving and removal. The effectiveness of air curtain design in reducing underwater sound propagation is highly variable ranging from reduction of zero to perhaps 15 dB in source level (CADOT 2009). However, the exact optimum design of air bubble curtains is still slightly qualitative, based on site conditions and engineering issues. As designed, there is no latitude in the ELCAS construction equipment to allow installation of bubble curtains. Typical bubble curtain arrangements for larger pier construction projects would not have the necessary support (power, air compressors, piping, etc.) found at remote ELCAS deployment sites within the SSTC (**Figure 11-2**);

   b. Cofferdam: Cofferdams are temporary structures used to isolate an area generally submerged underwater from the water column. Cofferdams are most commonly fabricated from sheet piling or inflatable water bladders. As designed, there is no latitude in the ELCAS construction equipment to allow installation of cofferdams;

   c. Isolation casing: Isolation casings are hollow casings slightly larger in diameter than the piling to be driven. The casing, typically a larger hollow pile, is inserted into the water column and bottom substrate. The casing then is dewatered, and the piling is driven within the dewatered isolation casing. As designed, there is no latitude in the ELCAS construction equipment to allow installation of isolation cases;

   d. Cushion blocks: Cushion blocks are blocks of material used with impact hammer pile drivers. They consist of blocks of material placed atop a piling during pile driving to minimize the noise generated while driving the pile. Materials typically used for cushion blocks include wood, nylon, and micarta blocks. The effectiveness of these materials within both the construction world and as potential ELCAS mitigation is not sufficiently studied, and its unknown if cushion blocks would effectively and significantly lower pile driving noise levels. Use of cushion blocks would require additional time to prepare and deploy on each ELCAS pile. The result could be significant time delays between individual ELCAS pile driving resulting is delays to the overall ELCAS training.

e. Changing pile material or size: Different pile materials, such as concrete, and\or smaller piles could reduce the sound intensity and associated ZOIs during ELCAS construction at SSTC. The ELCAS, however, is a pre-manufactured system using 24 inch steel piles, designed for optimal operation overseas and deployment on specified Navy cargo ships. Navy personnel are not able to use incompatible piles in this pre-manufactured system, which might compromise the ELCAS' military specifications and design.

Figure 11-2. Representative large engineering scale air curtain bubble screens not applicable as ELCAS alternative mitigation measure.

2. Seasonal or Daily Restrictions- Changing the time when pile driving or removal occurs is another construction based technique. The following are two temporal measures that other civilian pier construction and repair projects have considered or used in the past to help minimize impacts to marine mammals, but for which the Navy asserts are not practical for ELCAS training.
   a. Constructing ELCAS at a different time of year: Shifting ELCAS training to summer months may help with transitory migratory species, such as the gray whale, which are not present during the summer within Southern California. The actual amount of pile removal exposures for gray whales is very small, and as explained earlier much more easy to mitigate with the applicable mitigation zone. Navy training cycles and curriculums are set to a fixed annual training schedule, however, to ensure that personnel are adequately trained for deployment, and resources are available to conduct that training. Restricting ELCAS training to by season would adversely impact the Navy's ability to ensure that personnel are adequately prepared for deployment, while not lending significant protection to marine mammals.
   b. Daylight Restriction: Restricting ELCAS pile driving and removal to only daylight hours could conceivably avoid impact to marine mammals by making visual sighting within the ELCAS mitigation zone easier. However, ELCAS operations in real world conditions are performed 24 hours a day to enable forces to offload materials from the ship to shore (via the ELCAS) as quickly as possible. Sailors need to train for these real world conditions, including night-time operations. Navy training cycles and curriculums, as well as resulting field deployments to training sites such as the SSTC, are set to a fixed annual training schedule with daily milestones of accomplishments that also include night time training. In addition, while under construction, there is significant floodlight use both on the ELCAS itself and at the pile driving or removal location pointing into the water so that operators can observe the results of these events. This same lighting would afford additional sighting opportunities for marine mammals within the 50 yards ELCAS mitigation zone at night.

11.4 Other SSTC Mitigation

As discussed in Sections 1 and 2, the Navy asserts that other SSTC training events do not rise to the level of harassment as specified under the Marine Mammal Protection Act.

The Navy, therefore, does not propose any additional mitigation measure other than those presented previously for underwater detonations and ELCAS pile driving and removal.

However, although not a mitigation measure per se, the Navy will continue to report any marine mammal incidents, strandings, or ship strikes consistent with ongoing similar reporting for the entire U.S. West Coast. For stranded marine mammals observed ashore or at sea by Navy personnel, or Navy ship or boat strikes to marine mammals, including within San Diego Bay and the SSTC, the Navy will continue its existing regional reporting of these events, if they happen, to the Stranding Coordinator at the NMFS Southwest Region. A stranding communication and information tree between the NMFS and Navy for these events has previously been developed for Southern California.

This now standard operating procedure will be updated annually, and applied for any and all marine mammal incidents that happen to also occur within San Diego Bay and the SSTC.

11.5 Mitigation Effectiveness

Mitigation of potential impacts depends on observers and range safety officers. For monitoring zones, observer positions would make best use of the available platforms and assets. The efficacy of visual detection depends on several factors related to the observers, environment, and monitoring platforms.

Training events involving underwater detonation occur during daylight hours with Beaufort sea-states of three or less at SSTC. Therefore, mitigation zones are typically clearly visible from the shore where the beach slopes up to provide an elevated position for a stable observation deck for complete binocular-aided observation of the mitigation area and sea-surface beyond 1,300 feet seaward of the VSW detonation locations. Beyond the VSW but within SSTC (limit of 72 feet depth), the mitigation area can increase to a radius of **1,410** feet or **500** yards in a circular fashion. Marine mammals at the surface in the mitigation zones immediately offshore have a higher probability of detection.

ELCAS training events involving pile driving and removal typically occur during daylight hours as well as nighttime with strong floodlights illuminating the areas. The 150 foot or 50 yard ELCAS mitigation zone is typically clearly visible from the pier, which is elevated above the water.

More importantly, physical characteristics of the environment and local circumstances substantially increase the probability of animals being on the surface. That is, conditions are substantially better for visual mitigation at SSTC than those typically encountered during offshore events when mitigation is used and deep-diving mammals can be encountered. More specifically, negative biases (availability and observer) are much reduced at SSTC compared to deeper water locations where water depth exceeds the diving abilities of sea lions, harbor seals, bottlenose dolphins, and gray whales.

Given these near-shore characteristics, the percent detection or detection effectiveness for various species that are usually associated with deeper at-sea zones and other methods of observation, do not apply nor do the detection probabilities associated with assessment surveys in deep water from ships or planes (Barlow 1995, Barlow 1999, Barlow et al. 2001, Buckland et al. 1993). While survey detection probabilities may not apply, environmental variables (sea state, relative visibility, glare, swell height) and observer training and locations at SSTC favor very good detection rates. No long- or deep-diving mammals are present, therefore, the 30-minute period of observation allows for improved probability of animals surfacing to be seen by either the dive team and associated support craft or the dedicated craft.

Because of the coastal nature of SSTC and near-shoreline volumes, marine animals will be at the surface much more frequently and not diving deeply or for extended periods of time as is typically assumed in deeper water. Though they will be easily sighted, numbers of marine mammals in the vicinity of events are expected to be quite low, as there are no seal or sea lion haul-outs nor are there intensively used dolphin feeding grounds within the SSTC.

Finally, similar to other Navy range complexes, a report on SSTC underwater detonations by explosive type, observations of interactions with marine mammals, and associated marine mammal monitoring (Section 13 and Appendix A) will be reported annually to NMFS' Office of Protected Resources.

12 MINIMIZATION OF ADVERSE EFFECTS ON SUBSISTENCE USE

Based on the discussions in Section 8, there are no adverse effects on the availability of species or stocks for subsistence use. Subsistence use is the traditional exploitation of marine mammals by native peoples for their own consumption.

13 MONITORING AND REPORTING MEASURES

Proposed SSTC Monitoring For This Incidental Harassment Authorization

The SSTC Monitoring Program, proposed by the Navy as part of this Incidental Harassment Authorization application, is focused on mitigation based monitoring and presented more fully in **Appendix A** of this application. Main monitoring techniques include use of civilian scientists as marine mammal observers during a sub-set of SSTC underwater detonation events to validate the Navy's pre and post event mitigation effectiveness, and observe marine mammal reaction, or lack of reaction to SSTC training events. Also, as stated in Section 11, the Navy proposes to conduct an acoustic monitoring project during the first field deployment of the Elevated Causeway System (ELCAS) to the SSTC. The objective of this project under the SSTC Monitoring Plan would be to empirically measure site-specific ELCAS underwater sound propagation at SSTC, with the goal of refining future marine mammal exposure estimates.

Long-term observations of marine mammal occurrence within the SSTC will leverage off the aerial surveys conducted as part of the Navy funded, science based region wide effort in Southern California discussed below (DoN 2009a, 2010a). In the 2011 annual Monitoring Plan update to the Southern California Range Complex, a new Southern California study area has been identified (DoN 2010). This new study area for aerial observation of marine mammal occurrence and behavior and stretches from the shoreline of SSTC to approximately 10 nm westward. Any results from survey efforts in this new study area during 2011 will be reported in the annual SSTC Monitoring Report to NFMS.

Ongoing Monitoring

The Navy has an existing Monitoring Plan that provides for site-specific monitoring for Marine Mammal Protection Act and Endangered Species Act listed species, primarily marine mammals, within Southern California including marine water areas off of the SSTC (DoN 2008b, 2009a, 2010a, NMFS 2009b). This monitoring plan was initially developed in support of the Southern California Range Complex Final Environmental Impact Statement/Overseas Environmental Impact Statement and subsequent Letter of Authorization by the National Marine Fisheries Service (NMFS) (DoN 2008b, 2009, 2010, NMFS 2009b). The primary goals of monitoring are to evaluate trends in marine species distribution and abundance in order to assess potential population effects from Navy training events and determine the effectiveness of the Navy's mitigation measures. The monitoring plan, adjusted annually in consultation with NMFS, includes aerial and ship based visual observations, acoustic monitoring, animal tagging, and other efforts such as oceanographic observations. The Navy, under the Southern California Range Complex Monitoring Plan, and working in collaboration with NMFS Southwest Fisheries Science Center, will solicit recommendations applicable to species associated with SSTC. This can include, but would not necessarily be limited to, small boat visual surveys along the ocean area of SSTC, and\or attaching satellite tracking tags to a number of individual animals from the coastal stock of bottlenose dolphins. While attaching tags to marine mammals is not an easy field effort, when successful satellite tracking can potentially provide significant information on bottlenose dolphin distribution, occurrence, and residence time within SSTC, while also contributing to the overall body of science for bottlenose dolphins in California. The Navy is not currently committing to increased boat surveys or tagging under the Southern California Range Complex monitoring specifically within the SSTC at this time, but will research opportunities for leveraged work at SSTC that could be added under an Adaptive Management provision of this Incidental Harassment Authorization application for future SSTC monitoring.

14 RESEARCH

World-wide, the Navy funded over $33M in marine mammal research in 2010. A summary of other Navy funded research accomplishments specific to the Southern California Range Complex is provided in significantly more detail in the Navy's Hawaii Range Complex-Southern California Monitoring Report for 2010 (DoN 2009, 2010).

The Navy sponsors a significant portion of research concerning the effects of human-generated sound on marine mammals. Major topics of Navy-supported research include the following:

- Gaining a better understanding of marine species distribution and important habitat areas,
- Developing methods to detect and monitor marine species before and during training,
- Understanding the effects of sound on marine mammals, and
- Developing tools to model and estimate potential effects of sound.

This research is directly applicable to Fleet training activities, particularly with respect to the investigations of the potential effects of underwater noise sources on marine mammals and other protected species.

Furthermore, various research cruises by the NMFS and by academic institutions have been augmented with additional funding from the Navy. The Navy has also sponsored several workshops to evaluate the current state of knowledge and potential for future acoustic monitoring of marine mammals. The workshops brought together acoustic experts and marine biologists from the Navy and other research organizations to present data and information on current acoustic monitoring research efforts and to evaluate the potential for incorporating similar technology and methods on instrumented ranges. Overall, the Navy will continue to fund ongoing marine mammal research, and is planning to coordinate long term monitoring/studies of marine mammals on various established ranges and operating areas. The Navy will also continue to research and contribute to university and external research to improve the state of the science regarding marine species biology and acoustic effects. These efforts include monitoring programs; data sharing with National Marine Fisheries Service (NMFS) from research and development efforts; and future research as described previously.

To date, there has been no significant Navy funded research within the much smaller spatial extent of the SSTC ocean area. As of this application, the Navy is unaware of other NMFS directed, or academic funded marine mammal research specific to the SSTC.

However, as discussed in Section 13 (Monitoring), the Navy will explore future funding of marine mammal research within SSTC as a leveraged part of existing Southern California efforts, if warranted conditional on researcher availability, funding, and logistics.

REFERENCES

Ahroon, W. A., R.P. Hamernik, and L. Sheau-Fang, 1996. The effects of reverberant blast waves on the auditory system.' J. Acoust. Soc. Am. 100, 2247–2257.

Allen, L.G., D. Pondella II, M.H. Horn (eds). 2006. The Ecology of Marine Fishes- California and Adjacent Waters. University of California Press, Los Angeles. 660 pp.

Allen, B.M, and R.P. Angliss. 2010. DRAFT Alaska Marine Mammal Stock Assessment Report: 2010. National Marine Fisheries Service, National Marine Mammal Laboratory, Alaska Fisheries Science Center April 2010.

Antonelis, G.A., Jr., B.S. Stewart, and W.F. Perryman. 1990. Foraging characteristics of female northern fur seals (*Callorhinus ursinus*) and California sea lions (*Zalophus californianus*). Canadian Journal of Zoology 68:150-158.

Au, W.W.L. 1993. The sonar of dolphins. Springer-Verlag, New York. 277 pp.

Au, W.W.L. 2000. Hearing in whales and dolphins: An overview. Pages 1-42 in Au, W.W.L., A.N. Popper, and R.R. Fay, eds. Hearing by whales and dolphins. New York, New York: Springer-Verlag

Aplin, J.A. 1947. The effect of explosives on marine life. California Fish and Game 33:23-30.

Baird, R.W. 2001. Status of harbour seals, *Phoca vitulina*, in Canada. Canadian Field-Naturalist 115(4):663-675.

Baraff, L. and M.T.Weinrich. 1993. Separation of humpback whale mothers and calves on a feeding ground in early Autumn. Marine Mammal Science 9:431-434.

Barlow J. 1995. The abundance of cetaceans in California waters. Part I: Ship surveys in summer and fall of 1991. Fishery Bulletin. 93:1-14.

Barlow, J. 1999. Trackline detection probability for long-diving whales. Pages 209-221 in G.W. Garner, S.C. Amstrup, J.L. Laake, B.F.J. Manly, L.L. McDonald, and D.G. Robertson, eds. Marine mammal survey and assessment methods. Brookfield, Vermont: A.A. Balkema.

Barlow, J., T. Gerrodette, and J. Forcada. 2001. Factors affecting perpendicular sighting distances on shipboard line-transect surveys for cetaceans. J. Cetacean Res. and Manage. 3(2):201-212.

Barlow, J and K.A. Forney. 2007. Abundance and population density of cetaceans in the California Current System. Fisheries Bulletin 105:509-526.

Bearzi, M. 2005. Aspects of the ecology and behavior of bottlenose dolphins (*Tursiops truncates*) in Santa Monica Bay, California. Journal of Cetacean Research and Management 7(1):75-83.

Bearzi, M. 2006. California sea lions use dolphins to locate food. Journal of Mammalogy 87(3):606-617.

Bearzi, M., C.A. Saylan, and A. Hwang. 2009. Ecology and comparison of coastal and offshore bottlenose dolphins (*Tursiops truncatus*) in California. Marine and Freshwater Research 60:584–593.

Bejder, L., A. Samuels, H. Whitehead, N. Gales, J. Mann, R. Connor, M. Heithaus, J. Watson-Capps, C. Flaherty and M. Krützen. 2006. Decline in relative abundance of bottlenose dolphins (*Tursiops* sp) exposed to long-term disturbance. Conservation Biology. 10:1523-1739

Bester M.N., Ferguson J.W.L., F.C. Jonker. 2002. Population densities of pack ice seals in the Lazarev Sea, Antarctica. Antarctic Science 14:123-127.

Bigg, M.A. 1981. Harbour seal *Phoca vitulina* Linnaeus, 1758 and *Phoca largha* Pallas, 1811. Pages 1-27 IN: S.H. Ridgway and R. Harrison, eds. Handbook of marine mammals, Volume 2: Seals. San Diego: Academic Press.

BjØrge, A. 2002. How persistent are marine mammal habitats in an ocean of variability? Pages 63-91 IN: P.G.H. Evans, and J.A. Riga, eds. Marine Mammals: Biology and Conservation. Kluwer Academic/Plenum Publishers, New York.

Bjørgesæter, A., K.I. Ugland, and A. Bjørge. 2004. Geographic variation and acoustic structure of the underwater vocalization of harbor seal (*Phoca vitulin*a) in Norway, Sweden and Scotland. Journal of the Acoustic Society of America 116(4):2459-2468.

Blackwell, S.B., J.W. Lawson, and M.T. Williams. 2004. Tolerance by ringed seals (*Phoca hispida*) to impact pile-driving and construction sounds at an oil production island. Journal of the Acoustical Society of America. 15:2346-2357.

Bodson, A. L. Miersch, B. Mauck, and G. Dehnhardt. 2006. Underwater auditory localization by a swimming harbor seal (*Phoca vitulina*). Journal of the Acoustic Society of America 120(3):1550-1557.

Bonnell, M.L. and R.G. Ford, 1987. California Sea Lion Distribution: A Statistical Analysis of Aerial Transect Data. The Journal of Wildlife management, 51(1):13-20.

Bonnell, M.L. and M.D. Dailey. 1993. Marine mammals. Pages 604-681. IN: M. D. Dailey, D. J. Reish and J.W. Anderson, eds. Ecology of the Southern California Bight: A synthesis and interpretation. Berkeley: University of California Press.

Bowen, W.D., S.J. Iverson, J.I. McMillan, and D.J. Boness. 2006. Reproductive performance in grey seals: age-related improvement and senescence in a capital breeder. J. Anim. Ecology 75: 1340-1351.

Bowles, A.E., M. Smultea, B. Wursig, D.P. DeMaster, and D. Palka. 1994. Relative abundance and behavior of marine mammals exposed to transmissions from the Heard Island Feasibility Test. Journal of the Acoustical Society of America. 96:2469-2484.

Braham, H.W. 1984. Distribution and migration of gray whales in Alaska. Pages 249-266. IN: Jones, M.L., S.L. Swartz, and S. Leatherwood, eds. The gray whale *Eschrichtius robustus*. San Diego, California: Academic Press.

Britt, J.R. 1986. Shock Wave Reflection and Refraction in Multi-Layered Ocean/Ocean Bottoms. DNA-TR-86-49 (Unclassified), Applied Research Associates under contract to the Defense Nuclear Agency, Albuquerque, NM, 130 pp.

Britt, J.R., R. J. Eubanks, and M. G. Lumsden. 1991. Underwater Shock Wave Reflection and Refraction in Deep and Shallow Water, Volume I, A User's Manual for the REFMS Code. Technical Report DNA-TR-91-15-V1 (Unclassified), Defense Nuclear Agency, Alexandria, VA.

Buckland, S.T., D.R. Anderson, K.P. Burnham, and J.L. Laake. 1993. Distance sampling Chapman and Hall: London. 226 p.

Cagniard, L. 1962., Reflection and Refraction for Progressive Seismic Waves, McGraw-Hill, New York, p. 282.

Calambokidis, J., J.D. Darling, V. Deecke, P. Gearin, M. Gosho, W. Megill, C.M. Tombach, D. Goley, C. Toropova, and B. Gisborne. 2000. Range and movements of seasonal resident gray whales from California to southeast Alaska. Final Report.

Calambokidis, J., J.D. Darling, V. Deecke, P. Gearin, M. Gosho, W. Megill, C.M. Tombach, D. Goley, C. Toropova, and B. Gisborne. 2002. Abundance, range and movements of a feeding aggregation of gray whales (*Eschrichtius robustus*) from California to southeastern Alaska in 1998. Journal of Cetacean Research and Management 4(3):267-276.

Calambokidis, J., T. Chandler, E. Falcone, and A. Douglas. 2004. Research on large whales off California, Oregon, and Washington in 2003. Annual Report for 2003. Contract number 50ABNF100065 Prepared for Southwest Fisheries Science Center, La Jolla, California by Cascadia Research, Olympia, Washington.

California Department of Transportation (CADOT). 2009. Technical Guidance for Assessment and Mitigation of the Hydroacoustic Effects of Pile Driving on Fish. February 2009.

Carretta, M.S. Lowry, C.E. Stinchcomb, M.S. Lynn, and R.E. Cosgrove. 2000. Distribution and abundance of marine mammals at San Clemente Island and surrounding offshore waters: results from aerial and ground surveys in 1998 and 1999. U.S. National Marine Fisheries Service, Southwest Fisheries Science Center. Administrative Report LJ-00-02. 43 pp.

Carretta, J.V., K.A. Forney, M.S. Lowry, J. Barlow, J. Baker, D. Johnston, B. Hanson, R.L. Brownell Jr., J. Robbins, D.K. Mattila, K.Ralls, M.M. Muto, D. Lynch, and L. Carswell. 2010. U.S. Pacific Marine Mammal Stock Assessments: 2010. US Department of Commerce, NOAA Technical Memorandum, NOAA-TM-NMFS-SWFSC-453.

Clarke R. 1956. Sperm whales off the Azores. Discovery Rep 28:239-298.

Clark, L.S., D.F. Cowan, and D.C. Pfeiffer. 2006. Morphological changes in the Atlantic bottlenose dolphin (*tursiops truncatus*) adrenal gland associated with chronic stress. Journal of Comparative Pathology. 135:208-216.

Coker, C.M., and E.H. Hollis. 1950. Fish mortality caused by a series of heavy explosions in Chesapeake Bay. Journal of Wildlife Management 14:435-445.

Connor, R.C. and M.R. Heithaus. 1996. Approach by great white shark elicits flight response in bottlenose dolphins. Marine Mammal Science. 12:602-606.

Costa, D.P., C. Kuhn, and M. Weise. 2007. Foraging Ecology of the California Sea Lion: Diet, Diving Behavior, Foraging Locations, and Predation Impacts on Fisheries Resources. California Sea Grant College, University of California, San Diego. Research Completion Reports. CA Sea Grant Final Report – 29 May 2007.

Costa, D.P., D.E. Crocker, J. Gedamke, P.M. Webb, D.S. Houser, S.B. Blackwell, D. Waples, S.A. Hayes, and B.J. Le Boeuf. 2003. The effect of a low-frequency sound source (acoustic thermometry of the ocean climate) on the diving behavior of juvenile northern elephant seals, *Mirounga angustirostris*. Journal of the Acoustical Society of America. 113.1155-1165.

Courbis, S. and G. Timmel. 2008. Effects of vessels and swimmers on behavior of Hawaiian spinner dolphins (*Stenella longirostris*) in Kealake'akua, Honaunau, and Kauhako bays, Hawai'I. Marine Mammal Science 25(2): 430-440.

Cox, T.M., T.J. Ragen, A.J. Read, E.E. Vos, and 32 others. 2006. Understanding the impacts of anthropogenic sound on beaked whales. Journal of Cetacean Research and Management 7(3):177-187.

Crane, N.L. and K. Lashkari. 1996. Sound production of gray whales, *Eschrichtius robustus*, along their migration route: A new approach to signal analysis. Journal of the Acoustical Society of America 100(3):1878-1886.

Croll D.A. C.W. Clark., J. Calambokidis., W.T. Ellison., and B.R. Tershy. 2001. Effects of anthropogenic low-frequency noise on the foraging ecology of Balaenoptera whales. Animal Conservation. 4:13-27.

Cummings, W.C., P.O. Thompson, and R. Cook. 1968. Underwater sounds of migrating gray whales, *Eschrichtius glaucus* (Cope). Journal of the Acoustical Society of America 44(5):1278-1281.

Cummings, W.C. and P.O. Thompson. 1971. Gray whales, *Eschrichtius robustus*, avoid the underwater sounds of killer whales, Orcinus orca. Fishery Bulletin 69(3):525-530.

David L. 2002. Disturbance to Mediterranean cetaceans caused by vessel traffic. In: G. Notarbartolo di Sciara (Ed.), Cetaceans of the Mediterranean and Black Seas: state of knowledge and conservation strategies. A report to the ACCOBAMS Secretariat, Monaco, February 2002. Section 11, 21 pp.

Deane, G.B. 1997. Sound generation and air entrainment by breaking waves in the surf zone. Journal of the Acoustic Society of America 102(5):2671-2689.

Deane, G.B. 2000. Long time-base observations of surf noise. Journal of Acoustic Society of America 107(2):758-770.

Dahlheim, M.E., H.D. Fisher, and J.D. Schempp. 1984. Sound production by the gray whale and ambient noise levels in Laguna San Ignacio, Baja California Sur, Mexico. Pages 511-541. IN: Jones, M.L., S.L. Swartz, and S. Leatherwood, eds. The gray whale *Eschrichtius robustus*. San Diego, California: Academic Press.

Dahlheim, M.E. and D.K. Ljungblad. 1990. Preliminary hearing study on gray whales (*Eschrichtius robustus*) in the field. Pages 335-346. IN: Thomas, J. and R. Kastelein, eds. Sensory abilities of cetaceans: Laboratory and field evidence. New York, New York and London, England: Plenum Press.

Deecke, V.B., Pj.J.B. Slater, and J.K.B. Ford. 2002. Selective habituation shapes acoustic predator recognition in harbour seals. Nature. 420-171-173.

Defran, R.H. and D.W. Weller. 1999. Occurrence, distribution, site fidelity, and school size of bottlenose dolphins (*Tursiops truncatus*) off San Diego, California. Marine Mammal Science 15(2):366-368.

Defran, R.H., D.W. Weller, D.L. Kelly, and M.A. Espinosa. 1999. Range characteristics of Pacific coast bottlenose dolphins (*Tursiops truncates*) in the Southern California Bight. Marine Mammal Science 15(2):381-393.

Department of the Navy (DoN). 2001. Environmental Impact Statement for the Shock Trial of the Winston S. Churchill, (DDG-81), Department of the Navy.

Department of the Navy (DoN). 2003. Commander, Naval Surface Forces Pacific (COMNAVSURFPAC) Instruction 3120.8F, Procedures for Disposal of Explosives at Sea/Firing of

Depth Charges and Other Underwater Ordnance. U.S. Department of the Navy, COMNAVSURFPAC.

Department of the Navy (DoN). 2008a. Final Environmental Impact Statement / Overseas Environmental Impact Statement for the Hawaiian Range Complex, May 2008. U.S. Department of the Navy.

Department of the Navy (DoN). 2008b. Final Environmental Impact Statement/Overseas Environmental Impact Statement for the Southern California Range Complex, December 2008. U.S. Department of the Navy.

Department of the Navy (DoN). 2009a. Marine Mammal Monitoring For the U.S. Navy's Hawaiian Range Complex and Southern California Range Complex- Annual Report 2009. U.S. Department of the Navy.

Department of the Navy (DoN). 2010a. Marine Mammal Monitoring For the U.S. Navy's Hawaiian Range Complex and Southern California Range Complex- Annual Report 2010. U.S. Department of the Navy.

Department of the Navy (DoN). 2010b. Silver Strand Environmental Impact Statement- DRAFT January 2010. U.S. Department of the Navy.

DoN and the San Diego Unified Port District (SDUPD), 2000. San Diego Bay Integrated natural Resources Management Plan. Prepared by Tierra Data Systems, Escondido, California.

Dudzik, K.J., K.M. Baker, and D.W. Weller. 2006. Mark-recapture abundance estimate of California coastal stock bottlenose dolphins: February 2004 to April 2005. SWFSC Administrative Report LJ-06-02C, available from Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037. 15p.

Eguchi, R. and J.T. Harvey. 2005. Diving behavior of the Pacific harbor seal (*Phoca vitulina richardii*) in Monterey Bay, California. Marine Mammal Science 21(2):283-295.

Eller, A. and R. Cavanaugh, 2000. Subsonic Aircraft Noise at and Beneath the Ocean Surface: Estimation of Risk for Effects on Marine Mammals. Science Applications International Corporation, McLean, VA, June 2000.

Elsayed , N.M. 1997. Toxicology of blast overpressure. Toxicology 121(1):1-15.

Elsayed, N.M. and N.V. Gorbunov. 2007. Pulmonary Biochemical and Histological Alterations after Repeated Low-Level Blast Overpressure Exposures. Toxicological Sciences 95(1):289–296.

Engelhard, G.H., S.M.J.M. Brasseur, A.J. Hall, H.R. Burton, and P.J.H. reijnders. 2002. Adrenocortical responsiveness in southern elephant seal mothers and pups during lactation and the effect of scientific handling. Journal of Comparative Physiology – B. 172:315-328.

Evans, D.L. and G.R. England. 2001. Joint interim report – Bahams Marine Mammal Stranding – event of 15-16 March 2000. U.S. Department of Commerce; Secretary of the Navy, vi+59 pp.

Feldkamp, S.D., R.L. DeLong, and G.A. Antonelis. 1989. Diving patterns of California sea lions, *Zalophus californianus*. Canadian Journal of Zoology. 67:872-883.

Finneran, J.J. 2003. Whole-lung resonance in a bottlenose dolphin (*Tursiops truncatus*) and white whale (*Delphinapterus leucas*). Journal of the Acoustical Society of America. 114:529-535.

Finneran, J.J., D.A. Carder, and S.H. Ridgway. 2001. Temporary threshold shift (TTS) in bottlenose dolphins *Tursiops truncatus* exposed to tonal signals. Journal of the Acoustical Society of America. 1105:2749(A), 142nd Meeting of the Acoustical Society of America, Fort Lauderdale, FL. December.

Finneran, J.J., C.E Schlundt, R. Dear, D.A Carder, and S.H Ridgway. 2002. Temporary shift in masked hearing thresholds (MTTS) in odontocetes after exposure to single underwater impulses from a seismic watergun. Journal of the Acoustical Society of America. 111:2929-2940.

Finneran, J.J., D.A. Carder, and S.H. Ridgway. 2003. Temporary threshold shift measurements in bottlenose dolphins *Tursiops truncatus*, belugas *Delphinapterus leucas*, and California sea lions *Zalophus californianus*. Environmental Consequences of Underwater Sound (ECOUS) Symposium, San Antonio, TX, 12-16 May 2003.

Finneran, J.J., and C.E. Schlundt. 2004. Effects of intense pure tones on the behavior of trained odontocetes. Space and Naval Warfare Systems Center, San Diego, Technical Document. September.

Finneran, J. J., D. A. Carder, C. E. Schlundt, and S. H. Ridgway, 2005. Temporary threshold shift (TTS) in bottlenose dolphins (*Tursiops truncatus*) exposed to mid-frequency tones, Journal of the Acoustic Society of America 118:2696-2705.

Finneran, J. J. and D. S. Houser, 2006. Comparison of in-air evoked potential and underwater behavioral hearing thresholds in four bottlenose dolphins (*Tursiops truncatus*). Journal of the Acoustical Society of America 119(5):3181-3192.

Finneran, J. J., C. E. Schlundt, B. Branstetter, and R. L. Dear. 2007. Assessing temporary threshold shift in a bottlenose dolphin (*Tursiops truncates*) using multiple simultaneous auditory evoked potentials. Journal of the Acoustical Society of America 122:1249–1264.

Foote, A.D., R.W. Osborne, and A.R. Hoelzel. 2004. Whale-call response to masking boat noise. Nature. 910-910.

Frankel, A.S. and C.W., Clark. 2002. ATOC and other factors affecting the distribution and abundance of humpback whales (Megaptera novaeangliae) off the north shore of Kauai. Marine Mammal Science. 18:644-662.

Gabriele, C.M., J.M. Straley, S.A. Mizroch, C.S. Baker, A.S. Craig, L.M. Herman, D. Glockner-Ferrari, M.J. Ferrari, S. Cerchio, O. von Ziegesar, J. Darling, D. McSweeney, T.J. Quinn II, and J.K. Jacobsen. 2001. Estimating the mortality rate of humpback whale calves in the central North Pacific Ocean. Can. J. Zool. 79:289-600.

Gailey, G., B. Wursig, and T.L. McDonald. 2007. Abundance, behavior, and movement patterns of western gray whales in relation to a 3-D seismic survey, Northeast Sakhalin Island, Russia. Environmental Monitoring and Assessment 134(1-3):75-91.

Gaspin, J.B. 1975. Experimental investigations of the effects of underwater explosions on swimbladder fish, I: 1973 Chesapeake Bay tests. Navel Surface Weapons Center Technical Report NSWC/WOL/TR 75-58, White Oak Laboratory, Silver Spring, Maryland.

Gaspin, J.B. 1983. Safe swimmer ranges from bottom explosives. Technical report 83-84. Naval Surface Weapons Center. White Oak, MD.

Gjertz, I. and A. Børset. 1992. Pupping in the most northerly harbor seal (Phoca vitulina). Marine Mammal. Science 8:103-109.

Goertner, J.F., M.L. Wiley, G.A. Young, and W.W. McDonald. 1994. Effects of underwater explosions on fish without swimbladders. Naval Surface Warfare Center Technical Report NSWC TR88-114, White Oak Division, Silver Spring, Maryland.

Goold, J.C. 1996. Acoustic assessment of populations of common dolphin, *Delphinus delphis,* in conjunction with seismic surveying. Journal of the Marine Biological Association of the United Kingdom. 76:811-820.

Goold, J.C. and P.J. Fish. 1998. Broadband spectra of seismic survey air-gun emissions, with reference to dolphin auditory thresholds. Journal of the Acoustical Society of America. 103-2177-2184.

Govoni, J.J., L.R. Settle, and M.A. West. 2003. Trauma to juvenile pinfish and spot inflicted by submarine detonations. Journal of Aquatic Animal Health 15:111-119.

Grigg, E.K., A.P. Klimley. S.G. Allen, D.E. Green, D.L. Elliott-Fisk, and H. Markowitz. 2009. Spatial and seasonal relationships between Pacific harbor seals (*Phoca vitulina richardii*) and their prey, at multiple scales. Fisheries Bulletin 107:359-372.

Hamernick, R.P. and K.D. Hsueh. 1991. Impulse noise: Some definitions, physical acoustics and other considerations. Journal of the Acoustical Society of America 90(1):189-196.

Hamernick, R.P., W.A. Ahroon, and K.D. Hsueh. 1991. The energy spectrum of an impulse: Its relation to hearing loss. Journal of the Acoustical Society of America 90(1):197-204.

Hamilton, E.L. 1980. Geoacoustic Modeling of the Sea Floor. Journal of the Acoustical Society of America 68(5):1313-1340.

Hanggi, E.B. and R.J. Schusterman. 1994. Underwater acoustic displays and individual variation in male harbour seals, *Phoca vitulina*. Animal Behaviour 48:1275-1283

Hanan, D. A. 1996. Dynamics of Abundance and Distribution for Pacific Harbor Seal, *Phoca vitulina richardii*, on the Coast of California. Ph.D. Dissertation, University of California, Los Angeles. 158pp.

Hanson, M.T. and R.H. Defran. 1993. The behavior and feeding ecology of the Pacific coast bottlenose dolphin, Tursiops truncatus. Aquatic Mammals 19:127-142.

Hapke, C.J., D. Reid, B.M. Richmond, P. Ruggiero, and J. List. 2006. National Assessment of Shoreline Change Part 3: Historical Shoreline Change and Associated Coastal Land Loss Along Sandy Shorelines of the California Coast. U.S. Geological Survey Open-file Report 2006-1219.

Harvey, J.T. and B.R. Mate. 1984. Dive characteristics and movements of radio-tagged gray whales in San Ignacio Lagoon, Baja California Sur, Mexico. In: The Gray Whale M.L. Jones, S. Swartz and S. Leatherwood (eds.), Academic Press, pp. 561-575.

Hastie, G.S., B. Wilson, and P.M. Thompson. 2006. Diving deep in a foraging hotspot: acoustic insights into bottlenose dolphin dive depths and feeding behaviour. Marine Biology 148: 1181–1188.

Hastings, M. C. 1990. Effects of Underwater Sound on Fish. Document No. 46254-900206-01IM. Project No. 401775-1600, AT&T Bell Laboratories.

Hastings, M.C., and A.N. Popper. 2005. Effects of Sound on Fish. Report prepared by Jones & Stokes for California Department of Transportation, Contract No. 43A0139, Task Order 1.

Hastings, M. 2007. Calculation of SEL for Govoni et al. (2003, 2007) and Popper et al. (2007) Studies. Report for Amendment to Project 15218, J&S Working Group, 14 December 2007. 7 pp.

Haviland-Howell, G., A.S. Frankel, C.S. Powell, A. Bocconcelli, R.L. Herman, and L.S. Sayigh. 2007. Recreational boating traffic: A chronic source of anthropogenic noise in the Wilmington, North Caroline Intracoastal Waterway. Journal of the Acoustical Society of America. 122:151-160.

Hawkins, A. 2005. Assessing the impact of pile driving upon fish. UC Davis: Road Ecology Center. Retrieved from: http://www.escholarship.org/uc/item/28n858z1.

Hawkins, E.R., D.F. Gartside. 2009. Interactive Behaviours of Bottlenose Dolphins (*Tursiops aduncus*) During Encounters with Vessels. Aquatic Mammals 35(2):259-268.

Heath, C.B. 2002. California, Galapagos, and Japanese sea lions *Zalophus californianus*, *Z. wollebaeki*, and *Z. japonicus*. Pp. 180-186. IN: W. F. Perrin, B. Wursig, and J. G. M. Thiewissen, eds. Encyclopedia of Marine Mammals. Academic Press.

Heitmeyer, R.M., S.C. Wales and L.A. Pflug. 2004. Shipping noise predictions: capabilities and limitations. Marine Technology Society Journal. 37:54-65.

Herder, M. J. 1986. Seasonal movements and hauling site fidelity of harbor seals, *Phoca vitulina richardsi*, tagged at the Russian River, California. MS Thesis. Humboldt State Univ. 52 pages.

Hewitt, R.P. 1985. Reaction of dolphins to a survey vessel: effects on census data. Fishery Bulletin 83(2):187-193.

Hildebrand, J.A. 2005. Impacts of Anthropogenic Sound. Marine Mammal Research: Conservation beyond Crisis. The Johns Hopkins University Press. pp 101-24.

Hildebrand. J. 2009. Anthropogenic and natural sources of ambient noise in the ocean. Marine Ecology Progress Series 395:5-20.

Holcomb, K, J.K. Young, and L.R. Gerber. 2009. The influence of human disturbance on California sea lions during the breeding season. Animal Conservation 12:592-598.

Houser, D.S. and J.J. Finneran. 2006. A comparison of underwater hearing sensitivity in bottlenose dolphins (*Tursiops truncatus*) determined by electrophysiological and behavioral methods. Journal of the Acoustical Society of America 120:1713-1722.

Houser, D.S. and J.J. Finneran. 2006. Variation in the hearing sensitivity of a dolphin population obtained through the use of evoked potential audiometry. Journal of the Acoustical Society of America 120:4090-4099.

Houser, D.S., A. Gomez-Rubio, and J.J. Finneran. 2008. Evoked potential audiometry of 13 Pacific bottlenose dolphins (*Tursiops truncates gilli*). Marine Mammal Science 24:28-41.

Hoover, A. A. 1988. Harbor seal. pp. 125-157 In J. W. Lentfer (ed.), Selected marine mammals of Alaska: Species accounts with research and management recommendations. Marine Mammal Commission, Washington, D.C.

Huber, H.R. 1991. Changes in the distribution of California sea lions north of the breeding rookeries during the 1982-83 El Nino. Pages 129-137. IN: F. Trillmich and K. A. Ono, eds. Pinnipeds and El Nino: responses to environmental stress. Springer-Verlag, Berlin and Heidelberg, Germany.

Jehl, J.R., and C.F. Cooper, eds. 1980. Potential effects of space shuttle booms on the biota and geology of the California Channel Islands: research reports. Center for Marine Studies, San Diego State University, San Diego, CA, Tech. Rep. 80-1. 246 pp.

Jensen, F.H., L. Bejder, M. Wahlberg, N. Aguilar Soto, M. Johnson, and P.T. Madsen. 2009. Vessel noise effects on delphinid communication. Marine Ecology Progress Series 395: 161–175.

Jones, M.L. and S.L. Swartz. 2002. Gray whale *Eschrichtius robustus*. Pages 524-536. IN: Perrin, W.F., B. Würsig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals. San Diego, California: Academic Press.

Jordan, S.A. 2008. Marine Species Acoustic Effects: Analysis of Underwater Detonations at the Silver Strand Training Complex. NUWC-NPT Technical Report 11,895. Naval Undersea Warfare Center, Newport, RI, 117 pp.

Kastak, D., and R. J. Schusterman. 1996. Temporary threshold shift in a harbor seal (*Phoca vitulina*). Journal of the Acoustical Society of America 100:1905-1908.

Kastak, D. and R.J. Schusterman. 1998. Low-frequency amphibious hearing in pinnipeds: Methods, measurements, noise, and ecology. Journal of the Acoustical Society of America 103(4):2216-2228.

Kastak, D. and R.J. Schusterman. 2002. Changes in auditory sensitivity with depth in a free-diving California sea lion (*Zalophus californianus*). Journal of the Acoustical Society of America 112(1):329-333.

Kastak, D., R.J. Schusterman, B.L. Southall, and C.J. Reichmuth. 1999. Underwater temporary threshold shift induced by octave-band noise in three species of pinniped. Journal of the Acoustical Society of America 106(2):1142-1148.

Kastak, D., B.L. Southall, R.J. Schusterman, and C.R. Kastak. 2005. Underwater temporary threshold shift in pinnipeds: effects of noise level and duration. Journal of the Acoustical Society of America. 118:3154-3163.

Kastelein, R.A., W.C. Verboom, m.Muijsers, N.V. Jennings, and S.v.d Heul. 2005. The influence of acoustic emissions for underwater data transmission on the behaviour of harbor porpoises (*Phocoena phocoena*) in a floating pen. Marine Environmental Research. 59-287-307.

Kastelein, R.A., P. Wensveen, and L. Hoek. 2009. Underwater hearing sensitivity of harbor seals (*Phoca vitulina*) for narrow noise bands between 0.2 and 80 kHz. Journal of the Acoustic Society of America 126(1):476-483.

Ketten, D.R. 1992. The marine mammal ear: Specializations for aquatic audition and echolocation. Pages 717-750. IN: D. Webster, R. Fay, and A. Popper, eds. The evolutionary biology of hearing. Berlin: Springer-Verlag.

Ketten, D.R. 1998. Marine mammal auditory systems: A summary of audiometric and anatomical data and its implications for underwater acoustic impacts. NOAA-TM-NMFS-SWFSC-256, Department of Commerce.

Keevin, T.M., G.L. Hempen, and D.J. Schaeffer. 1997. Use of a bubble curtain to reduce fish mortality during explosive demolition of Locks and Dam 26, Mississippi River. Pages 197-206. IN: Proceedings of the Twenty-third Annual Conference on Explosives and Blasting Technique, Las Vegas, Nevada, International Society of Explosive Engineers, Cleveland, Ohio.

Kryter, K.D. W.D. Ward, J.D. Miller, and D.H. Eldredge. 1966. Hazardous exposure to intermittent and steady-state noise. Journal of the Acoustical Society of America 48:513-523.

Laney, H. and R. Cavanaugh, 2000. Supersonic Aircraft Noise at and Beneath the Ocean Surface: Estimation of Risk for Effects on Marine Mammals. Science Applications International Corporation, McLean, VA, June 2000.

Largier, J.L. 1995. San Diego Bay Circulation. Final Report. Center for Coastal Studies, Scripps Institute of Oceanography, University of California, San Diego. Prepared for the California State Water Resources Control Board and the California Regional Water Quality Control Board, San Diego Region. July.

Laughlin, J. 2005. Underwater Sound Levels Associated With Restoration Of The Friday Harbor Ferry Terminal. Washington Department of Transportation. Friday Harbor Ferry Terminal Restoration Project. May 2005. 125 pp.

Laughlin, J. 2007. Underwater Sound Levels Associated With Driving Steel And Concrete Piles Near The Mukilteo Ferry Terminal. Washington Department of Transportation. WSF Mukilteo Test Pile Project. March 2007. 64 pp.

Lazauski, C. and G. Mitchell. 2006. The Modeling and Simulation of Underwater Acoustic Energy. Exposure Due to Near Surface Explosions on Marine Mammals. NUWC-NPT Reprint Report 11,773, Naval Undersea Warfare Center Division, Newport, RI.

Lazauski, C.J., T.N. Fetherston, and G.H. Mitchell. 1999. Analysis of Acoustic Effects on Marine Mammals Occurring in the Proposed East Coast Shallow-Water Training Range Locations. NUWC-NPT Technical Report 11,158. Naval Undersea Warfare Center Division, Newport, Rhode Island, Newport, RI, 175 pp.

Lazauski, C.J. and G.A. Mitchell. 2008. Use of Monte Carlo Methods to Determine the Sensitivity of Acoustic Exposure Simulations Bioacoustics:250-252.

Leatherwood, J. S. 1974. A Note on Gray Whale Behavioral Interactions with Other Marine Mammals. Marine Fisheries Review 36(4):50-51.

Leatherwood, S., R.R. Reeves, W.F. Perrin, and W.E. Evans. 1982. Whales, Dolphins, and Porpoises of the Eastern North Pacific and adjacent Arctic Waters: A Guide to Their Identification. NMFS, NOAA, U.S. Dept. of Commerce, NOAA Technical Report NMFS Circular 444.

Leatherwood, S., R.R. Reeves, W.F. Perrin, and W.E. Evans. 1988. Whales, dolphins, and porpoises of the eastern North Pacific and adjacent Arctic waters: A guide to their identification. New York: Dover Publications, Inc.

Lowry, M.S. and J.V. Carretta. 1999. Market squid (*Loligo opalescens*) in the diet of California sea lions (*Zalophus californianus*) in southern California (1981-1995). CalCOFI Reports 40:196-207.

Lowry, M.S. and K.A. Forney. 2005. Abundance and distribution of California sea lions (*Zalophus californianus*) in central and northern California during 1998 and summer 1999. Fishery Bulletin 103:331-343.

Lowry, M.S. and J.V. Carretta. 2003. Pacific harbor seal, *Phoca vitulina richardii*, census in California during May-July 2002. NOAA Technical Memorandum NMFS-SWFSC-353. 47 pp.

Lowry, M.S., B.S. Stewart, C.B. Heath, P.K. Yochem, and J.M. Francis. 1991. Seasonal and annual variability in the diet of California sea lions *Zalophus californianus* at San Nicolas Island, California, 1981-86. Fishery Bulletin 89:331-336.

Lowry, M.S., J.V. Carretta, and K.A. Forney. 2005. Pacific harbor seal, *Phoca vitulina richardsi*, census in California during May - July 2004. Administrative Report LJ-05-06, available from Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037. 38 p.

Lowry, M.S., P. Boveng, R.J. DeLong, C.W. Oliver, B.S. Steward, H. DeAnda and J. Barlow, 1992. Status of the California sea lion (*Zalophus californianus californianus*) population in 1992. Southwest Fisheries Science Center Administrative Report LJ-92-32. 34 pp.

Lowry, M.S., J.V. Carretta, and K.A. Forney. 2008. Pacific harbor seal census in California during May-July 2002 and 2004. California Fish and Game 94(4):180-193.

Lusseau, D. 2003. Effects of tour boats on the behaviour of bottle-nose dolphins: using Markov chains to model anthropogenic impacts. Conservation Biology 17:1785–1793

Madsen, P.T., M.A. Johnson, P.J. Miller, A.N. Soto, J. Lynch, and P.L. Tyack. 2006. Quantitative measures of air-gun pulses recorded on sperm whales (Physeter macrocephalus) using acoustic tags during controlled exposure experiments. Journal of the Acoustical Society of America. 120:2366-2379.

Malcolm, C.D., D.A. Duffus, and S.G. Wishniowski. 1996. Small scale behaviour of large scale subjects: diving behaviour of a grey whale. Western Geography. 5/6:35-44.

Malcolm, C.D. and D.A. Duffus. 2000. Subjective and statistical analysis of dive data from a TDR attached to a gray whale (*Eschrichitius robust u s*). Journal of Cetacean Research and Management 2(3):177-182.

Maldini-Feinholz, D. 1996. Pacific coastal bottlenose dolphins (*Tursiops truncatus gilli*) in Monterey Bay, California. Master's thesis, San Jose State University.

Malme, C.I., B. Wursig, J.E. Bird, and P.L. Tyack., 1986. Behavioral responses of gray whales to industrial noise: Feeding observations and predictive modeling, National Oceanic and Atmospheric Administration, Outer continental Shelf Environmental Assessment Program, Final Report of the Principal Investigators, Anchorage, Alaska: BBB Report No. 6265. OCS Study MMS 88-0048; NTIS PB88-249008.

Mate, B.M. and J. Urbán-Ramirez. 2003. A note on the route and speed of a gray whale on its northern migration from Mexico to central California, tracked by satellite-monitored radio tag. Journal of Cetacean Research and Management 5(3):1-3.

McDonald, M.A., JA. Hildebrand, and S.M. Wiggins. 2006. Increases in deep ocean ambient noise in the North Pacific west of San Nicholas Island, California. Journal of the Acoustical Society of America. 120:711-718.

McEwen, B., and J. Wingfield, 2003. The concept of allostasis in biology and biomedicine. Hormonal Behavior 2003 Jan 43(1):2-15. The Rockefeller University, NY.

Melin, S.R. and R.L. DeLong. 2000. At-sea distribution and diving behavior of California sea lion females from San Miguel Island, California. Pages 407-412. IN: D.R. Browne, K.L. Mitchell, and H.W. Chaney, eds. Proceedings of the Fifth California Islands Symposium. OCS Study MMS 99-0038. Camarillo, California: Minerals Management Service.

Melin, S.R., R.L. DeLong, D.B. Siniff. 2008. The effects of El Nino on the foraging behavior of lactating California sea lions (*Zalophus californianus californianus*) during the nonbreeding season. Canadian Journal of Zoology 86:192-206.

Merkel & Associates Inc. 2008. Marine Mammal Surveys In The Vicinity Of The Point Loma Naval Complex, San Diego, California- Final report September 2008. Prepared For: Naval Facilities Engineering Command Southwest, San Diego, CA. Prepared by: Merkel & Associates, Inc., San Diego, CA. 18 pp.

Miksis J.L., Grund, M.D., Nowacek, D.P., Solow, A.R., Connor R.C. and Tyack, P.L. 2001. Cardiac Responses to Acoustic Playback Experiments in the Captive Bottlenose Dolphin, *Tursiops truncates*. Journal of Comparative Psychology. 115:227-232.

Miksis-Olds, J.L., P.L. Donaghay, J.H. Miller, P.L. Tyack, and J.A. Nystuen. 2007. Noise level correlates with manatee use of foraging habitats. Journal of the Acoustical Society of America. 121:3011-3020.

Miller, J.D. 1974. Effects of noise on people. Journal of the Acoustical Society of America 56:729–764.

Moore, S.E. and J.T. Clarke. 2002. Potential impact of offshore human activities on gray whales (*Eschrichtius robustus*). Journal of Cetacean Research and Management 4(1):19-25.

Moore, S.E., J. Urbán R., W.L. Perryman, F. Gulland, H. Pérez-Cortés M., P.R. Wade, L. Rojas-Bracho and T. Rowles. 2001. Are gray whales hitting 'K' hard? Marine Mammal Science 17(4):954-958.

Moore, S.E., K.M. Wynne, J.C. Kinney, and J.M. Grebmeier. 2007. Gray whale occurrence and forage southeast of Kodiak, Island, Alaska. Marine Mammal Science 23(2):419-428. DOI:410.1111/j.1748-7692.2007.00102.x.

Morton, A.B., and H.K. Symonds. 2002. Displacement of *Orcinus orca* (L.) by high amplitude sound in British Columbia, Canada. ICES Journal of Marine Science. 59:71-80.

Moulton, V.D., W.J. Richardson, R.E. Elliott, T.L. McDonald, and M.T. Williams. 2005. Effects of an offshore oil development on local abundance and distribution of ringed seals (*Phoca hispida*) of the Alaskan Beaufort Sea. Marine Mammal Science. 21(2):217-242.

Nachtigall, P.E., D.W. Lemonds, and H.L. Roitblat. 2000. Psychoacoustic studies of dolphins and whales. Pages 330-363. IN: Hearing by Dolphins and Whales, W.W.L. Au, A.N. Popper, and R.R. Fay, eds. Springer, New York.

Nachtigall, P.E., J.L. Pawloski, and W.W.L. Au. 2003. Temporary threshold shift and recovery following noise exposure in the Atlantic bottlenosed dolphin (*Tursiops truncatus*). Journal of the Acoustical Society of America 113:3425-3429.

Nachtigall, P.E., A. Supin, J.L. Pawloski, and W.W.L. Au. 2004. Temporary threshold shift after noise exposure in bottlenosed dolphin (*Tursiops truncatus*) measured using evoked auditory potential. Marine Mammal Science. 20:673-687.

National Center for Coastal Ocean Science (NCCOS). 2005. A Biological Assessment of the Channel Island National Marine Sanctuary- A Review of Boundary Expansion Concepts for NOAA's National Marine Sanctuary Program. Prepared by NCCOS's Biogeographic Team in cooperation with the National Marine Sanctuaries Program, Silver Springs, MD. NOAA Technical Memorandum NOS NCCOSS 21. 215 pp.

National Marine Fisheries Service (NMFS). 2001. 66FR22450 (Taking and Importing Marine Mammals; Taking Marine Mammals Incidental to Naval Activities- Final Rule for the shock trial of the WINSTON S. CHURCHILL (DDG-81), 4 May 2001).

National Marine Fisheries Service (NMFS). 2006. Taking and Importing Marine Mammals; Taking Marine Mammals Incidental to Conducting Precision Strike Weapons Testing and Training by Eglin Air Force Base in the Gulf of Mexico. Federal Register 71:67810-67824.

National Marine Fisheries Service (NMFS), Barlow, J. 2007. National Marine Fisheries Science Center. Gray whale migration. San Diego, CA, private communication with J. Marshall,.

National Marine Fisheries Service (NMFS). 2008a. Incidental Take of Marine Mammals; Taking of Marine Mammals Incidental to Conducting Precision Strike Weapons Testing and Training by Eglin Air Force Base in the Gulf of Mexico. Federal register 73:15742-15743.

National Marine Fisheries Service (NMFS). 2008b. Taking and Importing Marine Mammals; Taking Marine Mammals Incidental to a U.S. Navy Shock Trial (USS MESA VERDE). Federal Register 73:43130-43138.

National Marine Fisheries Service (NMFS). 2009a. Taking and Importing Marine Mammals; U.S. Navy Training in the Hawaii Range Complex; Final Rule. Federal Register 74:1456-1491.

National Marine Fisheries Service (NMFS). 2009b. Taking and Importing Marine Mammals; U.S. Navy Training in the Southern California Range Complex; Final Rule. Federal Register 74:3882-3918.

National Research Council (NRC). 2003. Ocean Noise and Marine Mammals. Prepared by the Committee on Potential Impacts of Ambient Noise in the Ocean on Marine Mammals, Ocean Studies Board, Division on Earth and Life Studies. The National Academies Press: Washington D.C.

National Research Council (NRC). 2005. Marine Mammal Population And Ocean Noise-Determining When Noise Causes Biologically Significant Effects. National Research Council of the National Academies. National Academies Press, Washington, D.C. 126 pp.

Naval Special Warfare Command (NSWC)/Anteon Corporation, Inc. unpublished. Very shallow water explosion tests at Naval Amphibious Base, Coronado, CA and San Clemente Island, CA: Conditions, results, and model predictions- 2005.

Ng, S.L., and S. Leung. 2003. Behavioral response of Indo=Pacific humpback dolphin (*Sousa chinensis*) to vessel traffic. Marine Environmental Research. 56:555-567.

Norris, K.S., and J.H. Prescott. 1961. Observations on Pacific cetaceans of Californian and Mexican waters. University of California Publications in Zoology 63:291-402.

Nowacek, D.P., M.P. Johnson, and P.L. Tyack. 2004. North Atlantic right whales (*Eubalaena glacialis)* ignore ships but respond to alerting stimuli. Proceedings of the Royal Society of London, part B. 271:227-231.

Nowacek, D.P., L.H. Thorne, D.W. Johnston, and P.L. Tyack, 2007. Responses of cetaceans to anthropogenic noise. Mammal Review. 37:81-115.

Oates, S.C. 2005. Survival, movements, and diet of juvenile harbor seals along central California. Master's Thesis, San Jose State University.

Ortiz, R.M., and G.A.J. Worthy. 2000. Effects of capture on adrenal steroid and vasopressin concentrations in free-ranging bottlenose dolphins (*Tursiops truncatus*). Comparative Biochemistry and Physiology. A. 125:317-324.

Parks, S.E., C.W. Clark, and P.L. Tyack. 2007. Short- and long-term changes in right whale calling behavior: The potential effects of noise on acoustic communication. Journal of the Acoustical Society of America. 122:3725-3731.

Patenaude, N. J., W.J. Richardson, M.A. Smultea, W.R. Koski, G.W. Miller, B. Wursig, and C.R. Greene. 2002. Aircraft sound and disturbance to bowhead and beluga whales during spring migration in the Alaskan Beaufort Sea. Marine Mammal Science 18(2):309-335.

Payne, P.M. and L.A. Selzer. 1989. The distribution, abundance an selected prey of the harbor seal, *Phoca vitulina concolor*, in southern New England. Marine Mammal Science 5(2):173-192.

Peeling, T.J. 1974. A Proximate Biological Survey of San Diego Bay, California. Naval Undersea Center, San Diego. NUC TP 389. 86 pp.

Perryman, W.L., M.A. Donahue, J.L. Laake, and T.E. Martin. 1999. Diel variation in migration rates of Eastern Pacific gray whales measured with thermal imaging sensors. Marine Mammal Science 15(2):426-445.

Poole, M.M. 1984. Migration corridors of gray whales along the central California coast, 1980-1982. Pp. 389-407. IN: M. L. Jones, S. L. Swartz, and S. Leatherwood (eds.), The Gray Whale, Eschrichtius robustus. Academic Press, Inc., Orlando. 600 pp.

Popper, A.N., T.J. Carlson, B.L. Southall, and R.L. Gentry. 2006. Interim Criteria for Injury of Fish Exposed to Pile Driving Operations: A White Paper.

Popper, A. N., M.B. Halvorsen, A. Kane, D.L. Miller, M.E. Smith, J. Song, P. Stein, and L.E. Wysocki. 2007. The effects of high-intensity, low-frequency active sonar on rainbow trout. Journal of the Acoustic Society of America 122: 623-635.

Popper, A.N. and M. Hastings. 2009. The effects of human-generated sound on fish. Integrative Zoology 4: 43-52.

Quaranta, A., P. Portalatini, and D. Henderson. 1998. Temporary and permanent threshold shift: An overview. Scandinavian Audiology. 27:75–86.

Reeder D.M. and K.M. Kramer, 2005. Stress in free-ranging mammals: integrating physiology, ecology, and natural history. Journal of Mammalogy 86:225-235.

Reeves, R.R., B.S. Stewart, P.J. Clapham, and J.A. Powell. 2002. National Audubon Society guide to marine mammals of the world. New York: Alfred A. Knopf

Rice, D.W. and A.A. Wolman. 1971. The life history of the gray whale, (*Eschrichtius robustus*). American Society of Mammalogists, Special Publication 3. 142 pp.

Rice, D.W., A.A. Wolman, and D.E. Withrow. 1981. Gray whales on the winter grounds in Baja California. Reports of the International Whaling Commission 31:477-489

Richardson, W. J., and C. I. Malme. 1995. Zones of Noise Influence. Pages 325-386. In: W. J. Richardson, C. R. Greene, C. I. Malme, and D. Thomson, eds. *Marine Mammals and Noise*. Academic Press, San Diego, CA.

Richardson, W.J., C.R. Greene, C.I. Malme, and D.H. Thomson. 1995. Marine Mammals and Noise. Academic Press, Inc., San Diego, CA.

Richardson, W.J., C.R. Greene Jr., W.R. Koski, M.A. Smultea, G. Cameron, C. Holdsworth, G. Miller, T. Woodley, and B. Wursig. 1991. Acoustic effects of oil production activities on bowhead and white whales visible during spring migration near Pt. Barrow, Alaska – 1990 phase. Report prepared by LGS Environmental Research Associates Ltd. For the U.S. Department of Interior, Minerals Management Service, Anchorage, Alaska. NTIS PB92-170430.

Ridgway, S.H. 2000. The auditory central nervous system. Pages 273-293. IN: W.W.L. Au, A.N. Popper, and R.R. Fay, eds. Hearing by Whales and Dolphins. Springer-Verlag, New York.

Ridgway, S. H., and D. A. Carder, 2001. Assessing hearing and sound production in cetaceans not available for behavioral audiograms: Experiences with sperm, pygmy sperm, and gray whales. Aquatic Mammals 27(3):267-276.

Ridgway, S.H., B.L. Scronce, and J. Kanwisher. 1969. Respiration and deep diving in the bottlenose porpoise. Science. 166:1651-1654.

Ridgway, S.H., D.A. Carder, R.R. Smith, T. Kamolnick, C.E. Schlundt, and W.R. Elsberry. 1997. Behavioral responses and temporary shift in masked hearing threshold of bottlenose dolphins, *Tursiops truncatus*, to 1-second tones of 141 to 201 dB re 1 μPa. Technical Report 1751, Revision 1. San Diego: Naval Sea Systems Command.

Ritter, F. 2002. Behavioural observations of rough-toothed dolphins (*Steno bredanensis*) off La Gomera, Canary Islands (1995-2000), with special reference to their interactions with humans. Aquatic Mammals 28(1):46-59.

Romano, T.A., M.J. Keogh, C. Kelly, P.Feng, L. Berk, C.E. Schlundt, D.A. Carder, and J.J. Finneran. 2004. Anthropogenic sound and marine mammal health: measures of the nervous and immune systems before and after intense sound exposure. Canadian Journal of Fisheries and Aquatic Science. 61:1124-1134.

Rugh, D.J. 1984. Census of gray whales at Unimak Pass, Alaska, November - December 1977 - 1979. Pages 225-248. IN: M.L. Jones, S.L. Swartz, and S. Leatherwood, eds. The Gray Whale *Eschrichtius robustus*. San Diego, California: Academic Press.

Rugh, D.J., K.E.W. Shelden, and A. Schulman-Janiger. 2001. Timing of the gray whale southbound migration. Journal of Cetacean Research and Management 3(1):31-39.

Rugh, D.J., R.C. Hobbs, J.A. Lerczak and J.M. Breiwick. 2005. Estimates of abundance of the eastern North Pacific stock of gray whales 1997-2002. Journal of Cetacean Research and Management 7(1):1-12.

San Diego Association of Governments (SANDAG). 2000. The San Diego Regional Beach Sand Project Final Environmental Impact Study/ Environmental Assessment. State Clearinghouse Number 1999041104.

Schlundt, C.E., J.J. Finneran, D.A. Carder, and S.H. Ridgway. 2000. Temporary shift in masked hearing thresholds of bottlenose dolphins, *Tursiops truncatus*, and white whales, *Delphinapterous leucas*, after exposure to intense tones. Journal of the Acoustical Society of America. 107:3496-3508.

Schlundt, C.E., R.L. Dear, D.A. Carder, and J.J. Finneran. 2006. Growth and recovery of temporary threshold shifts in a dolphin exposed to mid-frequency tones with durations up to 128 s. Journal of the Acoustical Society of America. 120:3227A.

Scholik, A. R., and H.Y. Yan. 2001. Effects of underwater noise on auditory sensitivity of a cyprinid fish. Hearing Research 152:17-24.

Scholik, A. R., and H.Y. Yan. 2002. The effects of noise on the auditory sensitivity of the bluegill sunfish, Lepomis macrochirus. Comp. Biochemical Physiology A 133:43-52.

Schusterman, R.J. 1974. Auditory sensitivity of a California sea lion to airborne sound. Journal of the Acoustical Society of America, 56:1248-1251.

Schusterman, R.J. 1977. Temporal patterning in sea lion barking (*Zalophus californianus*). Behavioral Biology, 20:404-408.

Schusterman, R.J. 1978. Vocal communication in pinnipeds. In: Studies of Captive Wild Animals, H. Markowitz and V. Stevens (Eds), Nelson Hall, Chicago.

Schusterman, R.J. and R.F. Balliet. 1969. Underwater barking by male sea lions (*Zalophus californianus*). Nature 222(5199):1179-1181.

Schusterman, R.J., Gentry, R., and Schmook, J. 1967. Underwater sound production by captive California sea lions. Zoologica, 52:21-24.

Schusterman, R.J., Balliet, R.F., and Nixon, J. 1972. Underwater audiogram of the California sea lion by the conditioned vocalization technique. Journal of the Experimental Analysis of Behavior, 17:339-350.

Schusterman, R.J., Gentry, R., and Schmook, J. 1996. Underwater vocalizations by sea lions: social and mirror stimuli. Science, 154:540-542.

Schwartz, M., A. Hohn, A. Bernard, S. Chivers, and K. Peltier. 1992. Stomach contents of beach cast cetaceans collected along the San Diego County coast of California, 1972-1991. Southwest Fisheries Science Center Adminstrative Report LJ-92-18. La Jolla, California: National Marine Fisheries Service.

Shane, S.H., R.S. Wells, and B. Würsig. 1986. Ecology, behavior and social organization of the bottlenose dolphin: A review. Marine Mammal Science 2(1):34-63.

Shelden, K.E.W., D.J. Rugh, and A. Schulman-Janiger. 2004. Gray whales born north of Mexico: Indicator of recovery or consequence of regime shift? Ecological Applications 14(6):1789-1805.

Siderius and Porter, 2006. Modeling Techniques for Marine-Mammal Risk Assessment. IEER Journal of Oceanic Engineering 31(1):49-60.

Southall, B.L., A.E. Bowles, W.T. Ellison, J.J. Finneran, R.L. Gentry, C.R. Greene Jr., D. Kastak, D.R. Ketten, J.H. Miller, P.E. Nachtigall, W.J. Richardson, J.A. Thomas, and P.L. Tyack. 2007. Marine mammal noise exposure criteria: Initial scientific recommendations. Aquatic Mammals, Special Issue 33.

St. Aubin, D.J. and J.R. Geraci. 1989. Adaptive changes in hematologic and plasma chemical constituents in captive beluga whales, *Delphinapterus leucas.* Canadian Journal of Fisheries and Aquatic Science. 46:796-803.

St. Aubin, D.J., Sh.H. Ridgway, R.S. Wells, and H. Rhinehart. 1996. Dolphin thyroid and adrenal hormones: Circulating levels in wild and semidomesticated *Tursiops truncates,* and influence of sex, age, and season. Marine Mammal Science. 12:1-13.

St. Aubin, D.J. and L.A. Dierauf. 2001. Stress and Marine Mammals. In Marine Mammal Medicine (second edition), eds. Dierauf, L.A. and F.M.D. Gulland, 253-269. Boca Raton, Florida: CRC Press.

St. Aubin, D.J. 2002. Further assessment of the potential for fishery-induced stress on dolphins in the eastern tropical Pacific. Southwest Fisheries Science Center, pp.1-12.

Stewart, B.S. and P.K. Yochem. 1984. Seasonal abundance of pinnipeds at San Nicolas Island, California, 1980-1982. Bulletin of the Southern California Academy of Sciences 83(3):121-132.

Stewart, B.S. and P.K. Yochem. 1994. Ecology of harbor seals in the Southern California Bight. Pages 123-134. IN: W.L. Halvorson and G.J. Meander, eds. Fourth California Islands Symposium: Update on the status of resources, Santa Barbara, California. Santa Barbara Museum of Natural History.

Stewart, B.S., and P.K. Yochem. 2000. Community ecology of California Channel Islands pinnipeds. Pages 413-420. IN: D.R. Brown, K.L. Mitchell, and H.W. Chaney, eds. Proceedings of the Fifth California Islands Symposium, Camarillo, California. Mineral Management Service. OCS Study MMS 99-0038.

Stevick, P.T., B.J. McConnel, and P.S. Hammond. 2002. Patterns of Movement. Pages 185-216. IN: A.R. Hoelzel, eds. Marine Mammal Biology- An Evolutionary Approach. Blackwell Publishing, Malden, MA.

Stone, G.S., L. Cavagnaro, A. Hutt, S. Kraus, K. Baldwin, and J. Brown. 2000. Reactions of Hector's dolphins to acoustic gillnet pingers. Department of Conservation, Wellington, NZ.

Sumich, J.L. 1984. Gray whales along the Oregon coast in summer, 1977-1980. Murrelet 65:33-40.

Teilmann, J., J. Tougaard, L.A. Miller, T. Kirketerp, K. Hansen, and S. Brando. 2006. Reactions of captive harbor porpoises (*Phocoena phocoena)* to pinger-like sounds. Marine Mammal Science. 22:240-260.

Terhune, J. and S. Turnbull. 1995. Variation in the psychometric functions and hearing thresholds of a harbour seal. Pages 81-93. IN: R.A. Kastelein, J.A. Thomas, and P.E. Nachtigall, eds. Sensory Systems of Aquatic Mammals. De Spil Publishers, Woerden, Netherlands.

Terhune, J.M. and W.C. Verboom. 1999. Right whales and ship noise. Marine Mammal Science 15: 256–258.

Tershy, B.R. and D. Breese. 1991. Sightings and feeding of gray whales in the northern Gulf of California. Journal of Mammalogy 72(4):830-831.

Thomas, J., and R. Kastelein. 1990h. Sensory Abilities of Cetaceans. Plenum Press, New York.

Tosi, C.H. and R.G. Ferreira. 2009. Behavior of estuarine dolphin, *Sotalia guianensis* (Cetacea, Delphinidae), in controlled boat traffic situation at southern coast of Rio Grande do Norte, Brazil Biodiversity and Conservation 18(1):67-78.

Turl, C.W. 1993. Low-frequency sound detection by a bottlenose dolphin. Journal of the Acoustical Society of America 94(5):3006-3008.

Urbán-Ramirez, J., L. Rojas-Bracho, H. Pérez-Cortés, A. Gómez-Gallardo, S.L. Swartz, S. Ludwig, and R.L. Brownell, Jr. 2003. A review of gray whales (*Eschrichtius robustus*) on their wintering grounds in Mexican waters. Journal of Cetacean Research and Management 5(3):281-295.

Urian, K.W., D.A. Duffield, A.J. Read, R.S. Wells, and E.D. Shell. 1996. Seasonality of reproduction in bottlenose dolphins, *Tursiops truncatus*. Journal of Mammalogy 77(2):394-403.

Urick R.J. 1972. Noise signature of an aircraft in level flight over a hydrophone in the sea. Journal of the Acoustical Society of America 52:993-999.

Urick, R.J. 1983. Principles of Underwater Sound for Engineers, McGraw-Hill, NY, 1975.

USFS. 2006. San Diego Bay National Wildlife Refuge Sweetwater Marsh and South San Diego Bay Units Final Comprehensive Conservation Plan and Environmental Impact Statement Summary – August 2006. United States Fish and Wildlife Service, California/Nevada Refuge Planning Office.

Van Parijs, S.M., P.J. Corkeron, J. Harvey, S.A. Hayes, D.K. Mellinger, P.A. Rouget, P.M. Thompson, M. Wahlberg, and K.M. Kovacs. 2003. Patterns in the vocalizations of male harbor seals. Journal of the Acoustical Society of America 113(6):3403-3410.

Walker, W.A. 1981. Geographical variation in morphology and biology of bottlenose dolphins (Tursiops) in the eastern North Pacific. NMFS-SWFC Administrative Report LJ-81-03C:1-17.

Ward, W.D. 1997. Effects of high-intensity sound. Pages 1497-1507. IN: M.J. Crocker, ed. Encyclopedia of Acoustics. Wiley, New York.

Wartzog, D., A.N. Popper, J. Gordon, and J. Merrill. 2003. Factors affecting the responses of marine mammals to acoustic disturbance. Marine Technology Society Journal. 37:6-15.

Watkins, W. A. 1986. Whale reactions to human activities in Cape Cod waters. Mar. Mammal Sci. 2(4):251-262.

Wells, R.S., L.J. Hansen, A. Baldridge, T.P. Dohl, D.L. Kelly, and R.H. Defran. 1990. Northward extension of the range of bottlenose dolphins along the California coast. Pages 421-431. IN: S. Leatherwood and R.R. Reeves, eds. The Bottlenose Dolphin. San Diego, Academic Press San Diego.

Wenz, G. M. 1962. Acoustic ambient noise in the ocean: Spectra and sources. Journal of the Acoustical Society of America 34:1936-1956.

Wolski, L.F., R.C. Anderson, A.E. Bowles, and P.K. Yochem. 2003. Measuring hearing in the harbor seal (*Phoca vitulina*): Comparison of behavioral and auditory brainstem response techniques. Journal of the Acoustical Society of America 113(1):629-637.

Würsig, B., S.K. Lynn, T.A. Jefferson, and K.D. Mullin. 1998. Behaviour of cetaceans in the northern Gulf of Mexico relative to survey ships and aircraft. Aquatic Mammals. 24:41-50.

Yazvenko, S.B., T.L. McDonald, S.A. Blokhin, S.R. Johnson, H.R. Melton, M.W. Newcomer, R. Nielson, and P.W. Wainwright. 2007. Feeding of western gray whales during a seismic survey near Sakhalin Island, Russia. Environmental Monitoring and Assessment. 134:93-106.

Yelverton, J.T., D.R. Richmond, W. Hicks, K. Saunders, and E.R. Fletcher. 1975. The relationship between fish size and their response to underwater blast. Report DNA 3677T prepared by Lovelace Foundation for Medical Education and Research for Director, Defense Nuclear Agency, Washington, DC.

Yelverton, J.T. 1981. Underwater Explosion Damage Risk Criteria for Fish, Birds, and Mammals, Manuscript, presented at the 102nd Meeting of the Acoustical Society of America. Miami Beach, FL. December 1982. 32pp.

Young, R.W. 1973. Sound Pressure in Water from a Source in Air and Vice Versa. Journal of the Acoustic Society of America 53:1708-1716.

Yost, W.A. 1994. Fundamentals of Hearing: An Introduction. Academic Press, San Diego.

APPENDIX A SSTC MONITORING PLAN

Prepared for

National Marine Fisheries Service

Office of Protected Resources

Prepared by

Department of the Navy

U.S. Pacific Fleet

Silver Strand Training Complex
Year 1 Monitoring Plan

01 October 2010

This Monitoring Plan is submitted to NMFS in support of the:

Taking and Importing Marine Mammals; U.S. Navy Training in the Silver Stand Training Complex; Incidental Harassment Authorization

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Introduction

The U.S. Navy has developed this Silver Strand Training Complex (SSTC) Monitoring Plan to provide marine mammal and sea turtle monitoring as required under the Marine Mammal Protection Act of 1972. Design of the SSTC Monitoring Plan represents part of a new Navy-wide range complex specific monitoring initiative. Many of the salient points to the Navy's range complex monitoring program are detailed more completely in previous Monitoring Plans, annual reports, and annual renewals (DoN 2009a, 2009b, 2010a).

The SSTC Monitoring Plan has been designed as a collection of focused "studies" to gather data that will allow the Navy to attempt to address the following questions developed in consultation with the National Marine Fisheries Service (NMFS):

Navy-wide Monitoring Research Questions

1. Are marine mammals and sea turtles exposed to mid-frequency active sonar, especially at levels associated with adverse effects (i.e., based on NMFS' criteria for behavioral harassment, Temporary threshold shift, or Permanent threshold shift)? If so, at what levels are they exposed?

2. If marine mammals and sea turtles are exposed to mid-frequency active sonar, do they redistribute geographically as a result of continued exposure? If so, how long does the redistribution last?

3. If marine mammals and sea turtles are exposed to mid-frequency active sonar, what are their behavioral responses to various levels?

4. **What are the behavioral responses of marine mammals and sea turtles that are exposed to explosives at specific levels?**

5. **Is the Navy's suite of mitigation measures for sonar and explosives (e.g., Protective Measures Assessment Protocol, major exercise measures agreed to by the Navy through permitting) effective at avoiding temporary threshold injury, injury, and mortality of marine mammals and sea turtles?**

Given the more limited scope of Navy training at the SSTC, **only NMFS question #4 and #5** will be addressed by the SSTC Monitoring Plan. This plan represents Year 1 in what is anticipated to be a five-year effort.

Species Under Consideration

Primary focus as discussed in the Navy's SSTC Draft Environmental Impact Statement (DoN 2010b) and associated Incidental Harassment Authorization application will be on species most likely to occur within the small spatial extent of SSTC, primarily the coastal stock of bottlenose dolphins, U.S. Stock of California sea lions, and the California stock of Pacific harbor seals.

Each monitoring technique has advantages and disadvantages that vary temporally and spatially, as well as support one particular study objective better than another. DoN 2009a, 2009b, and 2010a discuss how some of these Navy funded techniques have been working within the context of marine mammal monitoring in the offshore waters of Southern California.

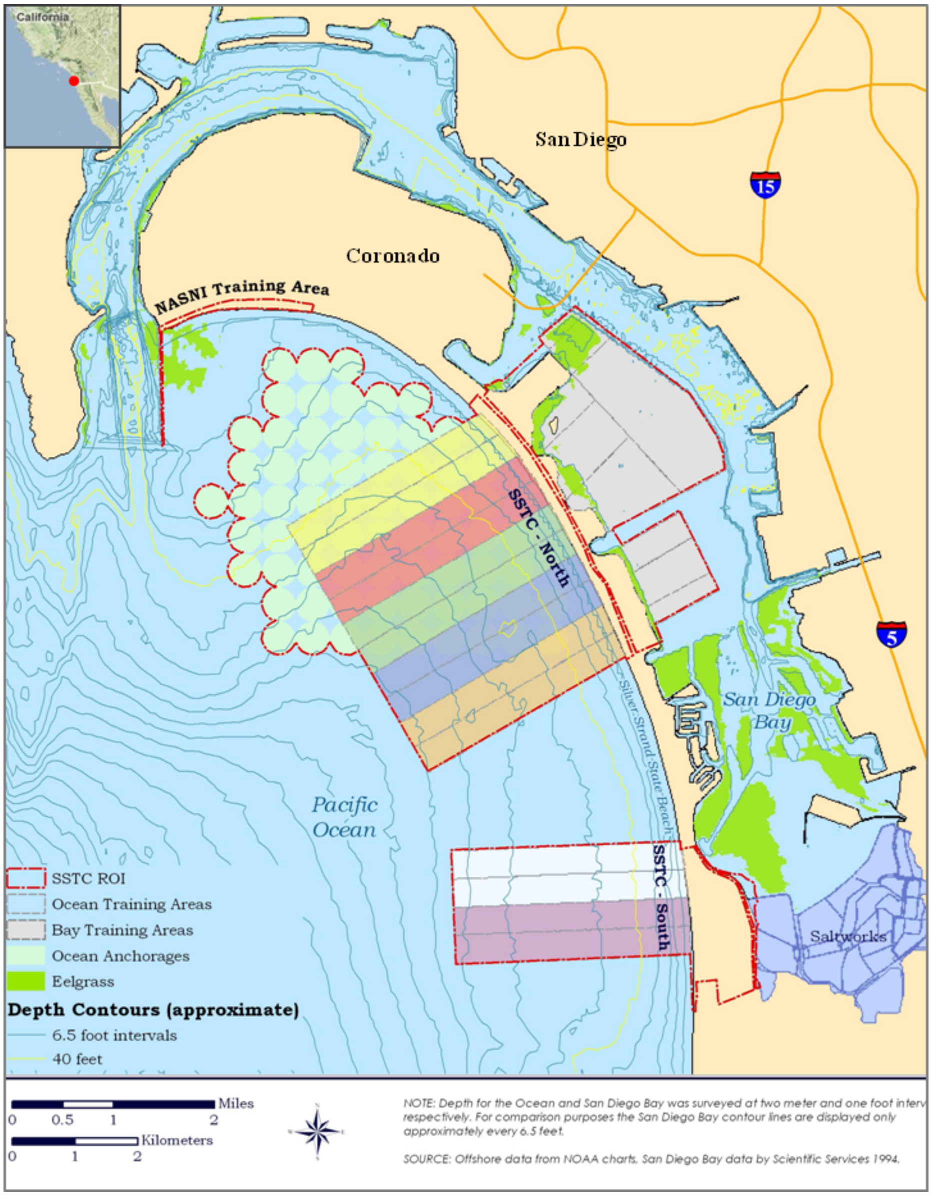

Figure MP-1. Map showing the Silver Strand Training Complex (SSTC)
SSTC region of interest outlined in red

SSTC Proposed Year 1 Monitoring

Monitoring methods initially proposed for the SSTC Year 1 Monitoring Plan include:

- Marine Mammal Observers (MMO) at SSTC underwater detonations
- ELCAS underwater propagation monitoring project
- Leverage aerial monitoring from other Navy-funded monitoring *

*conducted under separate Southern California Range Complex Monitoring Plan

Marine Mammal Observer At A Sub-set of SSTC Underwater Detonations

Civilian scientists acting as Marine Mammal Observers (MMOs) will be used to observe a sub-set of the SSTC underwater detonation events. The goal of MMOs is two-fold. One, to validate the suite of SSTC specific mitigation measures applicable to a sub-set of SSTC training events, and to observer marine mammal behavior in the vicinity of SSTC training events.

MMOs will be field-experienced observers that are either Navy biologists or contracted marine biologists. These civilian MMOs will be placed either alongside existing Navy SSTC operators during a sub-set of training events, or on a separate small boat viewing platform. Use of MMOs will verify Navy mitigation efforts within the SSTC, offer an opportunity for more detailed species identification, provide an opportunity to bring animal protection awareness to Navy personnel at SSTC, and provide the opportunity for an experienced biologist to collect data on marine mammal behavior. Data collected by the MMOs is anticipated to integrate with a Navy-wide effort to assess Navy training impacts on marine mammals (DoN 2009a, 2009b). Events selected for MMO participation will be an appropriate fit in terms of security, safety, logistics, and compatibility with Navy underwater detonation training. MMOs will collect the same data currently being collected for more elaborate offshore ship-based observations including but not limited to: 1) location of sighting; 2) species; 3) number of individuals; 4) number of calves present; 5) duration of sighting; 6) behavior of marine animals sighted; 7) direction of travel; 8) environmental information associated with sighting event including Beaufort sea state, wave height, swell direction, wind direction, wind speed, glare, percentage of glare, percentage of cloud cover; and 9) when in relation to Navy training did the sighting occur [before, during or after the detonation(s)].

The MMOs will not be part of the Navy's formal reporting chain of command during their data collection efforts. Exceptions will be made if a marine mammal or sea turtle is observed by the MMO within the SSTC specific mitigation zones the Navy has formally proposed to the NMFS. The MMO will inform any Navy operator of the sighting so that appropriate action may be taken by the Navy trainees. A more complete description of MMO procedures is being continually refined based on 2009 and 2010 offshore MMO lessons learned and experience in both Southern California and Hawaii.

ELCAS Underwater Propagation Monitoring Project

The Navy proposes to conduct an underwater acoustic propagation monitoring project during the first available ELCAS deployment at the SSTC under this Monitoring Plan. The acoustic monitoring would provide empirical field data on actual ELCAS pile driving and removal underwater source levels, and propagation specific to ELCAS training at the SSTC. These results will be used to either confirm or refine the Navy's exposure predictions (source level, F value, exposures) in the Navy's next subsequent annual Incidental Harassment Authorization application.

Leverage from Existing Navy-funded Marine Mammal Research

The Navy will report results obtained annually from the Southern California Range Complex Monitoring Plan (DoN 2009a, 2009b) for areas pertinent to the SSTC. In the Navy's 2011 Letter of Authorization renewal application and subsequent Year 3 Southern California Monitoring Plan (DoN 2010a), a new study area for aerial visual survey was created. This area would start at the shoreline of the oceanside Boat Lanes at SSTC and extend seaward to approximately 10 nm offshore. The goal of these aerial visual surveys is to document marine mammal occurrence within a given sub-area of Southern California. Significant surface area can be covered by a survey aircraft flying at 800 to 1,000 feet for approximately five hours. The use of both airplanes and helicopters as aerial platforms will be considered for the survey area off SSTC. Both aircraft type, in particular the helicopter, provide excellent platforms for documenting marine mammal behaviors and through digital photography and digital video. DoN 2009b and 2010 documents some of the offshore accomplishments obtained from two years of Navy-funded aerial monitoring in Southern California.

SSTC Year 1 Monitoring Objectives

The Navy's proposed Year 1 monitoring metrics for the SSTC are included in **Table MP-1**.

Table MP-1. Navy's proposed Year 1 Monitoring Plan goals for the SSTC.

Monitoring Technique	Implementation	
Marine Mammal Observers (MMO) STUDIES 4, 5	Opportunistic; unit-level underwater detonation training events within SSTC, as available **[goal of between 2-4% of the SSTC total annual authorized underwater detonations (311), approximately 6-12 detonations]**	Adaptive Management Review with NMFS prior to Year 2 monitoring
ELCAS Acoustic Monitoring STUDIES n/a	Opportunistic; Conduct an acoustic monitoring project at the first ELCAS deployment to SSTC. Goal would be to obtain empirically measured field data on actual in-situ ELCAS underwater sound propagation at SSTC **(1 study project)**	
Present Results for Other Leveraged Navy-funded Regional Studies STUDIES 2	Present results from ongoing, other Navy funded marine mammal research in Southern California (Southern California Range Complex Monitoring Plan) pertinent to SSTC	

TOTAL Navy 2011 Goal:

- **Assign MMOs to observe a sub-set representing a range of 2-4% (6-12 events) of annual SSTC authorized underwater detonations**
- **Conduct ELCAS underwater acoustic monitoring project (when ELCAS is first field deployed to SSTC)**
- **present results as available from other Navy funded research projects as available**

NMFS-NAVY 2008 AGREED UPON RESEARCH QUESTIONS

Study 1= Are marine mammals and sea turtles exposed to mid-frequency active sonar, especially at levels associated with adverse effects (i.e., based on NMFS' criteria for behavioral harassment, temporary threshold shift, or permanent threshold shift)? If so, at what levels are they exposed?

Study 2= If marine mammals and sea turtles are exposed to sonar, do they redistribute geographically as a result of continued exposure? If so, how long does the redistribution last?

Study 3= If marine mammals and sea turtles are exposed to mid-frequency active sonar, what are their behavioral responses to various levels?

Study 4= What are the behavioral responses of marine mammals and sea turtles that are exposed to explosives at specific levels?

Study 5= Is Navy's suite of mitigation measures for sonar and explosives, and major exercise measures agreed to by Navy through permitting effective at avoiding temporary threshold shift, injury, and mortality of marine mammals and sea turtles?

Analysis and Reporting

SSTC Monitoring Plan data collection will begin when the SSTC Incidental Harassment Authorization is issued by the NMFS, and the Monitoring Plan becomes final. An annual report will be provided to the NMFS Office of Protected Resources of all MMO observations, ELCAS monitoring if applicable that year, and any assessment that can be completed based on review of that year's monitoring results.

Adaptive Management For Monitoring In The SSTC

On an annual basis established by the issuance date of the SSTC Incidental Harassment Authorization, the Navy and NMFS will conduct an adaptive management review of the SSTC Monitoring Program.

Adaptive management is an iterative process of optimal decision making in the face of uncertainty, with an aim to reducing uncertainty over time via system monitoring.

Within the natural resource management community, adaptive management involves ongoing, real-time learning and knowledge creation, both in a substantive sense and in terms of the adaptive process itself. Adaptive management, especially in terms of marine ecosystems and spatial management, focuses on learning and adapting, through partnerships of managers, scientists, and other stakeholders who learn together how to create and maintain sustainable ecosystems (Gregory 2006, Leslie and McLeod 2007, Williams el at. 2007, deYoung et al. 2008, Ruckelshaus et al. 2008, Levin et al. 2009, Curtin and Prellezo 2010, Foley et al 2010, Gibbs et al. 2010, Johnson 2010). Adaptive management helps science managers maintain FLEXIBILTY in their decisions, knowing that uncertainties exist and provides managers the latitude to change direction; will improve UNDERSTANDING of ecological systems to achieve management objectives; and is about taking ACTION to improve progress towards desired outcomes (Williams et al. 2007). Further discussion of adaptive management in the natural resource community is available from the U.S. Department of Interior's Adaptive Management Guidelines:

http://www.doi.gov/initiatives/AdaptiveManagement/index.html

The NMFS has acknowledged that the SSTC monitoring will enhance the understanding of how underwater detonations (as well as other environmental conditions) may, or may not, be associated with marine mammal injury or behavioral disturbance. Additionally, NMFS also pointed out that information gained from the investigations associated with the Navy's monitoring may be used in the adaptive management of mitigation or monitoring measures in subsequent NMFS authorizations, if appropriate. Therefore, the Navy's adaptive management of SSTC monitoring under its Marine Mammal Protection Act responsibilities involves close coordination with NMFS to align marine mammal monitoring with the overall objectives stated within the Introduction to this report. This monitoring plan for SSTC currently represents Year 1 of a 5-year effort to occur over the span of the SSTC Environmental Impact Statement. As such, it would be premature to draw detailed conclusions or initiate comprehensive monitoring changes without further consultation following presentation of Year 1 results, and NMFS review.

Southern California Marine Mammal Workshop January 2010

A Southern California marine mammal workshop was conducted in January of 2010 with recognized marine mammal scientists, regional NMFS representatives, and interested organizations. The workshop proceedings and recommendations are summarized in Kerosky et al. 2010. There were several prevalent themes throughout the workshop. One of the more important consensus workshop agreements was the need for expanded information on baseline marine mammal distribution, biology, and behavior. Another agreement was the need to expand the collaboration and sharing of information between various marine mammal science disciplines.

Part of the SSTC Monitoring Plan will contribute to the collection of baseline marine mammal behavior data.

U.S. Ocean Policy

On 19 July 2010, the President signed a new Executive Order on Stewardship of the Ocean, Our Coasts, and the Great Lakes which adopted the final recommendation of the Interagency Ocean Policy Task Force. Key recommendations include "Use the best available science and knowledge to inform decisions affecting the ocean…" and "Increase scientific understanding of ocean…" (EO 2010, CEQ 2010). Another integral part of these policy directions was to instill a collaborative spirit within the Federal Government in the planning, management, and program execution of ocean science projects. Both of these tenants, improved and using best available science along with increased collaboration, are similar to preceding recommendations of the Joint Subcommittee on Ocean Science and Technology (JSOST) on "Addressing the Effects of Human-Generated Sound on Marine Life: An Integrated Research Plan for U.S. federal agencies "(Southall et al. 2009).

The Navy shall make every attempt to comply with the directions and intent of these policies in context of monitoring within the SSTC. SSTC monitoring reports will be released to the public after review by the NMFS and will be posted to NMFS' Office of Protected Resources website. Scientific data on marine mammal sighting and occurrence applicable to the SSTC area will be posted to public scientific data collaboration sites such as, but not limited to, the Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations (OBIS SEAMAP) site:

http://seamap.env.duke.edu/

Literature Cited

CEQ. 2010. Final Recommendations Of The Interagency Ocean Policy Task Force-July 19, 2010. White House Council on Environmental Quality.

Curtin, R and R. Prellezo. 2010. Understanding marine ecosystem based management: A literature review. Marine Policy 34(5):821-830.

deYoung, B. , M. Barange, G. Beaugrand, R. Harris, R.I. Perry, M. Scheffer, and F. Werner. 2008. Regime shifts in marine ecosystems: detection, prediction and management. Trends in Ecology & Evolution 23(7):402-409.

Department of the Navy (DoN). 2009a. Southern California Range Complex Monitoring Plan-FINAL 09 January 2009. U.S. Department of the Navy. 46 pp.

Department of the Navy (DoN). 2009b. Marine Mammal Monitoring For the U.S. Navy's Hawaiian Range Complex and Southern California Range Complex- Annual Report 2009. U.S. Department of the Navy. 135 pp.

Department of the Navy (DoN). 2010a. Marine Mammal Monitoring For the U.S. Navy's Hawaiian Range Complex and Southern California Range Complex- Annual Report 2010. U.S. Department of the Navy.

Department of the Navy (DoN). 2010b. Silver Strand Environmental Impact Statement- DRAFT January 2010. U.S. Department of the Navy.

EO. 2010. Executive Order- Stewardship of the Ocean, Our Coasts, and the Great Lakes- July 19, 2010. Office of the White House.

Foley, M.M. , B.S. Halpern, F. Micheli, M.H. Armsby, M.R. Caldwell, C.M. Crain, E. Prahler, N. Rohr, D. Sivas, M.W. Beck, M.H. Carr, L.B. Crowder, J. E. Duffy, S.D. Hacker, K.L. McLeod, S.R. Palumbi, C.H. Peterson, H.M. Regan, M.H. Ruckelshaus, P.A. Sandifer, and R.S. Steneck. 2010. Guiding ecological principles for marine spatial planning. Marine Policy 34(5):955-966.

Gibbs, M.T., R. Bustamante, and A.J. Richardson. 2010. Adaptive strategy recommended for US ocean planning. Nature 465, 685 (10 June 2010) | doi:10.1038/465685c.

Gregory, R., D. Ohlson, J. Arvai. 2006. Deconstructing Adaptive Management: Criteria for Applications to Environmental Management. Ecological Applications 16(6):2411-2425.

Johnson, T.R. 2010. Cooperative research and knowledge flow in the marine commons: Lessons from the Northeast United States. International Journal of the Commons 4(1):251–272.

Kerosky, S., M. Richie, L. Munger, J. Hildebrand (eds). 2010. Southern California Marine Mammal Workshop- Summary Report. Southern California Marine Mammal Workshop, Pacific Life Building, Newport Beach CA, January 9-10, 2010.

Leslie, H.M. and K.L. McLeod. 2007. Confronting the Challenges of Implementing Marine Ecosystem-Based Management. Frontiers in Ecology and the Environment 5(10):540-548.

Levin, P.S., M.J. Fogarty, S.A. Murawski, and D. Fluharty. 2009. Integrated Ecosystem Assessments: Developing the Scientific Basis for Ecosystem-Based Management of the Ocean. PLoS Biol 7(1): e1000014. doi:10.1371/journal.pbio.1000014

http://www.plosbiology.org/article/info:doi/10.1371/journal.pbio.1000014

OSTP. 2009. Memorandum on Interagency Ocean Science and Technologies Priorities For FY2011. Executive Office of the President, Office of Science and Technology Policy. September 25, 2009.

Ruckelshaus, M., T. Klinger, N. Knowlton, and D.P. DeMaster. 2008. Marine Ecosystem-based Management in Practice: Scientific and Governance Challenges. BioScience 58(1):53-63.

Southall, B., Berkson, J., Bowen, D., Brake, R., Eckman, J., Field, J., Gisiner, R., Gregerson, S., Lang, W., Lewandoski, J., Wilson, J., and Winokur, R. 2009. Addressing the Effects of Human-Generated Sound on Marine Life: An Integrated Research Plan for U.S. federal agencies. Interagency Task Force on Anthropogenic Sound and the Marine Environment of the Joint Subcommittee on Ocean Science and Technology. Washington, DC.

Williams, B.K., R.C. Szaro, and C.D. Shapiro. 2007. Adaptive Management: The U.S. Department of the Interior Technical Guide. Adaptive Management Working Group, U.S. Department of the Interior, Washington, DC.