REQUEST FOR

INCIDENTAL HARRASSMENT OF MARINE MAMMALS RESULTING FROM THE U.S. NAVY TRAINING AND TESTING ACTIVITIES CONDUCTED WITHIN THE SILVER STRAND TRAINING COMPLEX

Submitted to:

Office of Protected Resources
National Marine Fisheries Service
1315 East-West Highway
Silver Spring, Maryland 20910-3282

Submitted by:

Department of the Navy
United States Pacific Fleet
250 Makalapa Drive
Pearl Harbor, HI 96860-3131

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ACRONYMS AND ABBREVIATIONS

dB	Decibel
C-4	Composition 4
CV	Coefficient of Variation
ELCAS	Elevated Causeway System
EOD	Explosive Ordnance Disposal
FR	Federal Register
kHz	Kilohertz
μPa	Micropascal
MMPA	Marine Mammal Protection Act
min	minute
msec	Millisecond
NEW	Net Explosive Weight
nm	Nautical mile
NMFS	National Marine Fisheries Service
NSW	Naval Special Warfare
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
RFD	Remote Firing Device
sec	second
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
TDFD	Time Delayed Firing Device
TNT	Trinitrotoulene
TTS	Temporary Threshold Shift
VSW	Very Shallow Water
ZOI	Zone of Influence

1 DESCRIPTION OF ACTIVITIES

Regulatory Background

Under Chapter 101(a)(5)(D) of the Marine Mammal Protection Act (MMPA) of 1972 (16 U.S.C. 1371 (a)(5)(D)), this document requests a reissuance from the National Marine Fisheries Service (NMFS) for Incidental Harassment Authorization from U.S. Navy training in the Silver Strand Training Complex (SSTC) for the period July 18, 2013 to July 17, 2014.

NMFS previously issued the Navy an Incidental Harassment Authorization for training activities within the SSTC covering the period from July 18, 2012 to July 17, 2013 (NMFS 2012a, 2012b). This new application is being sought to cover the subsequent period to July 17, 2014.

Table 1-1 below shows MMPA permit documentation applicable to the SSTC and NMFS's 2012 authorization. Information contained in these references provide a complete description of the background for the Navy's request, overview of the SSTC, and description of the specified activities, description of marine mammals in the area, discussion of potential effects or lack of effects of specified activities on marine mammal, mitigation, marine mammal monitoring, and associated reporting (Navy 2010, 2011a, 2011b, 2012).

Where practical, this application will refer to the references shown in Table 1-1 for detailed background information, and will summarize the most pertinent level of detail necessary to inform NMFS' consultation.

Table 1-1. Silver Strand Training Complex MMPA documents.

Date	Source	Title	Citation
February 16, 2010	Navy	Incidental Harassment Authorization Application for Navy Training Conducted within the Silver Strand Training Complex	Navy 2010
January 2011	Navy	Silver Strand Training Complex Environmental Impact Statement FINAL	Navy 2011a
November 10, 2011	Navy	ADDENDUM #1 to Incidental Harassment Authorization Application for Navy Training Conducted within the Silver Strand Training Complex	Navy 2011b
July 18, 2012	NMFS	Incidental Harassment Authorization for the U.S. Navy's Silver Strand Training Complex	NMFS 2012a
July 24, 2012	NMFS	Takes of Marine Mammals Incidental to Specified Activities; Navy Training Conducted at the Silver Strand Training Complex, San Diego Bay (77 FR 43238)	NMFS 2012b
August 21, 2012	Navy	Record of Decision for Final Environmental Impact Statement for the Silver Strand Training Complex, San Diego, California	Navy 2012

Overview of SSTC

The SSTC, described in **Table 1-2** 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 San Diego 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). Another oceanside sub-area designated Training Area-Kilo is approximately 500 yards west of the SSTC-SOUTH boat lanes; SSTC-NORTH also includes south San Diego Bay in-water training areas, designated Alpha through Hotel and the Lilly Ann Drop Zone.

Table 1-2. 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 contiguous ocean boat lanes each 500 yards wide stretching 4,000 yards seaward. Boat lanes identified by color and number (Yellow 1 through Orange 2, see Figure 1-1). Each individual boat lane is 500 yards wide (or 1,000 yards per color).	Small charge weight (≤29 lbs NEW) underwater detonations at various water depths. ELCAS pile driving and removal training
SSTC- SOUTH Boat Lanes (11-14) and Beach Training Areas	Four beach training areas and four contiguous ocean boat lanes (11-14). The four boat lanes are each 500 yards wide stretching 4,000 yards seaward. Each boat lane (1,000 yards per color) and are divided into White 1 and 2 and Purple 1 and 2.	Small charge weight (≤29 lbs NEW) underwater detonations at various water depths. ELCAS pile driving and removal training
Training Area-Kilo (TA-K)	Location approximately 500 yards past end of SSTC-SOUTH boat lanes designated for some underwater detonations. This location is a point with 500 yard circular buffer around it and shares the same bathymetry and bottom conditions as the Boat Lanes. TA-K site is used to avoid training conflicts with other SSTC training (underwater detonation and non-underwater detonation) within the SSTC-SOUTH boat lanes.	Small charge weight (< 29 lbs NEW) underwater detonations

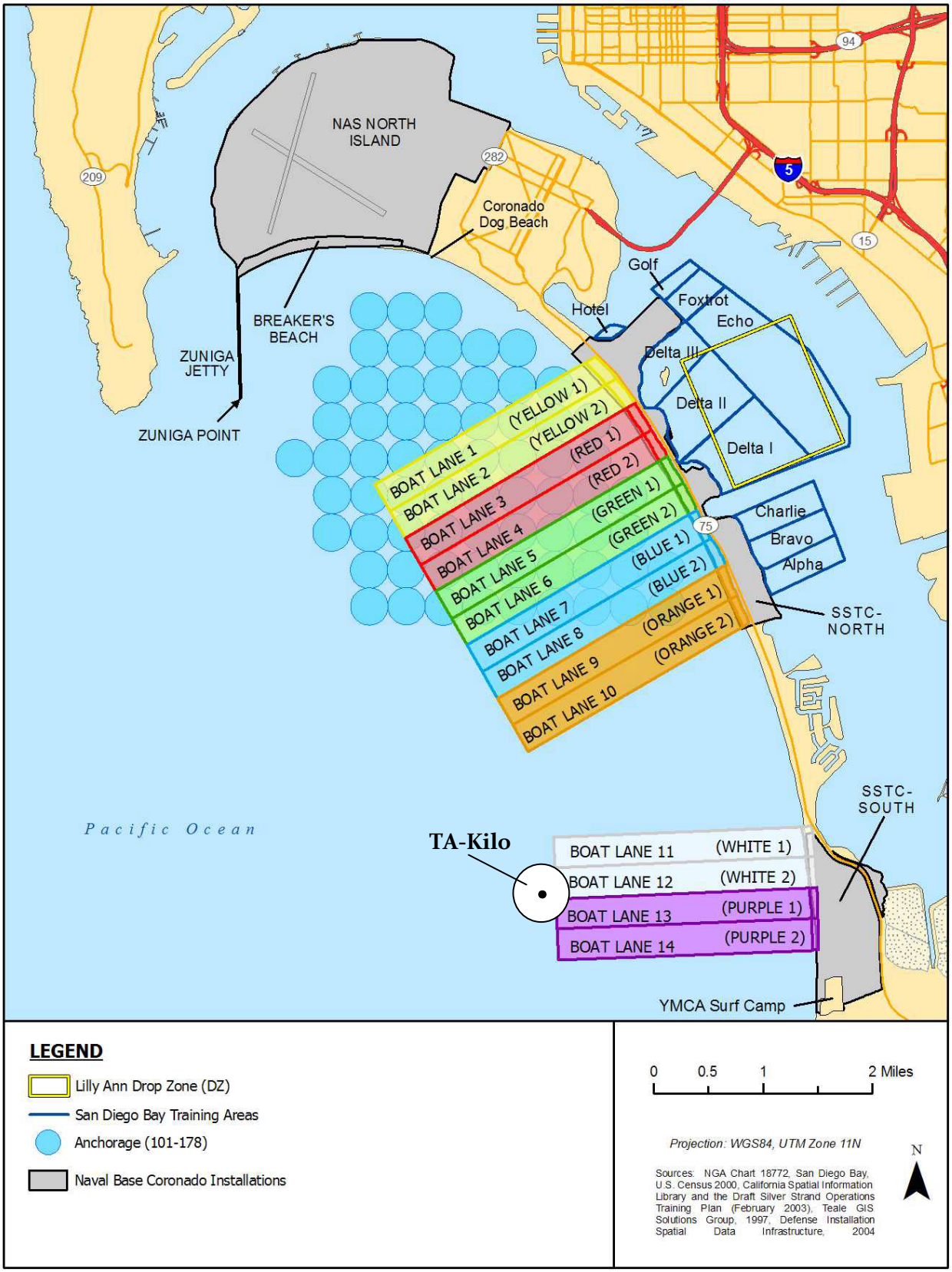

Figure 1-1. Silver Strand Training Complex And Associated Sub-Training Areas.

Proposed Action

For this application, the Navy maintains that only underwater detonations and Elevated Causeway System (ELCAS) pile driving/pile removal training events at SSTC have the potential to rise to the level of harassment as defined under MMPA, as amended in 1994.

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 MMPA, are more completely described in the SSTC Final Environmental Impact Statement (Navy 2011a).

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 (**Figure 1-1**). **Table 1-3** and **Table 2-1** describes the types of underwater detonation training events conducted within the SSTC. The basic discussions of some underwater detonation procedures below typically apply to all underwater detonation training events at SSTC with the exception of the Unmanned Underwater Vehicle Neutralization and Airborne Mine Neutralization System.

General Underwater Detonation Procedures

-Prior to getting underway, all EOD and NSW conduct a detailed safety and procedure briefing to familiarize everyone with the goals, objectives, and safety requirements (including mitigation zones) applicable to the particular training event.

-For safety reasons given the training nature of many of these events, underwater detonations only occur 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).

-EOD or NSW personnel can be transported to the planned detonation site via small boat or helicopter depending on the training event (*see Table 1-2*). Small boats can include 7-m Rigid Hull Inflatable Boats (RHIB), zodiacs, or other similar craft as available to the particular unit.

-Once on site, the applicable mitigation zone is established and visual survey commences for 30 minutes. Divers enter the water to conduct the training objective which could include searching for a training object such as a simulated mine or mine-like shape.

-For the detonation part of the training, the explosive charge and associate charge initiating device are taken to the detonation point. The explosives Navy EOD and NSW use are military forms of C-4. In order to detonate C-4, a fusing and initiating device is required. The two main types of Navy charge initiating devices are discussed in a subsequent Chapter.

-Following a particular underwater detonation, additional personnel in the support boats (or helicopter) keep watch within the mitigation zone for 30 minutes.

-Concurrent with the post-detonation survey, divers return to the detonation site to confirm the explosives detonated correctly and retrieve any residual material (pieces of wire, tape, large fragments, etc.).

Types of Detonation Initiating Devices

The Navy uses both timed-delayed and positive control to initiate a particular underwater detonation depending on the training event in question (**Table 1-3**) and in particular, the training objectives applicable to that underwater detonation. The time-delay firing is called the Timed Delay Firing Device (TDFD). The most common positive control firing is called a Remote Firing Device (RFD). TDFDs are the simplest, safest, least expensive, most operationally sound method of initiating an underwater detonation. TDFDs are used because of their light weight ease of employment and low magnetic signature in cases of mines sensitive to magnetic fields. In addition, TDFD are HERO [1] safe meaning there is reduced risk of accidental detonations from nearby radios or other electronics. In addition, TDFD which are consumed during an underwater detonation, completely eliminate the need to re-deploy swimmers from a helicopter or boat to recover equipment used with positive control firing devices such as the RFD. The TDFD also allows sufficient time for EOD personnel to swim outside of the detonation plume radius and human safety buffer zone after the timer is set. For a surface detonation training events involving a helicopter or a boat, the minimum time-delay that is reasonable for EOD divers to make their way outside of the detonation human safety buffer zone is approximately 10 minutes. For underwater detonations training events at depth using small boats, the time-delay can be minimized to five minutes, however, this would require the instructors to handle initiation of the detonation and therefore would result in decreased training value for students.

A RFD, a type of positive control device, can be used to initiate an underwater detonation, but it is not normally preferred as the primary firing device due to HERO concerns from the radio controlled electric detonator, Operational Risk Management (i.e., safety) considerations, and established Navy tactical procedures. Current Navy RFD use a radio signal to remotely detonate a charge. By using electronic positive control devices such as the RFD as an the only alternative to a TDFD, additional electronic signals and metal from the receiver and wiring is unnecessarily introduced into an influence ordnance operating environment. It is not sound safety principles or good demolition practice to combine different firing circuits to a demolition charge. For instance, in a live mine field, Navy dive platoons expect there to be additional risks, such as unknown mines with different types of influence firing circuits (i.e., detonated by contact, magnetic field, or certain sounds) in close proximity to a mine they are trying to destroy. The use of a TDFD reduces these risks by limiting the possibility of unintentionally triggering detonation from other mines. Underwater demolition needs to be kept as simple and streamlined as possible, especially when divers and influence ordnance are considered. In an open ocean environment, universal use of RFDs would greatly increase the risk of misfire due to component failure, and put unnecessary stress on all needed connections and devices (adding 600 – 1,000 feet of firing wire; building\deploying an improvised, bulky, floating system for the RFD receiver; adding another 180 feet of detonating cord plus 10 feet of additional material).

RFDs, therefore, are not considered a practicable alternative for all underwater detonations. While positive control devices do allow for instantaneous detonation of a charge and are used for some SSTC training events, exclusive use of RFD introduce operationally unsound tactics, thereby

[1] Hazards of Electromagnetic Radiation to Ordnance (HERO)- High intensity radio frequency fields produced by modern radio and radar transmitting equipment can cause sensitive electroexplosive devices contained in ordnance systems and detonators to detonate prematurely. HERO safe items are resistant to this interference.

increasing future risks to Navy dive teams. It is essential that EOD and NSW platoons qualify annually with necessary time-delay certification, maintain proficiency, and train to face real-world scenarios that require use of TDFDs.

Table 1-3. Detailed descriptions of SSTC underwater detonation training events.

TRAINING Event /duration	Description: Table 1-3 details total amount of annual underwater explosive use for SSTC. Below descriptions talk about % of training that may also include non-explosive training periods. ALL explosive training occurs on the ocean side of SSTC with the exception of SWAG which could be done in both the ocean and south San Diego Bay. Training events that could use either time-delay or remote firing are indicated. More details on charge weight and expected use provided in Table 2-1.
Shock Wave Action Generator (SWAG) 1 day 74 per year-Bay 16 per year- ocean	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. SWAG training is the ONLY explosive event that take place within south San Diego Bay [Area "Echo" (see Figure 1-1)], and within the oceanside areas of the SSTC.
Mine Counter Measure (MCM) 1 day 58 per year (time-delay or remote firing)	MCM training events are performed from a small boat to locate and identify suspected inert training mine(s) either at mid-column or on the sea floor at a water depth generally ≤ 72 feet near or within the SSTC oceanside Boat Lanes. An EOD dive team dives to locate the suspected mine. Once located, a single explosive charge (≤10-20 lbs NEW) using either a TDFD or RFD is placed next to the mine to neutralize it (i.e., placing explosives on mines for the purposes of destroying them). The EOD team returns to the boat and pulls back to a safe distance prior to detonation of the single countercharge. The "neutralized" training mine or mine-shape is then raised, towed to shore, beached, and retrieved.
Floating Mine 1 day 53 per year (time-delay or remote firing)	EOD divers are inserted into the ocean via helicopter or small boat. They then subsequently swim to an inert, floating mine or mine-shaped object in water depths of less than 72 feet near or within the SSTC oceanside Boat Lanes. A single explosive countercharge (≤ 5 lbs NEW) is placed on the mine\mine-shape using either a TDFD or RFD. The EOD team returns to the boat (or helicopter) and pulls back to a safe distance prior to detonation of the countercharge.
Dive Platoon 1 day 8 per year (time-delay or remote firing)	EOD divers are inserted into the ocean via helicopter or small boat, dive to depths of 30-72 feet near or within the SSTC oceanside Boat Lanes, and locate inert training mine or mine shapes. Once located, sequential detonation charges (≤3.5 lbs NEW) using either a TDFD or RFD are placed on the mine shape. The EOD team returns to the boat (or helicopter) and pulls back to a safe distance prior to detonation of the countercharge.
Very Shallow Water (VSW) Mine Counter Measure 1 day 60 per year (time-delay or remote firing)	VSW MCM involves training on locating, identifying, and neutralizing mines placed either mid-column or on the sea floor at a water depth of ≤ 24 feet near or within the SSTC oceanside Boat Lanes. Detonation charges (≤10-20 lbs NEW) with either a TDFD or RFD are used. Actual detonations occur during approximately 60 % of these training events and will ONLY occur near and within the SSTC oceanside Boat Lanes. Complimentary in-Bay training (40%) will not use any explosives and is designed to train divers on underwater navigation and mine localization.
Unmanned Underwater Vehicle (UUV) 1 day 4 per year	This training is for EOD divers to learn how to deploy UUVs. One to two small boats transport personnel to a site. UUVs explore the area, photograph, and collect hydrographic information. After analysis is complete, Navy marine mammals are dispatched to localize and mark potential suspect objects, followed by divers to confirm identification. Approximately 3% of events involve divers placing a single charge (≤10-15 lbs NEW) to neutralize the simulated mine using RFD in water depths from 10 to 72 feet near and within the SSTC oceanside Boat Lanes (on the bottom or up to 20 feet from the surface). Complimentary training within south San Diego Bay is strictly for UUV operator training

TRAINING Event /duration	**Description: Table 1-3 details total amount of annual underwater explosive use for SSTC. Below descriptions talk about % of training that may also include non-explosive training periods. ALL explosive training occurs on the ocean side of SSTC with the exception of SWAG which could be done in both the ocean and south San Diego Bay. Training events that could use either time-delay or remote firing are indicated. More details on charge weight and expected use provided in Table 2-1.**
	and does not use underwater detonations.
MK8 Marine Mammal / Marine Mammal Systems (MMS) 1 day 16 per year (time-delay or remote firing)	EOD divers work with the assistance from the Navy's trained marine mammals to detect underwater objects and simulated mines. Approximately 10% of training involves the setting of a charge (≤13- or ≤29 lbs NEW) using either a TDFD or RFD to detonate simulated mines. Single charges are laid within water depths of 24 to 72 feet, 20 feet from the surface or below near and within the SSTC oceanside Boat Lanes. In some cases, sequential bottom laid detonations are used and charges are places in water depths of 10 to 72 feet near and within the SSTC oceanside Boat Lanes.
Mine Neutralization 1 day 4 per year (time-delay or remote firing)	EOD divers are inserted via helicopter or boat for underwater demolition training. Divers search at depth to locate suspected inert mine or mine shapes. Once located, underwater detonation is performed with eight sequential charges (≤3.5 lbs NEW each) using either a TDFD or RFD in water depths of 30 to 72 feet near and within the SSTC oceanside Boat Lanes.
Surf Zone Test & Evaluation 1 day 2 per year (time-delay or remote firing)	To support improving clearance capability in the surf zone (out to 10 feet of water), EOD tests and evaluates effectiveness of new detection and neutralization equipment in surf conditions near or within the SSTC oceanside Boat Lanes. Actual use of explosives occurs during only 1% of training events and involves deployment of a single charge (≤20 lbs NEW) using either a TDFD or RFD.
Unmanned Underwater Vehicle Neutralization 1 day 4 per year	Training consists of placing 2 sequential charges consisting of a Seafox (3.3 lbs NEW) or Archerfish (3.57 lbs NEW) charge placed from depths of 10 feet to the bottom in water depth less than 72 feet near or within the SSTC oceanside Boat Lanes.
Airborne Mine Neutralization System (AMNS) 1 day 10 per year	A MH-60S helicopter deploys an AMNS underwater vehicle into the water near or within the SSTC oceanside Boat Lanes. In training, the AMNS is used to search, locate, and destroy simulated mines or mine shapes. The AMNS vehicle is self-propelled and unmanned. Approximately 20% of the training would involve using remotely detonated charges (≤3.5 lbs NEW) placed by the AMNS.
Naval Special Warfare (NSW) Underwater Demolition Qualification/ Certification 1 day 12 per year (time-delay or remote firing)	Provides NSW teams with experience in underwater detonations. At water depths of 10 to 72 feet near or within the SSTC oceanside Boat Lanes, NSW divers place either 2 sequential charges (≤ 12.5-13.75 lbs NEW) using either a TDFD or RFD on metal plates along the bottom, or a single charge (≤25.5 lbs NEW) using either a TDFD or RFD placed on a metal plate from a depth of 20 feet to the bottom.
Naval Special Warfare (NSW) Underwater Demolition Training 1 day 12 per year (time-delay or remote firing)	Up to 40 NSW personnel participate in this training activity involving small groups swimming to shore from small inflatable boats located approximately 1,000 yards offshore; boats may also be beached on shore. For underwater detonation training, a single charge (≤ 10 lbs NEW) using either a TDFD or RFD may be placed and detonated on the bottom near or within the oceanside SSTC Boat Lanes or a single charge (≤ 3.6 lbs NEW) (if within five feet of the surface) is manually detonated in water less than 24 feet deep.
Naval Special Warfare (NSW) SEAL Delivery Vehicle (SDV) /Advanced SEAL Delivery System Certification to Deploy 14 day 40 per year	Designed to certify SDV Team operators for deployment, events include direct action, reconnaissance, and counter-terrorism. Training may include navigation runs into and out of the San Diego Bay, hydrographic reconnaissance, over the beach training, combat swimmer, and underwater detonation training. Based on training tempo, multiple events could occur. Underwater detonation events that may be coordinated with other SDV training involve placing a single charge (≤ 10 lbs NEW) in water depths of 24 feet or less from mid-water column to the seafloor near or within the SSTC oceanside Boat Lanes. The entire SDV Certification process is a 14 day evolution, although underwater detonations would not be used every day.

ELCAS Training

Elevated Causeway System (ELCAS) is a modular pre-fabricated causeway pier. 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. 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 Chapters of piles are installed, causeway platforms are then hoisted and secured onto the piles with hydraulic jacks and cranes. 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 during this application period (July 2013-July 2014).

2 DURATION AND LOCATION OF ACTIVITIES

Training events would be conducted at the Silver Strand Training Complex (SSTC) along the appropriate training timeline (**Figure 1-1, Tables 1-2, 1-3**).

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.

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, 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.

In the summer of 2011, the Navy funded a new benthic habitat survey to re-assess benthic habitat and bottom conditions (Navy 2011c) with results shown in **Figure 2-1**. A second follow-on benthic habitat survey was performed in the late summer and fall of 2012 to cover areas between SSTC-North and SSTC-South, as well as areas further offshore to the 120-foot contour.

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).

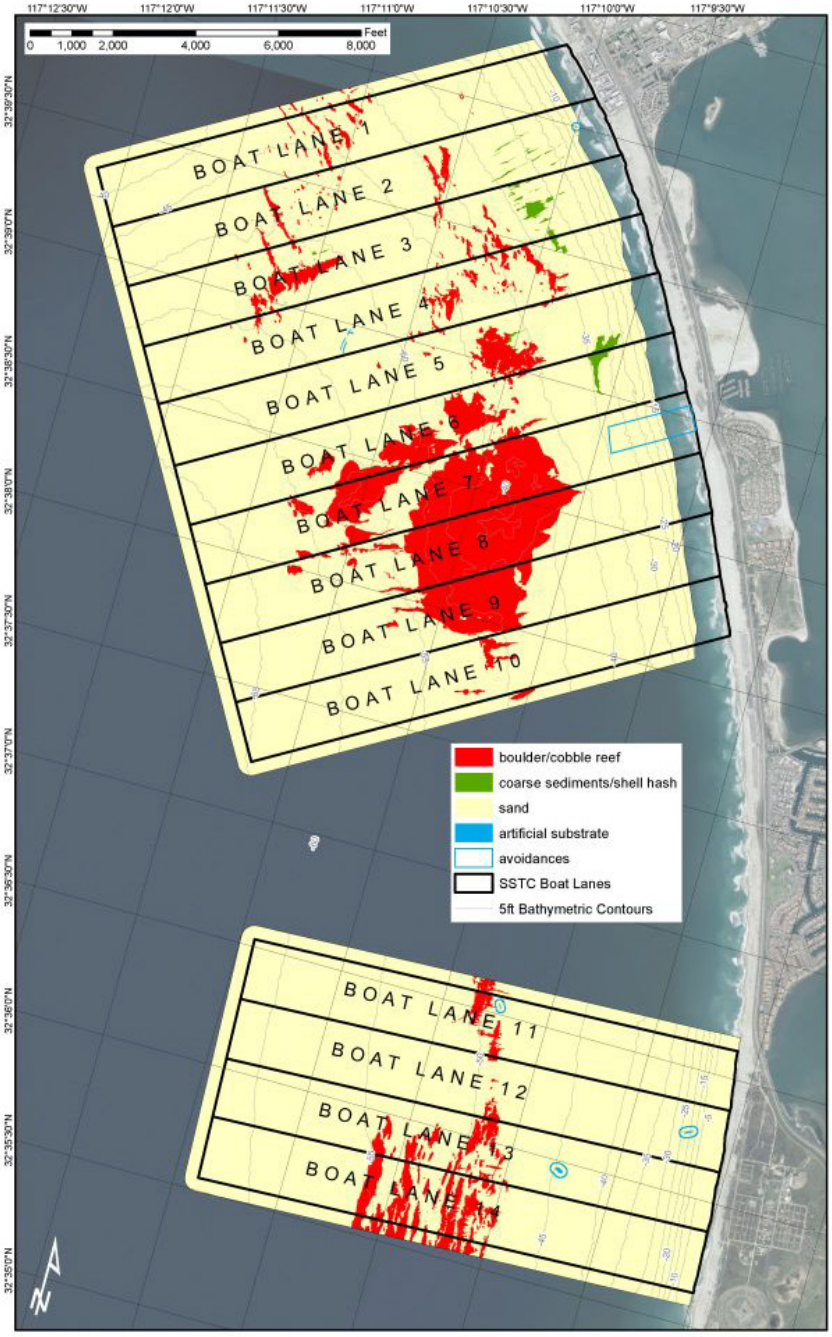

Figure 2-1. Bathymetry and substrate within the SSTC ocean boat lanes based on summer 2011 Navy-funded benthic habitat survey.

Duration and Annual Amount of SSTC Underwater detonations

Table 2-1 shows the underwater detonation training event types 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**).

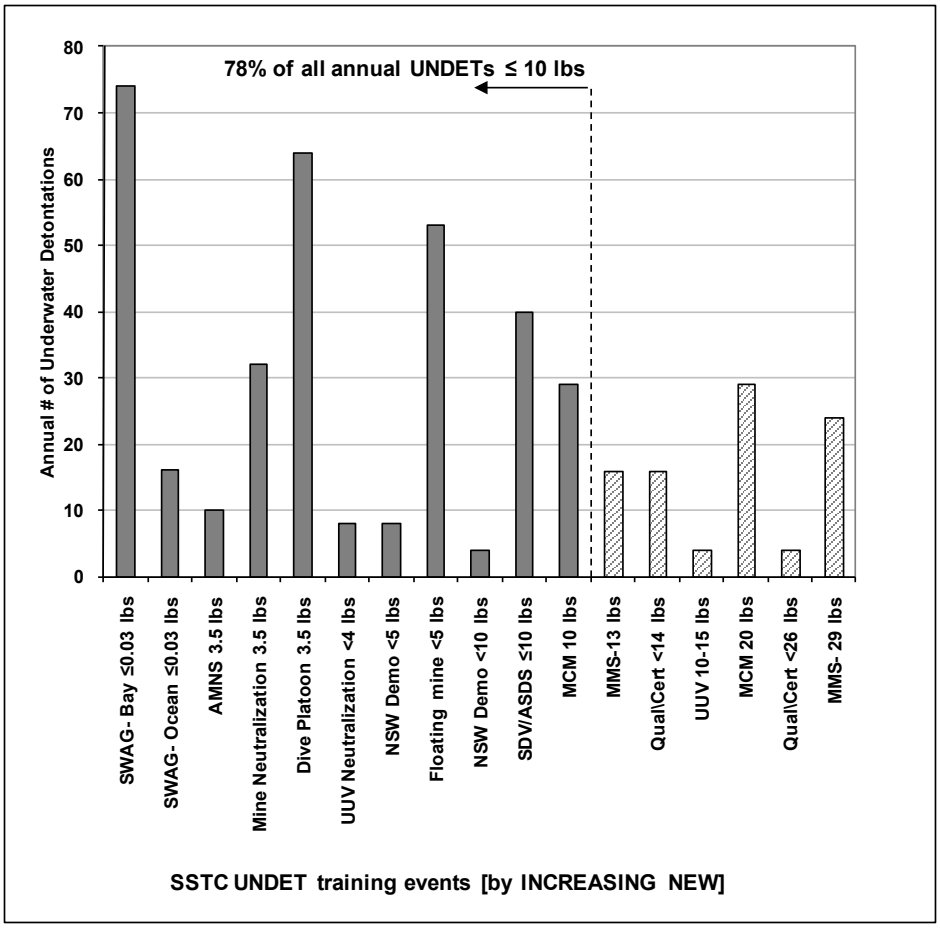

Figure 2-2. SSTC underwater detonations listed by increasing charge weight.

Table 2-1. SSTC annual underwater explosive events.

#	Underwater Detonation Training Event Type	NEW (lbs)	# of Sequential Det-onations * (#/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 [T]	≤ 10 to 20	1/det	≤ 72	Mid-water	29	Oceanside Boat Lanes 1-10,11-14
5	Mine Counter Measure [T]	≤ 10 to 20	1/det	≤ 72	Bottom	29	Oceanside Boat Lanes 1-10,11-14
6	Floating Mine [T]	≤ 5	1/det	≤ 72	Surface (< 5 feet)	53	Oceanside Boat Lanes 1-10,11-14
7	Dive Platoon* [T]	≤ 3.5	8/det	30–72	Bottom	8	Oceanside Boat Lanes 1-10,11-14
9	Very Shallow Water Mine Counter Measure [T]	≤ 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 [T]	≤ 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* [T]	≤ 3.5	8/det	30–72	Bottom	4	Oceanside Boat Lanes 1-10,11-14
N2	Surf Zone testing and evaluation [T]	≤ 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

[T] Indicates that some events (but not all) could use time-delayed initiation (TDFD) or remote firing (RDF)

* # 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.

≤ indicates that less explosive weight could be used as deemed appropriate for a particular training event. Zones of Influence modeled for each training event category, however, were calculated based on the maximum charge weight for that event type.

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 (*Zalophus californianus*), Pacific harbor seal (*Phoca vitulina richardii*), bottlenose dolphin (coastal stock) (*Tursiops truncatus*), and migratory gray whale (*Eschrichtius robustus*) (Leatherwood et al. 1982, 1988, Reeves et al. 2002, Barlow and Forney 2007, Allen and Angliss 2012, Carretta et al. 2012a, 2012b). A fifth species, long-beaked common dolphin (*Delphinus capensis*) may be a more periodic transient through SSTC than NMFS surveys have indicated in the past.

Table 3-1 summarizes population status and abundance. 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,).

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 (as discussed in Navy 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 Chapters 5 and 6 may reflect a proportionate over-estimation.

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] (CV)	Annual Population Trend	Occurrence	Warm Season (May-Oct) Presence and Density [2] (#/km²)	Cold Season (Nov-Apr) Presence and Density (#/km²)
Pinnipeds California sea lion *Zalophus californianus* U.S. stock	296,750 [3]	Increasing	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 30,196 (CV=0.16) Est. SOCAL only [4] abundance 5,271	Increasing	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 (CV=0.13) But likely 450-500	Stable	Limited, small population within one km of shore	YES 0.202	YES 0.202
Long-beaked common dolphin *Delphinus capensis* California stock	27,046 (CV=0.59)	Unknown	Common near-shore species; occurrence may be variable due oceanographic conditions	YES 0.096	YES 0.037
Mysticetes Gray whale *Eschrichtius robustus* Eastern North Pacific stock	19,126 (CV=0.07) Migratory	Increasing >3.2%	Transient within California, seasonal migrations	NO 0	YES 0.014

1 All abundance estimates from NMFS Stock Assessment Reports (Carretta et al 2012a, Allen and Angliss 2012) 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

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

Marine Mammal Species Regularly Expected Within or Adjacent to SSTC

There are five 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, long-beaked common dolphin, and more infrequently gray whale. None are listed as threatened or endangered under the Endangered Species Act.

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

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 and were sighted during all seasons and in all areas with survey coverage from nearshore to offshore areas (Carretta et al. 2000). Between October 2008 to May 2001, systematic Navy-funded aerial monitoring within the offshore waters of Southern California estimated an California sea lion at-sea abundance of 3,466 animals (Jefferson et al. 2012).

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).

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. The pupping and mating season for California sea lions begins in late May and continues through July (Heath 2002). 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. Weise et al (2006) also documented changes in sea lion foraging based on oceanographic conditions.

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).

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

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. 2012a). 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. 2012a). 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). 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).

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.

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

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 (Bearzi et al. 2009). The California Coastal Stock is the only one of these two stocks likely to occur within the SSTC. 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, Bearzi et al. 2009, Carretta et al. 2012a). 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). Newborn calves are seen throughout the year and reproduction may be influenced by productivity and food abundance (Urian et al. 1996).

Long-Beaked Common Dolphin (*Delphinus capensis*), California Stock

Long-beaked common dolphins (*Delphis capensis*) are found year-round in the waters off California (Carretta et al 2000; Bearzi 2005; Carretta et al 2012a, Carretta et al 2012b). The distribution and abundance of long-beaked common dolphins appears to be variable on interannual and seasonal time scales (Dohl et al. 1986; Heyning and Perrin 1994; Barlow 1995; Forney et al. 1995; Forney and Barlow 2007, Carretta et al 2012b). As oceanographic conditions change, long-beaked common dolphins may move between Mexican and U.S. waters, and therefore a multi-year average abundance estimate is the most appropriate for management within the U.S. waters (Carretta et al. 2012a, 2012b). California waters represent the northern limit for this stock and animal's likely movement between U.S. and Mexican waters. No information on trends in abundance is available for this stock because of high interannual variability in line-transect abundance estimates (Carretta et al. 2012a, 2012b). Heyning and Perrin (1994) detected changes in the proportion of short-beaked to long-beaked common dolphins stranding along the California coast, with the short-beaked common dolphin stranding more frequently prior to the 1982-83 El Niño (which increased water temperatures off California), and the long-beaked common dolphin more frequently observed for several years afterwards. Thus, it appears that both relative and absolute abundance of these species off California may change with varying oceanographic conditions (Carretta et al. 2012a, 2012b). Common dolphin distributions may be related to bathymetry (Hui 1979). Long-beaked common dolphins are usually found within 50 nautical miles (nm) (92.5 km) of shore with significantly more occurrence near canyons, escarpments, and slopes (Heyning and Perrin 1994; Barlow et al. 1997; Bearzi 2005, 2006). Group size ranges from less than a dozen to several thousand individuals (Barlow and Forney 2007; Barlow et al. 2010).

Recent anecdotal accounts from Navy Explosive Ordnance Disposal (EOD) divers remark on periodic sightings of large dolphin pods within the more seaward portions of the SSTC that are likely long-beaked common dolphin. During SSTC Navy-funded marine mammal monitoring during conducted over two days in November 2012, there were confirmed sightings of long-beaked common dolphin pods in the outer portions of SSTC in approximately 75 feet of water (**Figure 4-1**). Unlike the large congregated schools common to this species, the long-beaked common dolphins seen consecutively over two days in November 2012 were in widely dispersed small sub-groups with between one to five dolphins in each group. Individual and small groups (n=2-3) were seen chasing bait fish to the surface and foraging (**Figure 4-1**). The dolphins were observed over the period of an hour and eventually left SSTC heading seaward.

Sparse information is available on the life history of long-beaked common dolphins, however, some information is provided for short-beaked common dolphins which may also apply to long-beaked dolphins. North Pacific short-beaked common dolphin females and males reach sexual maturity at roughly 8 and 10 years, respectively (Ferrero and Walker 1995). Peak calving season for common dolphins in the eastern North Pacific may be spring and early summer (Forney 1994). Barlow (2010) reported average group size for long-beaked common dolphins within a Southern California-specific stratum as 195 individuals from a 2008 survey along the US West Coast.

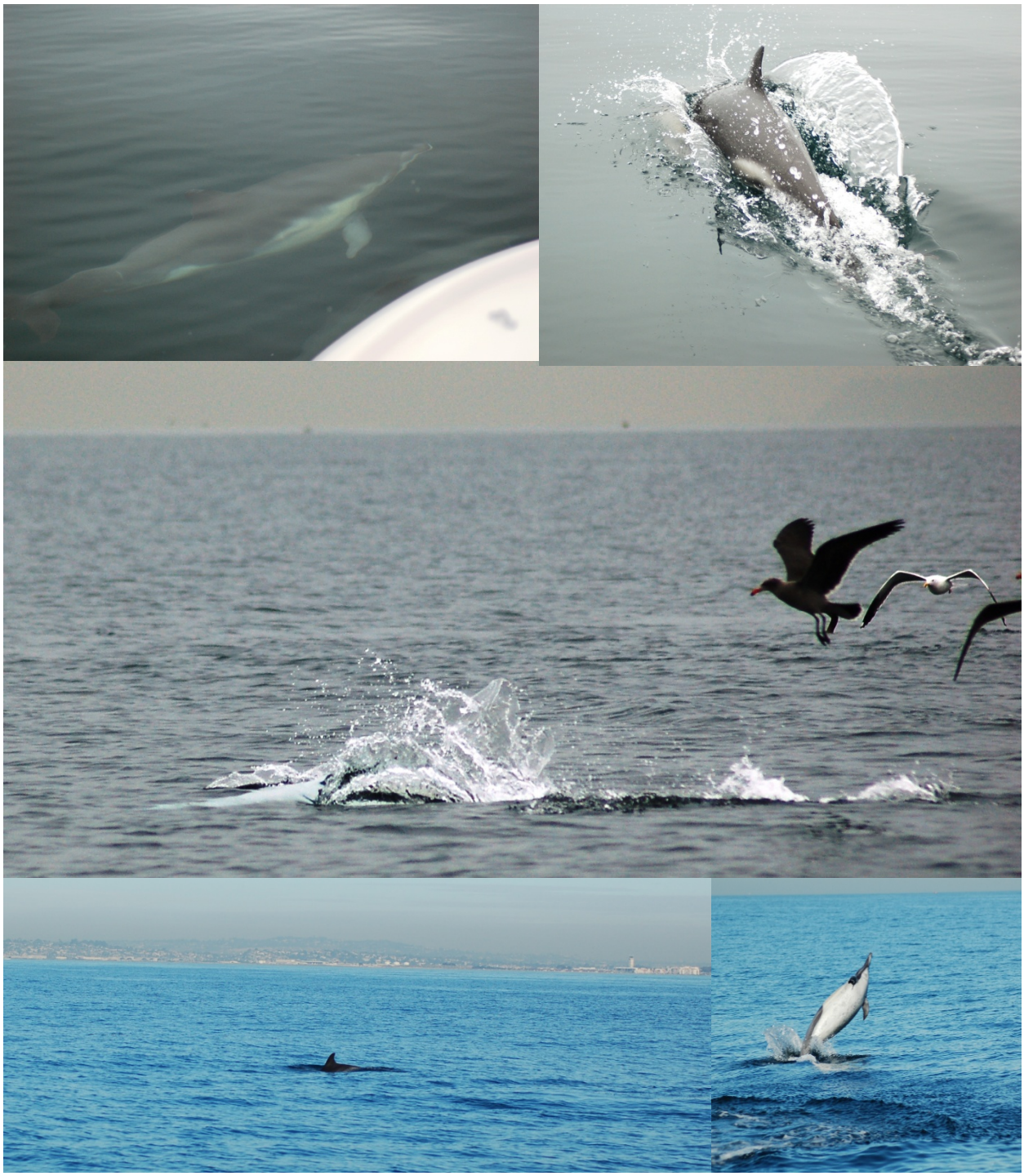

Figure 4-1. Photos of long-beaked common dolphins observed during Navy-funded monitoring in the seaside portions of the SSTC on November 15 and 16, 2012.
(Top left and right: long-beaked common dolphins passing monitoring boat Nov. 15th ; Middle: surface foraging dolphin Nov. 15; Bottom left: one of two long-beaked common dolphins Nov. 16th (Naval Base Coronado seen in background); Bottom right: breaching dolphin Nov. 16th (no Navy training activities were ongoing at the time of these observations)

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

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. 2000, 2002, 2004). 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).

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 2012). 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)

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).

Marine Mammal Species Not Regularly Expected Within or Adjacent to SSTC (Rare Species Relative to SSTC)

There are three marine mammal dolphin species commonly found within both coastal and offshore waters of Southern California (Carretta et al. 2012a). However, there is no documented NMFS sighting data, or other anecdotal information currently available as to likely presence within the very near-shore, shallow waters associated with the SSTC boat lanes. These dolphin species include, in likely order of probable rare occurrence, Pacific white-sided dolphin, Risso's dolphin, and short-beaked common dolphin. None of these species are listed as threatened or endangered under the Endangered Species Act.

The Navy is including these three additional dolphin species in this analysis in the rare event of their movement through the SSTC boat lanes.

Pacific White-sided Dolphin (*Lagenorhynchus obliquidens*), California/Oregon/ Washington Stock

While Pacific white-sided dolphins could potentially occur year-round in Southern California, surveys suggest a seasonal north-south movement of in the eastern North Pacific, with animals found primarily off California during the colder water months and shifting northward into Oregon and Washington as water temperatures increase during late spring and summer (Green et al. 1992, 1993; Forney 1994; Forney and Barlow 2007; Barlow 2010). Salvadeo et al. (2010) propose that increased global warming may increase a northward shift in Pacific white-sided dolphins. The Pacific white-sided dolphin is most common in waters over the continental shelf and slope, however, sighting records and captures in pelagic driftnets indicate that this species also occurs in oceanic waters well beyond the shelf and slope (Leatherwood et al. 1984). Soldevilla et al. (2010a) reported the possibility of two distinct eco-types of Pacific white-sided dolphins occurring in Southern California based on passive acoustic detection of two distinct echolocation click patterns. No population trends have been observed in California or adjacent waters. Barlow (2010) reported average group size for Pacific white-sided dolphins within a Southern California-specific stratum as 17 from a 2008 survey along the US West Coast.

Risso's Dolphin (*Grampus griseus*), California/Oregon/ Washington Stock

Off the U.S. West coast, Risso's dolphins are commonly seen on the shelf in the Southern California and in slope and offshore waters of California, Oregon and Washington (Soldevilla et al. 2010b, Carretta et al. 2010). Animals found off California during the colder water months are thought to shift northward into Oregon and Washington as water temperatures increase in late spring and summer (Green et al. 1992). The southern end of this population's range is not well documented, but previous surveys have shown a conspicuous 500 nm distributional gap between these animals and Risso's dolphins sighted south of Baja California and in the Gulf of California (Mangels and Gerrodette 1994). Thus this population appears distinct from animals found in the eastern tropical Pacific and the Gulf of California (Carretta et al. 2012a). As oceanographic conditions vary, Risso's dolphins may spend time outside the U.S. Exclusive Economic Zone. Barlow (2010) reported average group size for Risso's dolphins within a Southern California-specific stratum as 23 from a 2008 survey along the US West Coast.

Short-Beaked Common Dolphin (*Delphinus delphis*), California/Oregon/Washington Stock

Short-beaked common dolphins are the most abundant cetacean off California, and are widely distributed between the coast and at least 300 nm distance from shore (Dohl et al. 1981; Forney et al. 1995; Barlow 2010; Carretta et al. 2012a). Along the U.S. West Coast, portions of the short-beaked common dolphins' distribution overlap with that of the long-beaked common dolphin. The northward extent of short-beaked common dolphin distribution appears to vary interannually and with changing oceanographic conditions (Forney and Barlow 1998). Barlow (2010) reported average group size for short-beaked common dolphins within a Southern California-specific stratum as 122 from a 2008 survey along the US West Coast.

5 HARASSMENT AUTHORIZATION REQUESTED

The Navy determined that its underwater detonation events and pile driving at Silver Strand Training Complex (SSTC) may result in incidental takings of marine mammals by Level B harassment. For that reason, the Navy is re-applying applying for a one year authorization for the take of marine mammals incidental to proposed training and testing activities for the period from July 2013 to July 2014.

The acoustic modeling approach taken in this 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, modeling results from SSTC analysis predicts 812 potential pre-mitigation exposures from underwater detonations and 986 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 (MMPA).

- For underwater detonations, the models estimated 168 level B exposures to coastal bottlenose dolphins, 52 Level B exposures to long-beaked common dolphins, and 99 level B exposures to California sea lions. For species with less likely occurrence within SSTC, there were 13 Level B exposures to Pacific white-sided dolphins, 32 exposures to Risso's Level B dolphins, and 448 Level B exposures to short-beaked common dolphin.

- For ELCAS pile driving and pile removal, the calculations estimated 208 Level B exposures to coastal bottlenose dolphins, 54 Level B exposures to long-beaked common dolphins, 122 Level B exposures to California sea lions, 12 Level B exposures to harbor seals, and 6 Level B exposures to gray whales. For species with less likely occurrence within SSTC, there were 12 Level B exposures to Pacific white-sided dolphins, 30 exposures to Risso's Level B dolphins, and 542 Level B exposures to short-beaked common dolphin. It should be noted, however, that the short-beaked common dolphin, the species representing 55% of the total ELCAS exposure estimate is also the species least likely to be present given their generally more offshore distribution. Their inclusion in this exposure estimate is a conservative addition of a relatively rare species within SSTC.

Given Navy's current mitigation procedures presented in Chapter 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 exposures is minimized or eliminated. The Navy does not anticipate that 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 1,799 marine mammals per year at SSTC in this 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 Harassment Authorization 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 (MMPA). This Chapter defines MMPA 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.

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 non-auditory system tissues. These are not independent pathways and both must be considered since the same sound could affect both auditory and non-auditory 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 non-auditory 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 non-injurious 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 non-auditory 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 Chapters 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.

Integration of Physiological and Behavioral Effects

This Chapter 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 Chapters 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 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 application and based upon a NMFS approved approach.

A "*physiological effect*" is defined within the context of this 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 Chapters.

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 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 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.

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 request and previous rulings (NMFS 2001, 2002, 2008), 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 application assumes that all injury is qualified as a physiological effect and, to be consistent with prior actions and rulings (NMFS 2001, 2008), 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, 2008, 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, 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, actual 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 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 application is unintentional and incidental to those events.

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.

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 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.

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 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 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.

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.

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 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 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.

Behavioral Effects and the Level B Harassment Zone

This 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 2008) 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 Chapter 11.

The short-duration underwater detonations and pile driving events proposed in this application are brief and time-isolated. In this 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.

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 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 application.

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

In this 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 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).

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**).

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**).

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 2008), and approved by NMFS through subsequent rulemaking (NMFS 2009a, 2009b) was used for the SSTC 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 1μPa^2-sec (full spectrum energy)
Level B Behavioral Harassment	TTS (dual criteria)	23 psi (peak pressure; explosives <2,000 lbs), or
		182 dB re1μPa^2-sec (peak 1/3 octave band)
	(sequential detonations only)	177 dB re 1μPa^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)

Assessing for Explosive Effects of Underwater Detonations

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 non-injurious 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.

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 Chapter 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])
- the ability for post-operation processing to evaluate the dosimeter exposure record and calculate exposure statistics for each species based on applicable thresholds

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** shows the conceptual model framework used for the SSTC impact analysis

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.

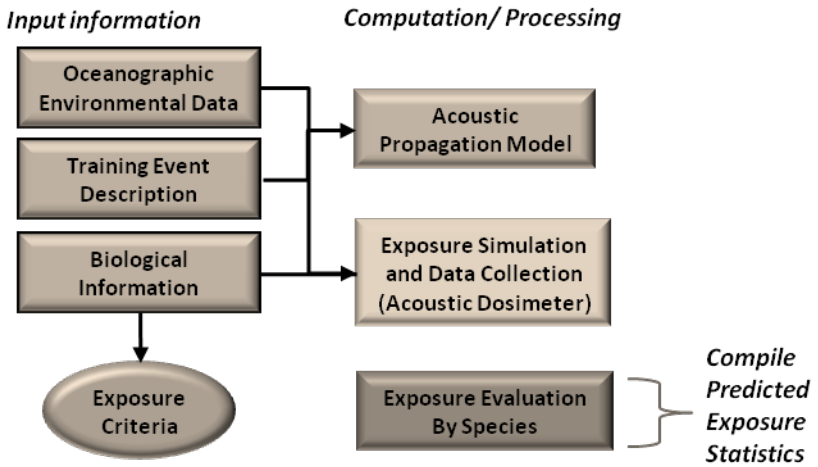

Figure 6-1. Generalized modeling process for estimating exposures from SSTC underwater detonations.

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. In **Figure 6-2**, 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.

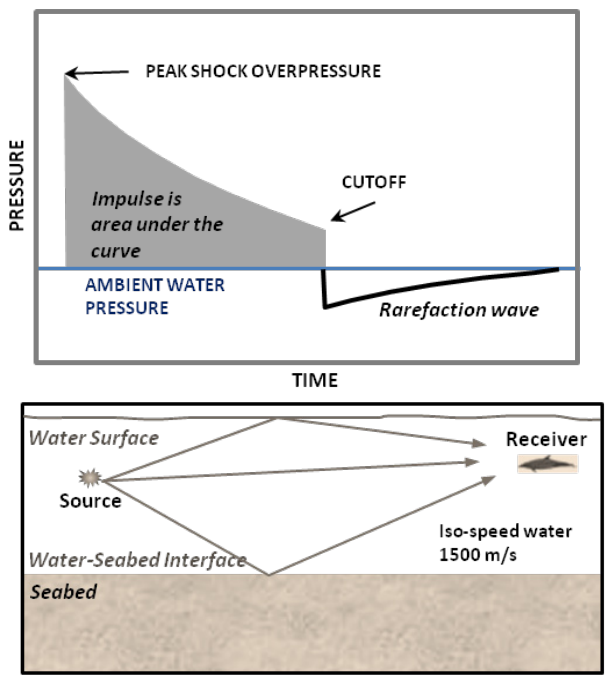

Figure 6-2. Generalized shock wave (top) and underwater pathways of shock waves and sound energy (bottom).
(adapted from Siderius and Porter 2006).

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. 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 Chapter 11) <u>are not</u> quantified or applied to these estimated exposures.

Predictive Modeling for Underwater Detonations- Modeling Specifics

The exposure quantities calculated by modeling were based on input data and processes described in Chapter 6. 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. 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). Swim speeds by species used for modeling purposes were: California sea lion- 2.00 meters/second (m/sec); Pacific harbor seal 1.00 m/sec; bottlenose dolphin 3.08 m/sec; and gray whale 1.86 m/sec. Another assumption was that 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 events (Jordan 2008).

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 6-3**). Software processing modules (red font) are stated for each step with two ultimate outcomes, ZOIs and marine mammal exposures.

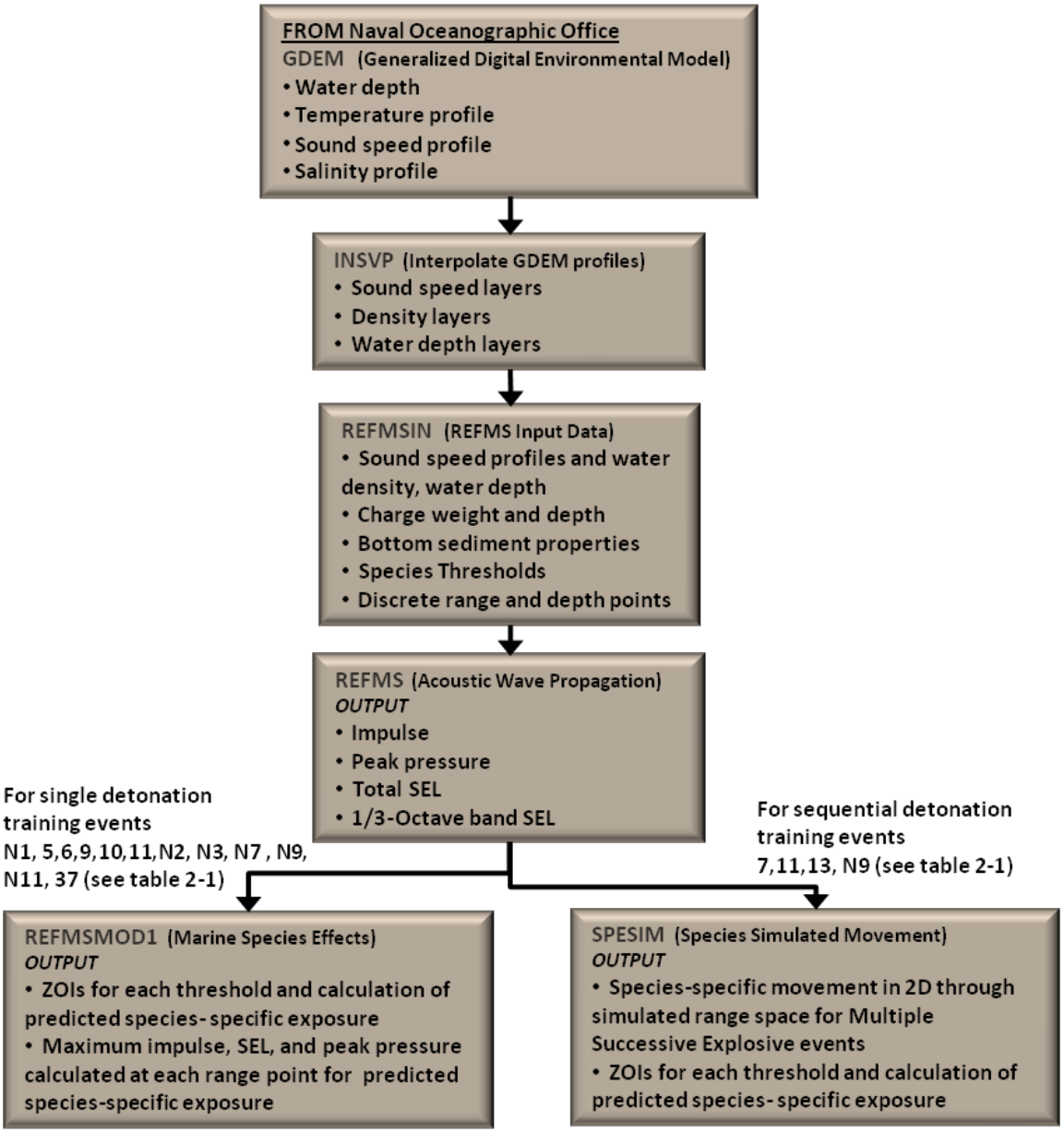

Figure 6-3. Computational sequence for determining effects of underwater detonations.

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 Chapter 11).

Therefore, all marine mammal exposures presented in this 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.

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 application

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 [2] scheduled to occur and sought in this authorization
- 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

2 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.

<u>Modeling Assumptions-</u> *Biological Assumptions* [3]

- 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

3 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. 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 application assumes an even distribution of marine mammals within SSTC for impact analysis purposes. 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 within 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. Marine mammals are not distributed evenly within the water column. Given the relatively shallow bathymetry of SSTC however, 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.

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.

Maximum Zones of influence (ZOI) for SSTC underwater detonations by training event are shown in **Table 6-2**.

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 6-2. 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

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 $\mu Pa^2 \cdot sec$ 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 Chapter 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 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.

VSW ZOI via Iso-model vs. REFMS- 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 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.

(However, based on conservative protection, the Navy in Chapter 11 proposes maintaining the currently established 700 yard VSW mitigation zone)

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 Chapter 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 6-3 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 Chapter 11, will minimize the number of marine mammal exposures shown in **Table 6-3**, 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

- 473 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
    - 31 annual exposures to long-beaked common dolphins
    - 7 annual exposures to Pacific white-sided dolphins
    - 19 annual exposures to Risso's dolphins
    - 263 annual exposures to short-beaked common dolphins *

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

- 339 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
    - 21 annual exposures to long-beaked common dolphins
    - 5 annual exposures to Pacific white-sided dolphins
    - 14 annual exposures to Risso's dolphins
    - 185 annual exposures to short-beaked common dolphins *

(note: Given their normally much further offshore distribution in Southern California, short-beaked common dolphin the least likely to occur of all species considered in this analysis)*

Table 6-3. SSTC modeled estimates of species exposed to underwater detonations without implementation of mitigation measures.

Expected 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 (to expected species)			114	153	0	0
Less Common species			**Level B**		**Level A Injury**	**Mortality**
Cetaceans	Long-beaked common dolphin	Warm	14	21	0	0
		Cold	7	10	0	0
	Pacific white-sided dolphin	Warm	2	3	0	0
		Cold	3	4	0	0
	Risso's dolphin	Warm	3	4	0	0
		Cold	11	15	0	0
	Short-beaked common dolphin	Warm	123	177	0	0
		Cold	62	86	0	0
Total Annual Exposures (to unexpected species)			225	320	0	0
Grand Total All Exposures			339	473	0	0

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.

Finally, all exposures are predicted without the application of the appropriate mitigation measures described in Chapter 11.

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. 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.).

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:

$$TL = F * \log (D_1/D_2)$$

Where:

TL = transmission loss (the sound pressure level at D_1 minus the sound pressure level at D_2, in RMS, dB re 1μPa)

F = attenuation constant

D_1 = distance at which the targeted transmission loss occurs

D_2 = 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[4] that the Navy take a still more conservative approach and use a F value of F=15.

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 Chapter 11.3 ELCAS mitigation).

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

ELCAS Pile Installation (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 for cetaceans and pinnipeds (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 (Vibratory)- 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)
- 5,076 yards for the Level B behavioral harassment for cetaceans and pinnipeds (120 dB RMS).

The above values reflect 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.

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".

<u>Pile Driving Potential Exposure Formula</u>

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 Chapter 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 Chapter, and without consideration of current mitigation measures, the Navy's estimate (**Table 6-4**) 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 to expected species (40 bottlenose dolphins, 20 California sea lions); 80 harassments to unexpected species (80 short-beaked common dolphins *). Total Level B, therefore, is 60+80= 140

(note: Given their normally much further offshore distribution in Southern California, short-beaked common dolphin the least likely to occur of all species considered in this analysis)*

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".

<u>Pile Removal Potential Exposure Formula</u>

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 Chapter, and without consideration of current mitigation measures, the Navy's estimate (**Table 6-4**) 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 to expected species (168 bottlenose dolphins, 102 California sea lions, 12 harbor seals, 6 gray whales); 558 harassments to unexpected species (54 long-beaked common dolphins, 12 Pacific white-side dolphins, 30 Risso's dolphins, 462 short-beaked common dolphins *). Total Level B, therefore, is 288+558= 846

(note: Given their normally much further offshore distribution in Southern California, short-beaked common dolphin the least likely to occur of all species considered in this analysis)*

Table 6-4. Exposure estimates from ELCAS pile driving\removal prior to implementation of mitigation measures.

Expected 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	Not applicable	0	0	0
		Removal	6	Not applicable	0	0
	Bottlenose Dolphin	Installation	Not applicable	40	0	0
		Removal	168	Not applicable	0	0
Pinnipeds	California Sea Lion	Installation	Not applicable	20	0	0
		Removal	102	Not applicable	0	0
	Harbor Seal	Installation	Not applicable	0	0	0
		Removal	12	Not applicable	0	0
Total Annual Exposures (to expected species)			288	60	0	0
Cetaceans	Long-beached common dolphin	Installation	Not applicable	0	0	0
		Removal	54	Not applicable	0	0
	Pacific white-sided dolphins	Installation	Not applicable	0	0	0
		Removal	12	Not applicable	0	0
	Risso's dolphin	Installation	Not applicable	0	0	0
		Removal	30	Not applicable	0	0
	Short-beaked common dolphin	Installation	Not applicable	80	0	0
		Removal	462	Not applicable	0	0
Total Annual Exposures (to less common species)			558	80	0	0
Grand Total All Exposures			846	140	0	0

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.
- 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 Chapter 11 are implemented.

The predicted annual exposures from impact analysis conducted for this Letter of 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; for unexpected species, no Level A injury or mortality to long-beaked common dolphins, Pacific white-sided dolphins, Risso's dolphins, or short-beaked common dolphins.
- 267 Level B exposures to bottlenose dolphins (168), 52 exposures to long-beaked common dolphins, and California sea lions (99) from underwater detonations; for unexpected species, 13 to Pacific white-sided dolphins, 32 to Risso's dolphins, and 448 short-beaked common dolphins.
- 348 Level B exposures to bottlenose dolphins (208), 54 Level B exposures to long-beaked common dolphins, California sea lions (122), harbor seals (12), and gray whales (6) from ELCAS pile driving and removal; for unexpected species, 12 to Pacific white-sided dolphins, 30 to Risso's dolphins, and 542 short-beaked common dolphins.

Expected Species

Bottlenose dolphin- There were no predicted mortality or Level A injury for bottlenose dolphins. Modeling predicted there would be 168 potential Level B exposures from underwater explosions and only 208 Level B exposures 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 exposures from underwater detonations and 122 potential Level B 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 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 exposures from ELCAS pile removal. Within SSTC, given the relatively shallow water, 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 6-3** and **6-4** for the bottlenose dolphin, California sea lion, and Pacific harbor seal, and gray whale are overly conservative estimates of harassment as discussed in Chapter 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, California sea lion, and harbor seal natural distribution, does not represent a significant breeding or foraging area. Gray whales are only transitory through Southern California during the cold season.

Less Common Species

Long-beaked common dolphins- There were no predicted mortality or Level A injury for long-beaked common dolphins. Modeling predicted there would be 52 potential Level B exposures from underwater explosions and 54 Level B exposures from ELCAS pile driving and removal. Of all the relatively rare species within SSTC, the long-beaked common dolphin is the most possible given its more near-shore coastal distribution (Bearzi, 2005, Carretta et al. 2010). Given high travel mode, low site fidelity to areas without significant bathymetric relief such as the low slope sandy bottom under the SSTC boat lanes (Hui 1979, Heyning and Perrin 1994, Bearzi, 2005, 2006), there is a high likelihood that pre-detonation mitigation would detect long-beaked common dolphins and therefore reduce exposures such that potential effects would be minimal.

Pacific white-side dolphins- There were no predicted mortality or Level A injury for Pacific white-sided dolphins. Modeling predicted there would be 13 potential Level B exposures from underwater explosions and 12 Level B exposures from ELCAS pile driving and removal. As discussed in Chapter 4, there is limited empirical data available to confirm Pacific white-sided species occurrence in the near shore water adjacent to the SSTC boat lanes. Movement of Pacific white-side dolphins into the SSTC boat lanes would likely be rare to very infrequent and limited in duration. There would be a high likelihood that pre-detonation mitigation would detect Pacific white-sided dolphins, if present at all, and therefore reduce exposures such that potential effects would be minimal.

Risso's dolphins- There were no predicted mortality or Level A injury for Risso's dolphins. Modeling predicted there would be potential 32 Level B exposures from underwater explosions and 30 Level B exposures from ELCAS pile driving and removal. As discussed in Chapter 4, there is limited empirical data available to confirm Risso's species occurrence in the near shore water adjacent to the SSTC boat lanes. More Risso's sighting occur further offshore (DoN 2009, Barlow 2010, Carretta et al. 2010, DoN 2010a). Movement of Risso's dolphins into the SSTC boat lanes would likely be rare to very infrequent and limited in duration. There would be a high likelihood that pre-detonation mitigation would detect Risso's dolphins, if present at all, and therefore reduce exposures such that potential effects would be minimal.

Short-beaked common dolphins- There were no predicted mortality or Level A injury for short-beaked common dolphins. Modeling predicted there would be potential 448 Level B exposures from underwater explosions and 542 Level B exposures from ELCAS pile driving and removal. As discussed in Chapter 4, there is limited empirical data available to confirm short-beaked common species occurrence in the near shore water adjacent to the SSTC boat lanes. More short-beaked common sighting occur further offshore (Bearzi 2005, DoN 2009, Barlow 2010, Carretta et al. 2010, DoN 2010a). Movement of short-beaked common dolphins into the SSTC boat lanes would likely be rare to very infrequent and limited in duration. There would be a high likelihood that pre-detonation mitigation would detect short-beaked common dolphins, if present at all, and therefore reduce exposures such that potential effects would be minimal.

Finally, 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 Chapter 11 are designed to reduce sound exposure of marine mammals to achieve the least practicable adverse effect on marine mammal species or stocks.

This 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 Chapter 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 (Chapter 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 IMPACTS 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 Chapters 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.

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 Chapter 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 Chapter 6 represent the maximum expected number of marine mammals that could be exposed to acoustic sources reaching Level B TTS harassment levels using the dual criteria TTS from Table 6-3. None of the previous modeling 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 Chapter to minimize the number of marine mammals potentially affected from training events at the Silver Strand Training Complex (SSTC).

Modeling results for Zones of Influence (ZOI) discussed in Chapter 6 were used to develop mitigation zones applicable to the mitigation measures for underwater detonations in water > 24 feet and Shock Wave Generator (SWAG) training events at the SSTC.

The ZOIs effectively represent a modeled 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 an expanded 700 yard mitigation zone for all positive control (RFD) underwater detonations conducted on the oceanside of the SSTC, a 700-1,500 yard mitigation zone around all timed-delay TDFS underwater detonations conducted on the oceanside of the SSTC, and a 60 yards mitigation zone around SWAG training events conducted on the oceanside and Bayside 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 based strictly on modeled ZOI (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.

In terms of differences between Very Shallow Water (VSW, < 24 feet depth) and shallow water (>24 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 and diving seabirds 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.

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 700 yard mitigation zone for positive control (i.e., RFD) events, and 700 to 1,500 yard mitigation zone for timed-delayed (i.e., TDFD) events depending on charge weight and delay time. The positive control 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 (450-470 yards) plus an additional conservative (i.e., over-protective) buffer that brings the final zone to 700 yards. The timed-delay mitigation zone derivation is described below.

- Shallow water (>24 feet) underwater detonation mitigation

  With a 700 yard mitigation zone for positive control (i.e., RFD) events, and 700 to 1,500 yard mitigation zone for timed-delayed (i.e., TDFD) events depending on charge weight and delay time. The positive control 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 an additional buffer that brings the final zone to 700 yards for RFD events. The timed-delay mitigation zone derivation is described below . Mitigation zone for much smaller SWAG detonations is 60 yards.

- ELCAS pile driving and removal mitigation

  With a 50 yard mitigation zone. This mitigation zone is based on the maximum range estimated to the Level A Cetacean Harassment criteria (180 dB RMS).

Derivation Of Timed Delayed Mitigation Zones

To increase the effectiveness of the shallow water mitigation zone when using time-delayed detonations (i.e., TDFD), an additional buffer zone is added to the base mitigation zone (700 yards) to allow sighting of marine mammals outside of the 700 yard buffer zone swimming into and near the detonation point prior to starting a timed-delay detonation. Using an average swim speed of 3 knots (102 yd/min) as representative of all dolphin species, the approximate distance an animal would travel within a given time-delay period between 5-10 minutes can be estimated. To account for differences between species or faster swimming by individuals within a species, the Navy and NMFS also agreed to add still another 200 yards to the original 3 knot derived ranges. **Table 11-1** shows 3 knot range plus the additional 200 yard buffer.

Table 11-1. Potential distance traveled based on swim speed and length of time-delay with additional 200 yard buffer.

Type	Swim Speed	Time-delay	Potential Distance Traveled
Dolphin	102 yards per minute	5 min	710 yards
		6 min	812 yards
		7 min	914 yards
		8 min	1,016 yards
		9 min	1,118 yards
		10 min	1,220 yards

Based on acoustic propagation modeling and anticipated ZOI by training event type and charge weight, the potential dolphin travel distances by time can be added to event specific ZOIs to produce a matrix of charge weight, selected delay time, and applicable mitigation zone. As long as animals are not observed within a given time-delayed mitigation zone before the time-delay detonation is set, then the animals would be unlikely to swim into the injury zone from outside the area within the time-delay window. Therefore, the Navy then added the swim speed, time-delay, additional buffer ranges (**Table 11-1**) to previously modeled ZOIs by charge weight.

Finally, to create a better marine mammal risk mitigation regime that is likely to achieve better success through more practical execution, Navy divided the span of training events into those requiring at 1,000 yard buffer zone (with 2 boats mitigation), and those requiring greater than a 1,400 yard buffer zone (3 boats mitigation, or 2 boats and 1 helicopter).

Table 11-2 shows the Navy's final mitigation zones and application for SSTC TDFD underwater detonations. This required in most cases rounding (most upward) the calculated ranges described above to the appropriate range category (1,000, 1,400, 1,500 yds).

These new mitigation zones and survey protocol are supportable from an operational perspective and will result in minimal risk of marine mammal injury or mortalities. The zones and the number of boats/helicopters used will allow for a thorough survey of the area in the weather conditions and sea states typically experienced during a training event.

Table 11-2. Navy's mitigation zone radius for TDFDs within SSTC based on size of charge and length of time-delay.

charge weight *	Time Delay					
	5 min	6 min	7 min	8 min	9 min	10 min
5 lb	1,000 yards	1,000 yards	1,000 yards	1,000 yards	1,400 yards	1,400 yards
10 lb	1,000 yards	1,000 yards	1,000 yards	1,000 yards	1,400 yards	1,400 yards
15-29 lb	1,000 yards	1,400 yards	1,400 yards	1,400 yards	1,500 yards	1,500 yards

For charge weights lower than those shown here, the next highest charge weight will be used (ex. 3.5 NEW charge would use the 5 lb mitigation range).

Navy mitigation applied:
1,000 yd = minimum of 2 observation boats
1,400/1,500 yd = minimum of 3 observation boats or 2 boats and 1 helicopter

Mitigation for Underwater Detonations in Very Shallow Water (<24 Feet)

Mitigation Measures For VSW Underwater Detonations Using Positive Control

1. Underwater detonations using positive control (remote firing devices) will only be conducted during daylight.
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 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 sighted 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 via operational change of command to Navy environmental representatives from 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 Chapter 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).

Mitigation Measures For VSW Underwater Detonations Using Time-Delay (TDFD Only)

1. Underwater detonations using timed delay devices will only be conducted during daylight.
2. Time-delays longer than 10 minutes will not be used. The initiation of the device will not start until the mitigation area below is clear for a full 30 minutes prior to initiation of the timer.
3. A mitigation zone of will be established around each underwater detonation location as indicated in the **Table 11-2** (1,000, 1,400, or 1,500) based on charge weight and length of time-delay used.
4. VSW ranges 1,000 yds:
   - For each VSW underwater detonation event with a mitigation zone of 1,000 yds, 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 at the seaward edge of the mitigation zone. The task of the boat 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. To the best extent practical, boats will try to maintain a 10 knot search speed.
   - A shore-based observer will also be deployed for VSW detonations in addition to boat based observers. 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). 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 or moving toward it.
5. VSW ranges ≥ 1,400:
   - A minimum of 2 boats and 1 shore-based observer will be used to survey for marine mammals (and other marine species such as diving birds and protected species such as sea turtles) at mitigation ranges ≥ 1,400 yards.
   - When conducting the surveys within a mitigation zone >1,400 yds, boats will position themselves near the mid-point of the mitigation zone radius (but always outside the detonation plume radius/human safety zone) and travel in a semi-circular pattern around the detonation location surveying both the inner (toward detonation site) and outer (away from detonation site) areas. When using 2 boats, each boat will be positioned on opposite sides of the detonation location, separated by 180 degrees. If using more than 2 boats, each boat will be positioned equidistant from one another (120 degrees separation for 3 boats, 90 degrees separation for 4 boats, etc.). If available, aerial visual survey support from Navy helicopters can be utilized, so long as to not jeopardize safety of flight. Helicopters will travel in a circular pattern around the detonation location.
6. A mitigation zone will be surveyed from 30 minutes prior to the detonation and for 30 minutes after the detonation.

7. Other personnel besides boat observers can also maintain situational awareness on the presence of marine mammals within the mitigation zone to the best extent practical given dive safety considerations.

   Divers placing the charges on mines will observe the immediate underwater area around a detonation site for marine mammals (and other marine species such as diving birds and sea turtles) and report sightings to surface observers.

8. If a marine mammal is sighted within an established 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.

9. Other personnel besides boat observers can also maintain situational awareness on the presence of marine mammals within the mitigation zone to the best extent practical given dive safety considerations. Divers placing the charges on mines will observe the immediate underwater area around a detonation site for marine mammals (and other marine species such as diving birds and sea turtles) and report sightings to surface observers.

10. If a marine mammal is sighted within an established 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.

11. Immediately following the detonation, visual monitoring for affected marine mammals (and other species such as birds and sea turtles) within the mitigation zone will continue for 30 minutes.

12. Any marine mammal or sea turtle observed after an underwater detonation either injured or exhibiting signs of distress will be reported to via Navy operational chain of command to Navy environmental representatives from 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.

Mitigation for Underwater Detonations in Shallow Water (>24 Feet)

Mitigation Measures For Underwater Detonations Using Positive Control
(Except SWAG and Timed Detonations)

1. Underwater detonations using positive control devices will only be conducted during daylight.
2. A mitigation zone of 700 yards will be established around each underwater detonation point.
3. A minimum of two boats, including but not limited to small zodiacs and 7-m 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.
4. 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.
5. 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).
6. Explosive detonations will cease if a marine mammal is visually detected within the mitigation zone. Detonations will re-commence if any one of the following conditions are met: (1) the animal is observed exiting the mitigation zone, (2) the animal is thought to have exited the mitigation zone based on its course and speed, or (3) the mitigation zone has been clear from any additional sightings for a period of 30 minutes.
7. 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 via Navy operational chain of command to Navy environmental representatives from 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.

Mitigation Measures For Underwater Detonations Using Time-Delay (TDFD Detonations Only)

1. Underwater detonations using timed delay devices will only be conducted during daylight.
2. Time-delays longer than 10 minutes will not be used. The initiation of the device will not start until the mitigation area below is clear for a full 30 minutes prior to initiation of the timer.
3. A mitigation zone will be established around each underwater detonation location as indicated in Table 11-3 based on charge weight and length of time-delay used. When conducting the surveys within a mitigation zone (either 1,000 or ≥1,400 yds), boats will position themselves near the mid-point of the mitigation zone radius (but always outside the detonation plume radius/human safety zone) and travel in a circular pattern around the detonation location surveying both the inner (toward detonation site) and outer (away from detonation site) areas.
4. Shallow water TDFD detonations 1,000 yds:
   - A minimum of 2 boats will be used to survey for marine mammals (and other marine species such as diving birds and protected species such as sea turtles) at mitigation ranges of 1,000 yds.
   - When using 2 boats, each boat will be positioned on opposite sides of the detonation location, separated by 180 degrees.
   - Two observers in each of the boats will conduct continuous visual survey of the mitigation zone for the entire duration of a training event.
   - To the best extent practical, boats will try to maintain a 10 knot search speed. This search speed was added to ensure adequate coverage of the buffer zone during observation periods. While weather conditions and sea states may require slower speeds in some instances, 10 knots is a prudent, safe, and executable speed that will allow for adequate surveillance. For a 1,000 yd radius buffer zone a boat travelling at 10 knots and 500 yds away from the detonation point would circle the detonation point 3.22 times during a 30 minute survey period. By using 2 boats, 6.44 circles around the detonation point would be completed in a 30 minute span.
5. Shallow water TDFD detonations ≥1,400 yds:
   - When using 3 (or more) boats, each boat will be positioned equidistant from one another (120 degrees separation for 3 boats, 90 degrees separation for 4 boats, etc.).
   - For a 1,400 yd radius mitigation zone, a 10 knot speed results in 2.3 circles for each of the three boats, or nearly 7 circles around the detonation point over a 30 minute span
   - If available, aerial visual survey support from Navy helicopters can be utilized, so long as to not jeopardize safety of flight.
   - Helicopters, if available, can be used in lieu of one of the boat requirements. Navy helicopter pilots are trained to conduct searches for relatively small objects in the water, such as a missing person. A helicopter search pattern is dictated by standard Navy protocols and accounts for multiple variables, such as the size and shape of the search area, size of the object being searched for, and local environmental conditions, among others.
6. A mitigation zone will be surveyed from 30 minutes prior to the detonation and for 30 minutes after the detonation.
7. Other personnel besides boat observers can also maintain situational awareness on the presence of marine mammals within the mitigation zone to the best extent practical given dive safety considerations.

Divers placing the charges on mines will observe the immediate underwater area around a detonation site for marine mammals (and other marine species such as diving birds and sea turtles) and report sightings to surface observers.

8. If a marine mammal is sighted within an established 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.
9. Immediately following the detonation, visual monitoring for affected marine mammals (and other species such as birds and sea turtles) within the mitigation zone will continue for 30 minutes.
10. Any marine mammal or sea turtle observed after an underwater detonation either injured or exhibiting signs of distress will be reported to via Navy operational chain of command to Navy environmental representatives from U.S. Pacific Fleet, Environmental Office, San Diego Detachment or Pearl Harbor. Using Marine Mammal Stranding protocols and communication trees established for the Southern California and Hawaii Range Complexes, the Navy will report these events to the Stranding Coordinator of NMFS' Southwest or Pacific Islands 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.

Mitigation Measures For Underwater SWAG Detonations (SWAG Only)

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

1. Underwater detonations using SWAG will only be conducted during daylight.
2. A mitigation zone of 60 yards will be established around each SWAG detonation site.
3. A minimum of two boats, including but not limited to small zodiacs and 7-m 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.
4. 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.
5. 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.

   Divers and personnel in support boats would monitor for marine mammals out to the 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 detonation either injured or exhibiting signs of distress will be reported to via Navy operational chain of command to Navy environmental representatives from 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.

Mitigation For ELCAS Training At SSTC

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 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 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.
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 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 Chapter 6.

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 seaward of the VSW detonation locations. Beyond the VSW but within SSTC, the mitigation area is radius **700** 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 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 (Chapter 13) will be reported annually to NMFS' Office of Protected Resources.

12 MINIMIZATION OF ADVERSE EFFECTS ON SUBSISTENCE USE

Based on the discussions in Chapter 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

The Silver Strand Training Complex (SSTC) Monitoring Plan, proposed by the Navy as part of this application, is focused on mitigation based monitoring as described in the next section. Broad scale Navy funded monitoring in support of Marine Mammal Protection Act (MMPA) authorization for the Navy's Southern California Range Complex typically has focused on the offshore waters north and west of the SSTC. For parts of three aerial surveys under the SOCAL monitoring in 2011-2012, special flight permission was obtained to survey the vicinity of the SSTC. As anticipated, sightings were limited and included several California sea lions (**Figure 13-1**) and a few unidentified dolphins, although the dolphin sightings were several miles offshore from the normal SSTC training area (**Figure 13-2**).

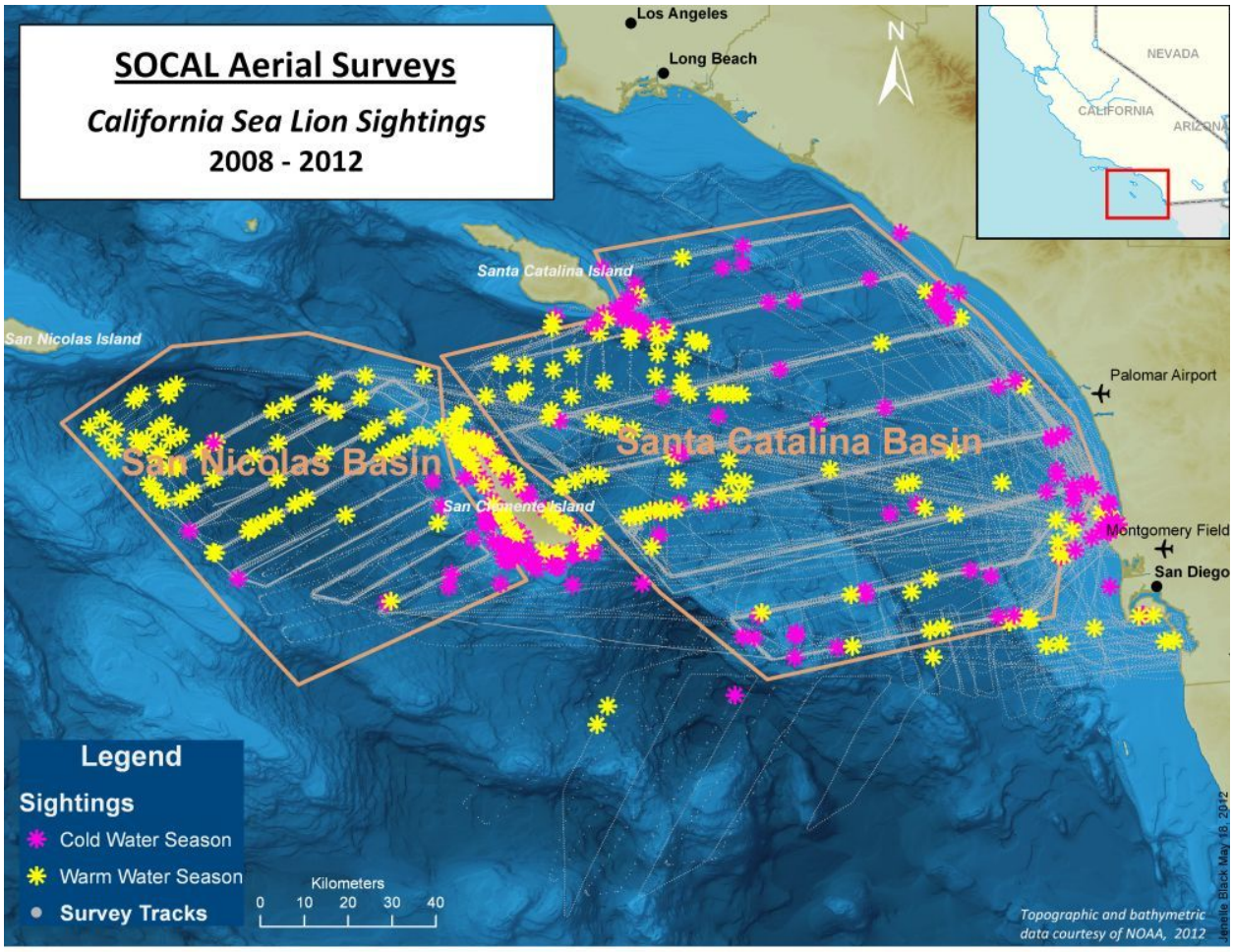

Figure 13-1. California sea lion sightings from Navy-funded aerial surveys in the nearshore and offshore waters of Southern California 2008-2012.

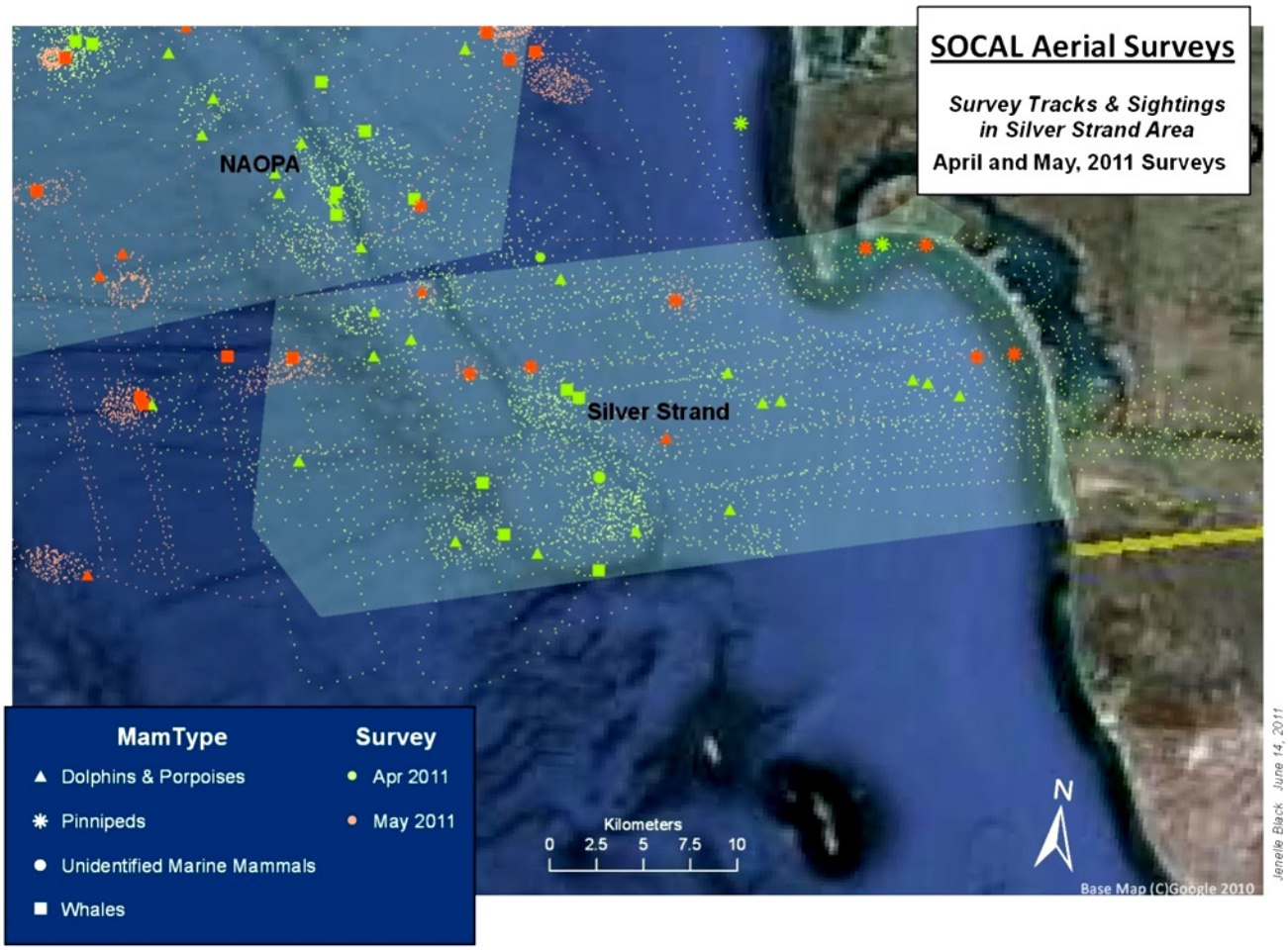

Figure 13-2. Aerial survey tracks and sightings in the Silver Strand area and offshore vicinity in April and May 2011.

As discussed in Chapter 4, Navy funded SSTC compliance monitoring in November 2012 documented sighting of two distributed groups of long-beaked common dolphins within the outer seaward portions of the SSTC over a two day period. More discussion of these sightings and other mitigation monitoring will be provided in the Navy's annual monitoring and mitigation report for SSTC due to NMFS in the summer of 2013.

SSTC Monitoring

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 Chapter 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.

Monitoring methods for the SSTC Year 2 Monitoring Plan (July 2013-July 2014) include:

- Marine Mammal Observers (MMO) at SSTC underwater detonations
- ELCAS underwater propagation monitoring project

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. 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.

To date, two underwater demolition training events have been observed by MMOs during the period from July 2012 through November 2012. Additional MMO mitigation monitoring will be performed in 2013.

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).

SSTC Year 1 Monitoring Objectives

The Navy's proposed monitoring metrics for the SSTC are included in **Table 13-1**.

Table 13-1. Navy's proposed Monitoring Plan for the SSTC.

Monitoring Technique	2013-2014 Implementation	
Marine Mammal Observers (MMO)	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	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	Present results from ongoing, other Navy funded marine mammal research in Southern California (Southern California Range Complex Monitoring Plan) pertinent to SSTC (if applicable)	

Analysis and Reporting

SSTC Monitoring Plan data collection will begin when the SSTC Letter of 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.

14 RESEARCH

In context of Navy activities within the much smaller spatial scale of the Silver Strand Training Complex (SSTC), to date, there has been no significant Navy funded research projects applicable to SSTC. As of this application, the Navy is unaware of other NMFS directed, or academic funded marine mammal research specific to the SSTC boat lanes or immediately adjacent.

The Navy does sponsor a significant portion of research concerning the effects of human-generated sound on marine mammals. 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.

The most current summary of other Navy funded research accomplishments specific to the offshore waters within the Southern California Range Complex is provided in significantly more detail in the Navy's annual Monitoring Report for 2012 (Navy 2012b).

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