Pinniped Monitoring during Missile Launches on San Nicolas Island, California, September 2011 - September 2012

Naval Air Warfare Center Weapons Division
Point Mugu, California

For Submittal To

National Marine Fisheries Service
Silver Spring, Maryland, and Long Beach, California

30 September 2012

Pinniped Monitoring during
Missile Launches on San Nicolas Island, California,
September 2011 - September 2012

by

John Ugoretz[a] and Charles R. Greene, Jr.[b]

[a] **NAVAIR Ranges Sustainability Office**
575 I Avenue, Suite 1, Bldg. 53 A, Code 52F00ME
Point Mugu, CA, 93117

and

[b] **Greeneridge Sciences Inc.**
6160-C Wallace Becknell Rd.
Santa Barbara, CA 93117
In Association with
Epsilon Systems Solutions, Inc.
9242 Lightwave Ave., Suite 100
San Diego, CA 92123-6404

For

National Marine Fisheries Service
Silver Spring, MD
and
Long Beach, CA

30 September 2012

Suggested format for citation:

Ugoretz, J. and C.R. Greene, Jr. 2012. Pinniped Monitoring During Missile Launches on San Nicolas Island, California, September 2011 - September 2012. Naval Air Warfare Center Weapons Division, Point Mugu, CA. 65 p.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACRONYMS AND ABBREVIATIONS

3-D	3-dimensional
ASL	above sea level
ATAR	Autonomous Terrestrial Acoustic Recorder
B807	Building 807
CFR	Code of Federal Regulations
cm	centimeter
CPA	Closest Point of Approach
dB	decibel
dBA	decibel, A-weighted, to emphasize mid-frequencies and to de-emphasize low and high frequencies to which human (and pinniped) ears are less sensitive
F	Fahrenheit
FOV	field of view
ft	feet
FLIR	Forward Looking InfraRed
hr	hour
Hz	Hertz
IHA	Incidental Harassment Authorization
in	inches
kg	kilogram
kHz	kilohertz
km	kilometer (1 km = 3281 ft, 0.62 mi, or 0.54 n.mi)
kts	knots or nautical miles per hour
lb	pounds
LOA	Letter of Authorization
m	meter
mi	mile
min	minute
mm	millimeter
MMPA	Marine Mammal Protection Act
M_{pa}	Frequency weighting appropriate for pinnipeds in air (see Gentry et al. 2004; Southall et al. 2007)
MSST	Multi-Stage Supersonic Target
NAWCWD	Naval Air Warfare Center Weapons Division
nm	nautical miles
NMFS	National Marine Fisheries Service
PTS	Permanent Threshold Shift
rms	root mean square (a type of average)
s	second
SEL	sound exposure level
SEL-A	A-weighted sound exposure level
SEL-M	M_{pa}-weighted sound exposure level
SNI	San Nicolas Island
SPL	sound pressure level
SPL-f	flat-weighted sound pressure level
SSST	Supersonic Sea-Skimming Target
TTS	Temporary Threshold Shift
μPa	micropascal

EXECUTIVE SUMMARY

The Naval Air Warfare Center Weapons Division (NAWCWD) holds a Letter of Authorization (LOA) issued by the National Marine Fisheries Service (NMFS) on 22 November 2011 allowing non-lethal takes of pinnipeds incidental to the Navy's missile launch operations on San Nicolas Island (SNI), California, from 1 December 2011 through 30 November 2012. The LOA was issued pursuant to 50 Code of Federal Regulations (CFR) 216.151–158 and §101(a)(5)(A) of the Marine Mammal Protection Act (MMPA), 16 United States Code (USC) §1371(a)(5)(A). Those regulations were initially issued for the period 2 October 2003 through 2 October 2008 and were reissued for the period 2 June 2009 through 2 June 2014. The regulations and associated LOAs allow for the 'take by harassment' of small numbers of northern elephant seals (*Mirounga angustirostris*), Pacific harbor seals (*Phoca vitulina*), and California sea lions (*Zalophus californianus*) during routine launches on Navy-owned SNI.

In the Navy's Petition for Regulations that led to promulgation of 50 CFR 216.151–158, a Monitoring Plan was proposed. This plan included provisions to monitor any effects of missile launch activities on pinnipeds hauled out at SNI in a manner similar to the preliminary monitoring that took place during 2001–2008. Pinniped species monitored on SNI during that period included the Pacific harbor seal, northern elephant seal, and California sea lion. In June 2010, a revised Monitoring Plan was submitted to NMFS that proposed the discontinuation of monitoring for northern elephant seals, as this species had shown little or no reaction to most missile launches. NMFS accepted this proposed change to the Monitoring Plan (NMFS 2010) and issued the new LOA to acknowledge the change. Thus, no elephant seal responses are discussed in this report.

Missiles Launched – September 2011 to September 2012

This report describes the results of the visual and acoustic monitoring program for missile launches from SNI during the September 2011 to September 2012 time period. It includes results from eleven missile launch events on seven separate days: two single launches on one day in 2011, three dual launches in 2011 and three single launches in 2012. Dual launches consisted of missile launched in rapid succession (e.g., less than 1 minute apart). Missiles launched included the GQM 163A "coyote" (GQM), Medusa MK66 (Medusa), Multi-Stage Supersonic Target (MSST), and Terrier Lynx. Two Terrier-Lynx missiles were launched during nighttime hours and all others missiles were launched in the daytime.

The launch azimuths caused the missiles to cross the SNI shoreline on the island's western end and pass over or near various pinniped haul-outs. Monitoring sites were established at beaches occupied by pinnipeds and Autonomous Terrestrial Acoustic Recorders (ATARs) and video systems were deployed. Audio recordings were obtained to document launch sounds at several distances from the launch trajectories of the missiles. The video and visual monitoring provided data on the behavioral reactions of pinnipeds hauled out during launches.

Pinniped Behavior during Missile Launches

Behavior of pinnipeds (California sea lions and Pacific harbor seals) hauled out on SNI beaches during missile launches was monitored by unattended video cameras which were set up before each launch. The video data were supplemented by direct visual scans of the haul-out groups several hours prior to the launches and following the launches. Monitoring was attempted at up to three sites during each launch, with launch-to-launch variation in the locations monitored and number of locations depending upon presence of hauled out pinnipeds. For each launch, the number, proportion, and (where determinable) maturity of the individual pinnipeds that responded in various ways were tabulated from the video, along with comparable data for those that did not respond overtly. No evidence of injury, mortality, pup abandonment, or other significant impact beyond movement was observed during or immediately succeeding any launches for the monitored pinniped species.

Estimated Numbers of Pinnipeds Affected

Approximately 902 California sea lions, 19 Pacific harbor seals, and no northern elephant seals were estimated to have been affected during the monitoring period. These figures are approximate and may over- or underestimate pinnipeds affected because they; (a) include extrapolations for pinnipeds on beaches that were not monitored on any given launch day, (b) very likely count some of the same individuals more than once, and (c) also exclude pinnipeds on some beaches that were not monitored. The pinnipeds included in these estimates either left the haul-out site in response to the launch, or exhibited prolonged movement or behavioral changes relative to their behavior immediately prior to the launch.

The results from the 2011–2012 monitoring period (and those from previous monitoring periods) suggest that any effects of the launch operations were minor, short-term, and localized, at least for northern elephant seals and California sea lions. Some Pacific harbor seals may have left their haul-out site until the following low tide, but numbers occupying haul-out sites shortly after a launch or the next day, were generally similar to pre-launch levels. It is not likely that any of the pinnipeds on SNI were adversely impacted by such behavioral reactions. While sound levels for two launches were slightly over that which might cause temporary threshold shift (TTS), launch sounds near the pinniped haul outs were below the range that could cause TTS or permanent hearing damage. In the unlikely event that any pinnipeds did incur temporary TTS during launches at SNI, this would have presumably been mild and recoverable.

1. MONITORING PROGRAM AND MISSILE LAUNCHES DESCRIBED

1.1 Monitoring Program

San Nicolas Island (SNI) is located approximately 65 miles (m) (~100 kilometers (km)) from the mainland coast of southern California (Fig. 1.1). Missiles are launched from one of two land-based launch complexes on the western part of SNI: Building 807 Launch Complex (B807) is located on the west coast of SNI, approximately 35 feet (11 meters (m)) above sea level (ASL), and the Alpha Launch Complex is located approximately 625 feet (190.5 m) ASL on the west-central part of SNI (Fig. 1.2). The missiles pass over or near pinniped haul-out sites located around the periphery of SNI. The pinniped species that commonly occur on SNI include northern elephant seals (*Mirounga angustirostris*), Pacific harbor seals (*Phoca vitulina*), and California sea lions (*Zalophus californianus*).

The Naval Air Warfare Center Weapons Division (NAWCWD) holds a Letter of Authorization (LOA) issued by the National Marine Fisheries Service (NMFS) on 22 November 2011 allowing non-lethal takes of pinnipeds incidental to the Navy's missile launch operations on San Nicolas Island (SNI), California, from 1 December 2011 through 30 November 2012. The LOA was issued pursuant to 50 Code of Federal Regulations (CFR) 216.151–158 and §101(a)(5)(A) of the Marine Mammal Protection Act (MMPA), 16 United States Code (USC) §1371(a)(5)(A). Those regulations were initially issued for the period 2 October 2003 through 2 October 2008 and were reissued for the period 2 June 2009 through 2 June 2014. The regulations and associated LOAs allow for the 'take by harassment' of small numbers of northern elephant seals, Pacific harbor seals, and California sea lions during routine launches on Navy-owned SNI.

Previously, separate LOAs were issued for this purpose for the periods October 2003 to October 2004, October 2004 to October 2005, February 2006 to February 2007, February 2007 to February 2008, February to October 2008, June 2009 to June 2010, June 2010 to June 2011 (later superseded by a December 2010 to November 2011 LOA). No launches took place during the February to October 2008 LOA period or during two intervals between expiry of one LOA and issuance of another (8 October 2005 to 2 February 2006 and 3 October 2008 through 3 June 2009).

A Monitoring Plan was proposed in the Petition for Regulations under which the December 2011 – November 2012 LOA was issued. The purpose of the monitoring was to characterize any effects of missile launch activities on Pacific harbor seals, northern elephant seals, and California sea lions hauled out at SNI. In June 2010, a revised Monitoring Plan was submitted to NMFS that proposed the discontinuation of monitoring for northern elephant seals, as this species had shown little reaction to most missile launches at SNI. NMFS accepted this proposed change to the Monitoring Plan (NMFS 2010); thus, elephant seals were not targeted for monitoring during the current report period, but occurred in the field of view (FOV) of some cameras monitoring other species.

The monitoring plan requires that, for each missile launched from SNI, simultaneous autonomous audio recording of launch sounds and video recording of sea lion and harbor seal behavior will occur. Generally monitoring will occur at three sites during each launch, dependent upon the presence of pinnipeds in various locations. This land-based monitoring will provide data required to characterize the extent and nature of "taking". In particular, it will provide the information needed to document the nature, frequency, occurrence, and duration of any changes in sea lion and harbor seal behavior resulting from missile launches, including the occurrence of stampedes (if any). These video and audio records will be used to further document sea lion and harbor seal responses to the launches. This will include the following components:

- Identify and document any change in behavior or movement that may occur at the time of the launch;
- Compare pre- and post-launch behavioral data on each launch day to quantify the interval required for pinniped numbers and behavior to return to normal[1] if there is a change as a result of launch activities;
- Compare received levels of launch sound with pinniped responses, based on acoustic and behavioral data from up to three monitoring sites at different distances from the launch site and flightline during each launch; from the data accumulated across a series of previous and future launches, establish the "dose-response" relationship[2] for launch sounds under different launch conditions;
- Ascertain periods or launch conditions when pinnipeds are most and least responsive to launch activities, and
- Document take by harassment and, although unlikely, any mortality or injury.

This report describes the results of the visual and associated acoustic monitoring program during the period between September 2011 and September 2012. During that period, eleven missile launch events on seven separate days: two single launches on one day in 2011 (7 December), three dual launches in 2011 (29 September, 03 November, and 16 December) and three single launches in 2012 (11 and 27 March and 12 June). Dual launches consisted of missile launched in rapid succession (e.g., less than 1 minute apart).

This report describes the missiles and their launch processes, the associated monitoring program, and the monitoring program results. The report includes four chapters: (1) background, introduction, and description of the Navy's missile launches [this chapter]; (2) acoustical monitoring during the missile launches [Chapter 2]; (3) visual monitoring of pinnipeds during those launches [Chapter 3]; and (4) estimated numbers of pinnipeds affected by the missile sounds during these launches [Chapter 4].

1.1.1 Acoustical Monitoring of Missile Launches

Audio recordings were attempted to document launch sounds at several distances from the launch trajectories of the missiles (See Chapter 2 for details). During most launches, audio recorders were placed near video cameras and recorders that were documenting pinniped reactions, thus obtaining paired acoustic and pinniped-response data. In addition to recording launch sounds, these audio recordings also documented the ambient noise levels to which the pinnipeds were exposed prior to and following launches. Objectives of the audio monitoring program included:

1. Documenting the levels and characteristics of launch sounds at several distances from the azimuths of the missiles;
2. Documenting the levels and characteristics of ambient sounds at the same locations as for the launch sounds, as a measure of the background noise against which the pinnipeds will (or will not) detect the launch sounds; and
3. Determining whether the sound levels from missile overflights were high enough to have the potential to induce Temporary Threshold Shift (TTS) in pinnipeds exposed to launch sounds.

---

[1] If numbers and/or behavior have not returned to "normal" within the duration of the autonomous recording, the duration of the period with reduced numbers will be reported as "greater than *x* minutes".

[2] This is equivalent to estimating behavioral zones of influence by comparing pinnipeds' reactions to varying received levels of launch sounds.

1.1.2 Visual Monitoring of Pinnipeds during Missile Launches

Video and visual monitoring provide data on focal groups of pinnipeds hauled out on SNI during launches (See Chapter 2 for details). The accumulation of such data across numerous launches helps provide data required to characterize the extent and nature of disturbance effects. In particular, it provides the information needed to document the nature, frequency, occurrence, and duration of any changes in pinniped behavior resulting from the missile launches, including the occurrence of stampedes from haul-out sites if they occur. A detailed description of the methods for the visual monitoring can be found in Section 3.2 of Chapter 3.

The video records were to be used to document pinniped responses to the launches. The objectives included the following:

1. Identify and document any change in behavior or movements that occurred at the time of the launch;
2. Quantify the interval required for pinniped numbers and behavior to return to normal if there was a change as a result of launch activities;
3. Compare received levels of launch sound with pinniped responses, based on acoustic and behavioral data from monitoring sites at different distances from the launch site and flightline during each launch; from the data accumulated across a series of launches, establish the "dose-response" relationship[3] for missile sounds under different launch conditions[4];
4. Ascertain periods or launch conditions when pinnipeds are most and least responsive to launch activities[4], and
5. Document numbers of pinnipeds affected by missile launches and, although unlikely, any mortality or injury.

1.2 Estimating Numbers of Pinnipeds Affected

The monitoring program for the missile launches on SNI was designed, in part, to provide the data needed to estimate the numbers of pinnipeds affected by the launches and the manner in which they were affected. Pinnipeds are assumed to be 'taken by harassment' if there is a reason to believe that auditory impairment (TTS) might have occurred as a result of a launch, or if biologically significant behavioral patterns of pinnipeds are disrupted. NMFS (2000) defined a biologically significant behavioral response as one "…that affects biologically important behavior[s], such as survival, breeding, feeding and migration, which have the potential to affect the reproductive success of the animal". As a corollary of that, NMFS (2002) stated that "…one or more pinnipeds blinking its eyes, lifting or turning its head, or moving a few feet along the beach as a result of a human activity are not considered a 'take' under the MMPA definition of harassment".

In this report, consistent with previous related reports, it is assumed that only those animals that met the following criteria would be counted as affected by launches:

---

[3] This is equivalent to estimating behavioral zones of influence by comparing pinnipeds' reactions to varying received levels of launch sounds.

[4] Determination of the dose-response relationship (objective 3, above) and conditions when pinnipeds were most or least responsive to launch sounds (objective 4) requires consideration of additional data, including data from the previous years of monitoring (Holst et al. 2008) and data from planned future monitoring. Therefore, objectives (3) and (4) are not addressed in the present report. However, an analysis using data from all previous monitoring years can be found in Holst et al. (2008).

1. Pinnipeds that were injured or killed during launches, if any (e.g., by stampedes);
2. Pinnipeds exposed to launch sounds strong enough to cause permanent or temporary auditory impairment (permanent threshold shift [PTS] or TTS);
3. Pinnipeds that left the haul-out site, or exhibited prolonged movement or behavioral changes (such as pups separated from mothers) relative to their behavior immediately prior to the launch.

In practice, no pinnipeds are known to have been injured or killed during launches monitored since August 2001, and few are believed to have received sounds strong enough to elicit TTS (Holst et al. 2008). Thus, the number of pinnipeds counted as potentially affected during the current monitoring period was primarily based on criterion 3 above - the number that left the haul-out site, or exhibited prolonged movement or other behavioral changes.

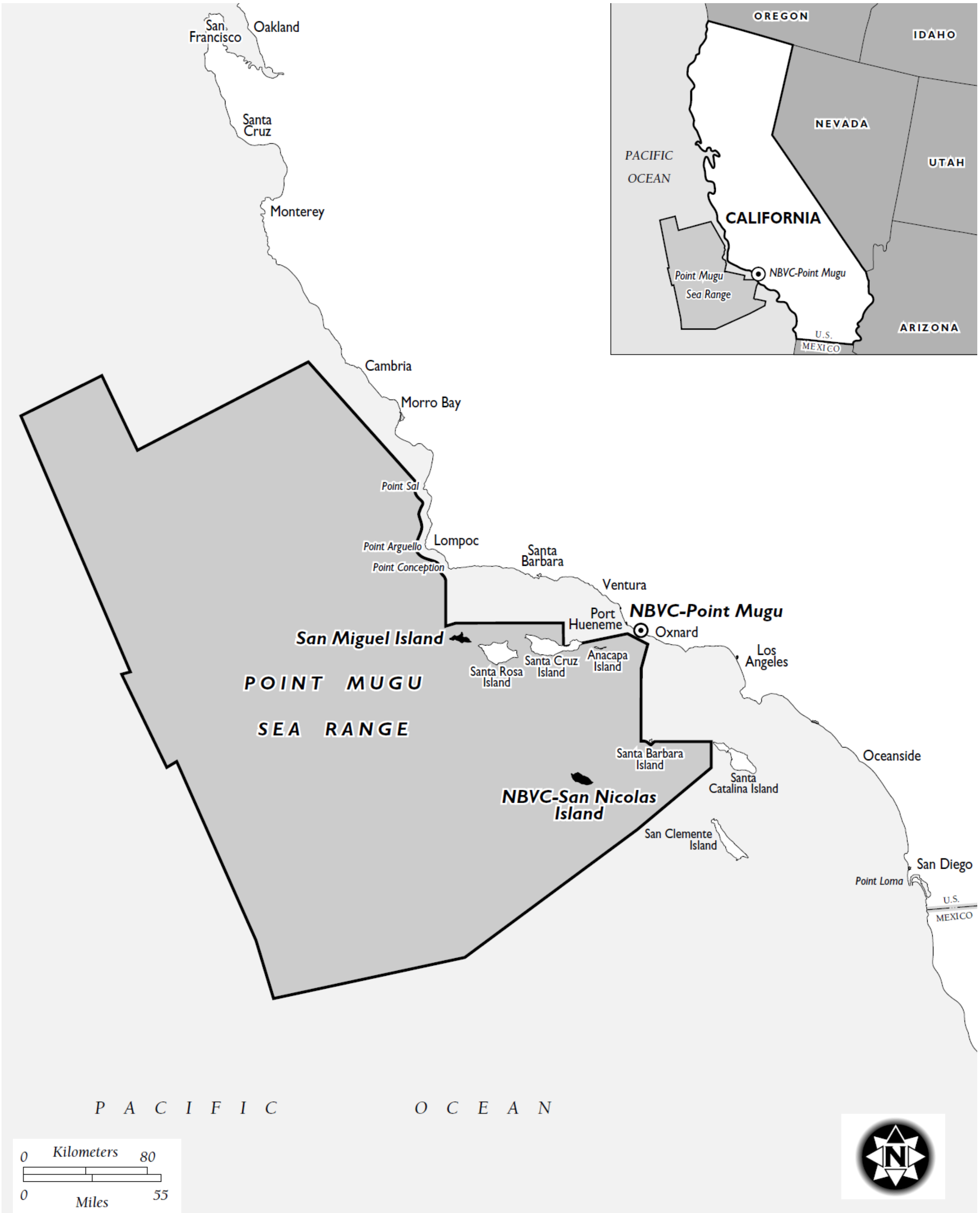


FIGURE 1.1. Regional site map of the Point Mugu Sea Range and San Nicolas Island, California (map by TEC, Inc.).

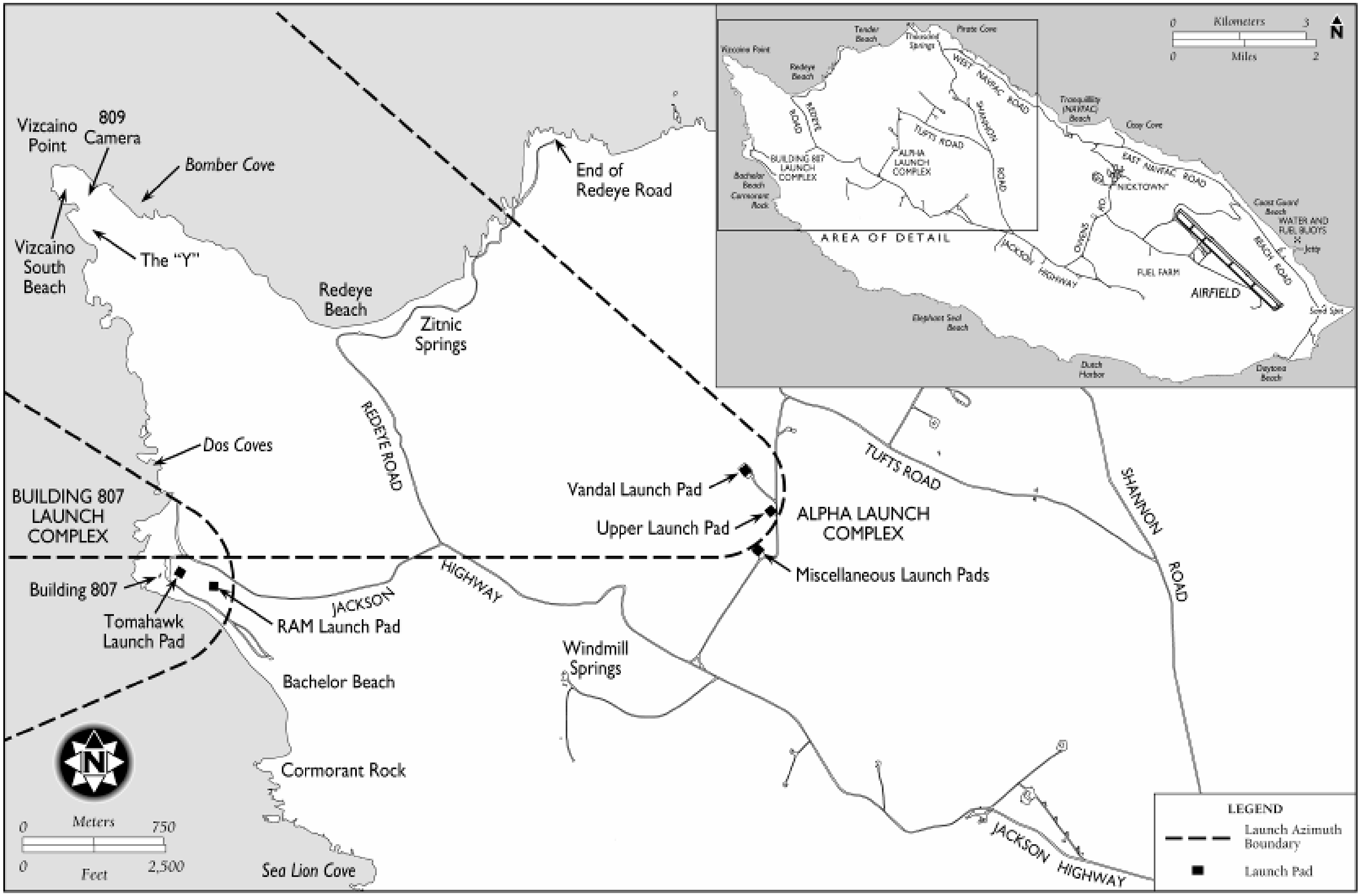


FIGURE 1.2. Map of San Nicolas Island, California, showing the Alpha Launch Complex, B807 Launch Complex, and the names of adjacent beaches on which pinnipeds are known to haul out. Also shown are the anticipated launch azimuths (dashed lines) for each launch complex. These launch azimuths are typical, although occasionally launch paths could pass outside these boundaries.

1.3 Missile Types Launched During the Monitoring Period

GQM-163A "Coyote" Supersonic Sea-Skimming Target

The Navy/Orbital Sciences Corp. GQM-163A "Coyote" (GQM) missile is an expendable target powered by a ducted-rocket ramjet. It is capable of flying at low altitudes (13 ft or 4 m cruise altitude) and supersonic speeds (Mach 2.5) over a flight range of 45 nautical miles (nm, 83 km) (Fig. 1.3). This missile is designed to provide a ground launched aerial target system to simulate a supersonic, sea-skimming Anti-Ship Cruise Missile (ASCM) threat. The GQM was developed to replace the Vandal missile target.

The GQM missile assembly consists of two primary subsystems: MK 12 or MK 70 solid propellant booster, and the GQM-163A target missile. The solid-rocket booster is about 18 inches (in) (46 centimeters [cm]) in diameter and is of the type used to launch the Navy's Standard surface-to-air missile. The GQM-163A target missile is 18 ft (5.5 m) long and 14 in (36 cm) in diameter, exclusive of its air intakes. It consists of a solid-fuel Ducted Rocket (DR) ramjet subsystem, Control and Fairing Sub-assemblies, and the Front End Subsystem (FES). Included in the FES is an explosive destruct system to terminate flight if required.

Medusa MK66

The Medusa is essentially a Hydra 70 MK66 rocket. The Hydra 70 is a Wrap-Around Fin Aerial Rocket with an Mk 66 motor. It weighs 13.6 lb (6.2 kg), is 41.7 in (1.06 m) long, with a diameter of 2.75 in (70 mm). It has an effective range of 5 miles (mi) (8 km) and a maximum range of 6.5 mi (10.5 km).

Multistage Sea Skimming Target (MSST)

The MSST is an anti-ship missile. It is a subsonic cruise missile with a supersonic terminal stage that approaches its target at low-level at Mach 2.8. It consists of a subsonic winged "cruise bus", which releases a supersonic "sprint vehicle" for terminal approach. The "sprint vehicle" is based on the GQM target missile.

Terrier-Lynx

The Terrier-Lynx is a two-stage, unguided, fin-stabilized, solid propellant rocket system designed to provide a realistic simulation of a medium-range ballistic missile. The first stage consists of the Terrier Mark 70 booster (body diameter of 45.7 centimeters [cm]), and the second stage consists of the Lynx rocket. The Lynx is 36 cm in diameter and 2.8 m long. The Terrier-Lynx vehicle has an overall length of ~9 m and a total weight at lift off of ~1270 kilograms [kg].

1.4 Launch Dates and Information

Between September 2011 and September 2012 there were 11 launches from SNI on 7 separate days (Table 1.1). The temperature during launches ranged from 53° to 62° Fahrenheit (F) at the control room, with winds between 4 and 20 knots (kts) (Table 1.1).

GQM-163A

Daytime launches of two separate GQM missiles occurred on December 7, 2011. These launches were separated by more than three hours and thus not considered to be a dual launch. Daytime launches of dual GQM missiles occurred on September 29 and December 16, 2011. The dual launches consisted of two missiles that were launched within seconds of each other. Each missile launched is included in the total above, but pinniped reactions to dual launches are analyzed as a single launch event. This is because the reaction to one of the missiles cannot be separated from the other and overall reactions tend to increase with the second missile launched. The GQMs were launched from the Alpha Launch Complex located 625 feet (190.5 m) ASL on the west-central part of SNI. The GQMs were all launched at an elevation angle of 14º above horizontal and crossed the west end of SNI at an altitude of approximately 1,700 feet (518 m). Elevation angle does not necessarily translate to a straight line for altitude change, as missiles may actively alter the rate of climb achieving a higher than expected altitude for a given distance from the launcher.

Medusa MK66

Dual Medusa MK66 missiles were launched during daytime hours on November 3, 2011. The Medusas were launched from the Alpha Launch Complex located 625 feet (190.5 m) ASL on the west-central part of SNI. The Medusa MK66 was launched at an elevation angle of 2º and crossed the shoreline at approximately 1,200 feet (365 m).

Multistage Sea Skimming Target (MSST)

A daytime launch of a single Multi-Stage Supersonic Target (MSST) missile occurred on June 12, 2012. The MSST was launched from the Alpha Launch Complex located 625 feet (190.5 m) ASL on the west-central part of SNI. The MSST was launched at an elevation angle of 20º and crossed the shoreline at an altitude of approximately 1,800 feet (548 m).

Terrier-Lynx

Single launches of Terrier-Lynx missiles occurred during nighttime hours on March 11, 2012 and March 28, 2012. The Terrier-Lynx missiles were launched at the Building 807 Launch Complex (B807) located on the west coast of SNI, 33 feet (11 meters (m)) above sea level (ASL). The Terrier-Lynx missiles were launched at an elevation angle of approximately 84º and crossed the shoreline at an altitude of approximately 1,500 feet (457 m).

TABLE 1.1. Launch data for the September 2011 – September 2012 report period.

Launch Date	Launch Time (local)	Missile Type	Launch Complex	Launch Azimuth (true)	Elevation Angle / Altitude Over Beach (Feet)	Weather at Control Room (Wind speed in knots)[1]	Video Quality	Audio Quality
9/29/2011	11:30	Dual GQM	Alpha	270°	14° / 3,000	N/A	Good	Good
11/3/2011	12:53	Dual Medusa MK66	Alpha	345°	2° / 1,200	10 kts SSE / 62° F	Unusable*	Good
12/7/2011	09:38	GQM	Alpha	291°	14° / 1,750	8 kts N / 56° F	Good	Good
12/7/2011	12:46	GQM	Alpha	335°	14° / 1,750	8 kts N / 56° F	Good	Good
12/16/11	17:50	Dual GQM	Alpha	335°	14° / 1,750	14 kts N / 59° F	Good	Good
3/11/2012	05:56	Terrier-Lynx	B807	260°	83° / 1,500	20 kts NW / 53° F	Good	Good
3/28/2012	02:33	Terrier-Lynx	B807	258°	84° / 1,500	4 kts WSW / 55° F	OK^	Good
6/12/2012	14:45	MSST	Alpha	250°	20° / 1,800	8 kts WNW / 60° F	OK^	Good

[1] The weather data were collected at the launch control room located between 2 and 5 kilometers from the missiles' closest point of approach to the shoreline; therefore weather conditions at pinniped haul-out sites near the closest point of approach may have differed.
N/A = not available.
* Two of two cameras failed due to battery issues.
^ Two of three cameras failed on 28 March and one of three on 12 June.

Based on a review of the literature (Lawson et al. 1998) completed prior to the start of monitoring, it was evident that the sound levels that might cause notable disturbance for each pinniped species are variable and context-dependent. Lawson et al. (1998) estimated the minimum received level, on an A-weighted Sound Exposure Level (SEL-A) basis, that might elicit substantial disturbance as 100 A-weighted decibels (dBA) reference 20 micropascals squared second (re 20 $\mu Pa^2 \cdot s$) for all pinnipeds. The 100 dBA re 20 $\mu Pa^2 \cdot s$ SEL pertains to exposures to prolonged sounds, which were taken to last at least several seconds. It is arguable how many of the launch sounds should be considered to be “prolonged” from the perspective of a pinniped at a fixed location on a beach. Measured durations of sound from various types of missiles launched from SNI typically range from much less than 1 s up to 21 s (Holst et al. 2008). In any event, the assumption that reactions might occur at distances up to those where received levels diminished to 100 dBA SEL (see Fig. 2.39 *in* Greene and Malme 2002) was one factor in selecting acoustic (and video) monitoring sites during the first year of monitoring in 2001. Sites at distances up to ~4 km from the launcher and/or launch trajectory are monitored, though closer sites selected when animals are present.

After reviewing video recordings of pinnipeds during launches at SNI during 2001–2002 (Holst and Lawson 2002), the 100-dBA SEL still seemed reasonable as a minimum received level that might elicit disturbance of California sea lions. However, 90 dBA SEL seemed more appropriate for Pacific harbor seals, as they showed a strong response to most launches, including a number of launches where received levels were <100 dBA SEL. In contrast, the majority of northern elephant seals usually exhibited little or no reaction to launch sounds. The received levels of sounds from the larger missiles, as measured in the first year of monitoring, indicated that levels at or above 90 dBA SEL could be expected out to distances of ~4 km from the launch trajectory (see Fig. 2.39 *in* Greene and Malme 2002). Thus, monitoring at sites located ~4 km from the launcher and/or launch trajectory continued during subsequent years. Continuing monitoring work has shown that some behavioral responses may extend to received sound levels lower than 90 dBA SEL.

Southall et al. (2007) note that M_{pa}-weighted (i.e., frequency-weighted appropriately for pinnipeds in air) SELs of 100 dB re 20 $\mu Pa^2 \cdot s$ could result in takes by harassment for pinniped species (M-weighted values are greater than A-weighted SELs for launch sounds; see Chapter 2). Previous monitoring at SNI has shown that California sea lions and Pacific harbor seals typically move along the beach and/or enter the water at M_{pa}-weighted SELs ≥100 dB re 20 $\mu Pa^2 \cdot s$. In fact, both species can be disturbed at lower levels. For example, Holst et al. (2008) noted that some Pacific harbor seals leave the haul out site and/or enter the water at SELs as low as 60 dB M_{pa}.

2. ACOUSTICAL MEASUREMENTS OF MISSILE LAUNCHES

2.1 Introduction

The acoustic measurement program for the monitoring period was consistent in approach and methodology with that used during the preceding years (Holst et al. 2008). Recordings of each missile's sound, as well as background sounds, were attempted at up to four sites during each missile flight. Autonomous Terrestrial Acoustic Recorders (ATARs), described below, were developed for this purpose by the Navy's acoustical contractor, Greeneridge Sciences Inc. (Greeneridge) of Santa Barbara, California. Maps of the launch azimuths and monitoring locations can be found in Chapter 3 (Fig. 3.1). Nineteen recordings were obtained during the monitoring period (Table 2.1).

2.2 Field Methods

2.2.1 Deployment of ATARs

Prior to each launch, ATARs were positioned at the launch pad and near pinniped haul out sites at varying distances from the planned launch azimuth, specifically at locations where pinniped responses were monitored (see Chapter 3). The recordings were planned to be suitable for quantitative analysis of the levels and characteristics of the received flight sounds. In addition to providing information on the magnitude, characteristics, and duration of sounds to which pinnipeds were exposed, these acoustic data and associated pinniped behavioral data will contribute to a longer-term dataset, analysis of which is intended to determine if there is a "dose-response" relationship between received sound levels and pinniped behavioral reactions (Holst, et al., in prep.).

Measured sound levels at various microphone locations can be used to characterize sound exposure vs. distance downrange and laterally from the launch azimuth. Analyses of this type for acoustic data collected for the period August 2001 through March 2008 were reported by Holst et al. (2008). In those analyses, factors that were considered included missile type, launch azimuth, launch characteristics (e.g., low- vs. high-angle launch), as well as weather, which is expected to have important effects on the received sounds. Given the limited number of launches during the monitoring period, no corresponding analysis of acoustic data has been done for these launches.

ATARs were set up at the recording locations up to several hours prior to the launch and were retrieved following the launch. The ATAR units were deployed by Navy biologists at sites as close as practical to as many as three pinniped haul-out sites at various distances from the launch site and launch trajectory. Total number of sites monitored depended upon the presence of pinnipeds on beaches in the potentially impacted area. Over the entire monitoring period (since August 2001), the Navy has distributed the ATARs such that, for types of missiles that are commonly launched at SNI, recordings have been made at a variety of different distances and locations relative to the flight trajectories and the launch pad.

TABLE 2.1. Missile launches and ATAR recording sites (also see Fig. 3.1).

Launch Date	Missile	Elevation Angle (º)	ATAR Locations	Recording Status
9/29/2011	Dual GQM	14	Alpha Pad, Phoca Reef, Dos Coves	3 OK
11/3/2011	Dual Medusa	2	Alpha Pad, Dos Coves	2 OK
12/7/2011	GQM	14	Alpha Pad, Dos Coves	2 OK
12/16/2011	Dual GQM	14	Alpha Pad, Dos Coves	2 OK
3/11/2012	Terrier-Lynx	83	B807^, Dos Coves, Pirates Cove, West Balloon	4 OK
3/28/2012	Terrier-Lynx	84	B807^, Dos Coves, West Balloon*	3 OK
6/12/2012	MSST	20	Alpha Pad, Dos Coves*, Phoca Reef	3 OK

* Launch event not above ambient sounds at monitoring location.
^ Measured sounds exceeded level where TTS may occur (129 dB re 20 $\mu Pa^2 \cdot s$ SEL-M) by ~1.5 dB.

2.2.2 ATAR Design

The ATARs are designed to record continuously and unattended for up to 13 hours (hr). It is necessary to use autonomous extended-duration recorders because safety considerations require placement of ATAR units at monitoring sites up to several hours prior to the launch. The extended recording capabilities of the ATAR units, as compared with digital audio tape (DAT) recording units used previously (e.g., Greene 1999), allow for recordings of flight sounds even when prolonged launch delays occur.

The ATARs record both high-level sounds (e.g., from missile launches) and normal background sounds. The ATARs record two sensor channels, each with a bandwidth of 3 to 20,000 Hertz (Hz). The principal components of an ATAR are two calibrated dissimilar microphones, two adjustable gain amplifiers (signal conditioners), and a Sound Devices 702 recorder which digitizes and records sound samples. In 2009, the Sound Devices 702 recorder replaced the notebook computer that was used to store the digital audio data previously. Figure 2.1 is a block diagram of an ATAR illustrating the types and arrangement of components.

Each ATAR includes two microphones that differ in sensitivity. One microphone is a PCB 106B50 quartz microphone (PCB Piezotronics Inc., Depew, NY). These relatively insensitive microphones, with sensitivity –202 dB re 1 volt per micropascal (V/μPa), were designed for transduction of strong signals with received sound levels up to 185 dB re 20 μPa. To record ambient sounds concurrently, each ATAR includes a more sensitive microphone, the TMS 130P10 (–157 dB re 1 V/μPa). This, in conjunction with the PCB 106B50, provides additional dynamic range. Each microphone signal is sampled at 44.1 kilohertz (kHz) and digitized to a 16-bit two-byte integer.

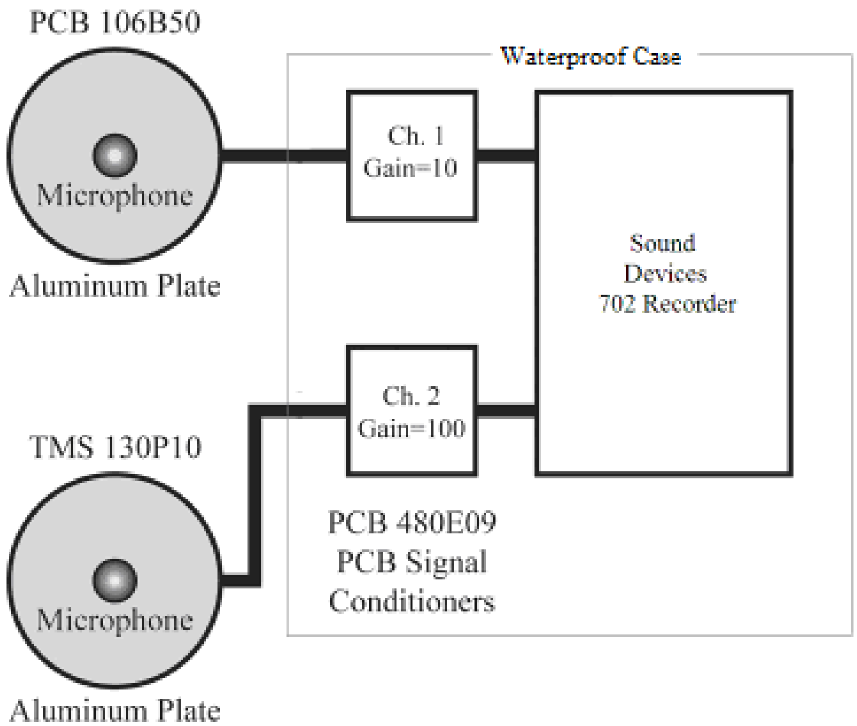


FIGURE 2.1. Block diagram of an Autonomous Terrestrial Acoustic Recorder (ATAR).

Each microphone requires a PCB model 480E09 signal conditioner. These low-noise amplifiers apply the microphone polarizing voltage. The signal conditioners have gain selections of 1, 10, and 100 (corresponding, respectively, to 0, 20, and 40 dB). The ATAR assemblies are carried in backpacks for set up at the recording sites.

The microphones are placed in hemispherical windscreens and positioned 2 - 3 millimeters (mm) from the flat side of the hemisphere. Each windscreen is affixed to the center of an aluminum base plate 6 mm thick and 56 cm in diameter. The purpose of the aluminum base plates is to provide a hard reflecting surface for high-frequency sounds. The ground itself is acoustically reflective at low frequencies. The combination of the base plates and the ground assures that the microphones sense the combined direct and reflected sound, as would an animal whose ears are near the ground (Greene 1999). The two base plates are set on the ground in an area generally free of vegetation.

2.3 Audio and Data Analysis Methods

Both time-series and frequency-domain analyses are performed on the acoustic data. Time-series results included signal waveform and duration, peak pressure level (peak), root mean square (rms) sound pressure level (SPL), and SEL. SPL and SEL were determined with three alternative frequency weightings: flat-weighted (SPL-f and SEL-f), A-weighted (SPL-A and SEL-A), and M_{pa}-weighted (SPL-M and SEL-M) basis. The M_{pa}-weighting procedure, appropriate for pinnipeds in air, is described in Southall et al. (2007) and in §2.3.3 below. Frequency-domain results included estimation of SPLs in one-third octave bands for center frequencies from 4 to 16,000 kHz. The following subsections describe how these values are defined and calculated.

2.3.1 Time-Series Analysis

The change in June 2009 from notebook computers to the Sound Devices 702 recorder resulted in a higher sensitivity at very low (<3 Hz) frequencies. Energy at such low frequencies has been noted in recordings near the launch site since 2009, providing much higher band levels of sound at the launcher than had been seen during recordings with the original ATARs. The band of interest has been 3–20,000 Hz. For the current data, a high pass filter with its breakpoint at 3 Hz has been used to suppress the lower frequency energy in the analyzed results. With this filter, the higher levels at the launcher are not manifest. Ignition at launch may result in an explosive type of sound not present during any other phase of flight, especially not over the pinniped haul-out sites. The explosive sound is manifest at the lowest frequencies, and the high pass filter has eliminated them without a significant change in the measured levels at the other receiving stations. To assure the quality and comparability of results among monitoring periods, all missile flight data recorded after the ATARs were changed in 2009 has been processed with the 3-Hz high pass filter.

All missile launch sound analyses require identification of a signal's beginning and end. This identification can be complicated by background noise (whether instrumental or ambient), poorly-defined signal onsets, and gradually diminishing signal "tails". To obtain a consistent measure of signal duration for each flight, we first defined a "net energy" E. This measure of energy in excess of background was calculated as the cumulative signal energy above mean background energy:

$$E = \frac{1}{fs}\sum_{i=1}^{N} (x_i^2 - \langle n^2 \rangle)\ \text{Pa}^2\ \text{s}$$

where x represents all data points in an event file, n represents only background noise data points before the flight sound, N is the total number of samples in the event file, and f_s is the sampling rate.

Based on this consistent definition of net energy E, the beginning and end of a flight sound is defined as the times associated with the accumulation of 5% and 95% of E.

Duration is defined as the difference between these start and end times.

Sound exposure is defined as 90% of E, representing total sound exposure in units of $\text{Pa}^2 \cdot \text{s}$. **SEL** was determined from $10 \cdot \log$ (sound exposure).

Sound pressure is defined as the square root of the sound exposure divided by the duration. Sound pressure is equivalent to the rms value of the signal, less background noise, over the duration. **SPL** was determined from $20 \cdot \log$ (sound pressure).

Peak instantaneous pressure is defined as the largest sound pressure magnitude (positive or negative) exhibited by the signal, even if the signal reached that level only momentarily.

Peak instantaneous pressure level is determined from 20 log (peak instantaneous pressure).

2.3.2 Frequency-Domain Analysis

Frequency-domain analysis was used to estimate how signal power was distributed in frequency. Flat-weighting was used for all frequency-domain analysis. Welch's (1967) "Weighted Overlapped Segment Averaging" (WOSA) method was used to generate representative power spectral densities in each case. Power spectral densities were calculated for the signal and pre-signal background noise on the low-sensitivity channel and for background noise on the high-sensitivity channel. These spectral density values were then summed into one-third octave bands.

For these analyses the "signal" is defined as consisting of the recorded data (missile signal plus background noise). This time series was segmented according to duration (determined from the broadband time series analysis) as follows:

- For duration > 1 s, use 32,768-sample blocks of total length 0.74 s with Blackman-Harris (Harris 1978) minimum three-term window, overlapped by 50%. This results in frequency cells spaced by 1.35 Hz and an effective cell width (resolution) of 2.3 Hz.
- For 0.0929 s < duration < 1 s, use 4096-sample blocks of total length 0.0929 s with Blackman-Harris minimum three-term window, overlapped by 50%. This results in frequency cells spaced by 10.77 Hz and an effective cell width (resolution) of 18.3 Hz.
- For duration < 0.0929 s, use the samples spanning the signal duration and apply a uniform window. This results in cell spacing in hertz given by the reciprocal of the record length in seconds. The cell width (resolution) is the same as the cell spacing.

Background noise data recorded on the high sensitivity channel, consisting of 4 s of data selected from before the missile signal, were segmented into 44,100-sample blocks overlapped by 50% and weighted by the Blackman-Harris minimum three-term window. This resulted in 1-Hz cell spacing and 1.7-Hz cell width, or resolution.

The spectral density values were integrated across standard one-third octave band frequencies to obtain summed SPLs for each band. This analysis was performed for the signal, the noise on the signal channel (low sensitivity channel), and the background noise (high sensitivity channel). When the cell spacing was broad, the lowest frequency one-third octave bands could not be computed. However, the cases of broad cell spacing correspond to cases of very short duration signals. Low frequencies are not important for short duration sounds.

2.3.3 Frequency Weighting

Frequency weighting is a form of filtering that serves to measure sounds over a broad frequency band with various schemes for de-emphasizing sounds at frequencies not heard well and retaining sounds at frequencies that animals hear well. The concept is that sound at frequencies not heard by animals is less likely to injure or disturb them, and therefore such sounds should not be included in measurements relevant to those animals. Time-series results for the full 3 to 20,000 Hz bandwidth were calculated for flat-, A-, and M_{pa}-weightings.

Flat-weighting leaves the signal spectrum unchanged. For instantaneous peak pressure, where the highest instantaneous pressure is of interest, it is not useful to diminish the level with filtering, so only the flat-weighted instantaneous peak pressure is relevant. Also, non-uniform weighting is not useful when reporting results for specific frequencies or narrow frequency bands. Therefore, only flat-weighting was used for frequency-domain analyses.

A-weighting shapes the signal's spectrum based on the standard A-weighting curve (Kinsler et al. 1982, p. 280; Richardson et al. 1995, p. 99). This slightly amplifies signal energy at frequencies between 1 and 5 kHz and attenuates signal energy at frequencies outside this band. This process is designed to mimic the frequency response of the human ear to sounds at moderate levels. It is a standard method of presenting data on airborne sounds. The relative sensitivity of pinnipeds listening in air to different frequencies is more-or-less similar to that of humans (Richardson et al. 1995), so A-weighting may, as a first approximation, be relevant to pinnipeds listening to moderate-level sounds.

M_{pa}-weighting arose from the ongoing effort to develop science-based guidelines for regulating sound exposures (Gentry et al. 2004; Southall et al. 2007). During this process, separate weighting functions have been developed for five categories of marine mammals, with these functions being appropriate in relation to the hearing abilities of those groups of mammals (Gentry et al. 2004; Southall et al. 2007). Two of these categories are pinnipeds hearing in water and in air, for which the weighting functions have been designated M_{pw} and M_{pa}, respectively. The five "M-weighting" functions are almost flat between the known or inferred limits of functional hearing for the species in each group, but down-weight ("attenuate") sounds at higher and lower frequencies. As such, they are analogous to the C-weighting function that is often applied in human noise exposure analyses where the concern is about potential effects of high-level sounds. With M_{pa}-weighting, the lower and upper "inflection points" are 75 Hz and 30 kHz[5]. For each launch whose sounds are reported here, we include the M_{pa}-weighted results as well as flat- and A-weighted results. Acoustic data based on M_{pa}-weighting are included because these values are likely to be needed in the future for purposes of assessing impacts on pinnipeds of sounds with high received levels, such as those during some missile overflights.

Measurement data from each launch are presented by one-third octave band in Appendix B. Thus, other weighting methods (e.g., C-weighting or species-specific weighting functions) could be applied to these data in the future if needed.

2.3.4 Closest Point of Approach (CPA) by the Missile

To relate missile sounds to the proximity of the missile's trajectory, the 3-dimensional (3-D) distance from the recording site to the CPA of the missile is calculated for each launch date and sound monitoring site. The CPA can either be the point where the missile crosses the SNI shoreline or at the launch pad, depending upon monitoring location and missile trajectory.

2.4 Results

2.4.1 Missile Flight Sounds

Acoustic monitoring results for all 11 launches are presented in Table 2.2. Four parameters are reported for the missile flight sounds: peak pressure level, SPL, SEL, and duration. The last three parameters are based on flat-, A-, and M_{pa}-weighting. These values are similar to sound levels recorded during previous launches from SNI (Holst et al. 2008). It was to be expected that A- and M_{pa}-weighted levels would be less than flat-weighted levels, consistent with the greater de-emphasis of low frequency components by A-weighting. Generally, sonic boom noise is strong at frequencies below 1000 Hz, which are de-emphasized with A- and (to a lesser degree) M_{pa}-weighting.

Two graphs are presented in Appendix B for each location at which the missile launch sounds were recorded. For each monitored location, both graphs are based on flat-weighted data; no graphs are presented for A- or M_{pa}-weighted waveforms. One graph presents the pressure signature (pressure vs. time waveform). The second presents the SELs by one-third octave band for each of three signals: (1) the missile sounds; (2) the background instrumentation noise from the low-sensitivity channel (the same sensor used to measure the missile sounds but using data recorded before the missile sounds); and (3) the background noise levels from the high-sensitivity channel (i.e., the ambient SPLs). Because the ambient sounds are continuous, expressing them as SELs is unconventional. However, for purposes of comparison

[5] The data obtained during the current monitoring period were only recorded at frequencies up to 20 kHz, so the (probably negligible) energy at 20–30 kHz is not included in calculating the M_{pa} (or other) measures.

with the transient missile sounds, one can consider the SPLs for ambient noise to be the SELs in a 1-s period.

2.4.2 Ambient Noise Levels

Background sounds were recorded on the second channel of each ATAR using a higher sensitivity microphone. As expected, this channel overloaded during the brief time while the missile flight sounds were received, but at other times recorded the background sounds reliably (i.e., at levels above the self-noise [instrumentation noise] of the sensing and recording electronics). The sound levels for the 10–20,000 Hz band were determined using an averaging time of 4.0 s. Flat-, M_{pa}-, and A-weighted ambient noise levels for the missile launches are presented in Table 2.3. The measured A-weighted values were quite low and comparable to sound levels expected in quiet residential areas. Much of the background sound was infrasonic energy in the 10–20 Hz band, probably mainly attributable to wind noise. When the 10–20 Hz components are excluded, broadband levels are typically 10 dB lower than those quoted for the 10–20,000 Hz band.

TABLE 2.2. Pulse parameters for flat-, A-, and M_{pa}-weighted sound from SNI missile launches, September 2011-September 2012.

Launch Date & Monitoring Site	CPA (km)	Flat-weighted sound				A-weighted sound			M_{pa}-weighted sound		
		Pk	SPL	SEL	Dur	SPL	SEL	Dur	SPL	SEL	Dur
Single Launches											
7 December 2011: GQM (1st of 2)											
Dos Coves	1.4	135.6	115.5	114.7	0.8	98.5	97.0	0.7	109.3	104.1	0.3
Near Launcher		137.5	115.8	119.2	2.2	95.6	99.3	2.3	106.0	109.6	2.3
7 December 2011: GQM (2nd of 2)											
Dos Coves	2.9	94.0	81.0	82.3	1.4	64.8	67.4	1.8	76.6	78.3	1.5
Near Launcher		119.4	49.8	117.1	1.7	94.3	97.2	1.9	104.9	108.6	2.3
11 March 2012: Terrier-Lynx											
Dos Coves	0.7	128.0	111.8	117.2	3.5	104.9	110.3	3.5	110.0	115.3	3.4
Pirates Cove	5.1	103.8	85.9	93.3	5.6	72.9	80.5	5.8	83.0	90.5	5.7
West Balloon	5.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Near Launcher		146.3	133.1	132.7	0.9	127.0	133.1	0.9	131.5	130.6	0.8
28 March 2012: Terrier-Lynx											
Dos Coves	0.7	124.0	110.6	116.7	4.0	101.8	107.5	3.8	108.2	113.9	3.8
West Balloon	5.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Near Launcher		145.3	132.1	132.5	1.1	126.3	126.2	1.0	130.6	130.5	1.0
12 June 2012: MSST											
Dos Coves	1.3	93.3	76.5	83.7	5.2	71.2	79.4	6.6	74.7	83.6	7.7
Phoca Reef	2.4	96.1	77.5	85.3	6.0	76.7	79.5	1.9	81.4	83.3	1.5
Near Launcher		130.5	116.1	118.9	19	109.7	111.7	1.6	113.4	118.2	1.9
Dual Launches											
29 September 2011: Dual GQM (first missile)											
Dos Coves Cliff	0.8	142.6	131.2	119.0	0.06	109.2	105.6	0.44	120.9	112.6	0.15
Phoca Reef	2.4	101.8	81.5	87.2	3.71	55.1	60.3	3.34	65.7	71.5	3.84
Near Launcher		135.4	117.4	121.4	2.49	101.1	105.1	2.59	111.2	115.3	2.56
29 September 2011: Dual GQM (second missile 5 s later)											
Dos Coves Cliff	0.8	144.4	134.4	119.8	0.03	111.3	107.6	0.42	120.9	113.4	0.18
Phoca Reef	2.4	101.8	82.6	88.5	3.94	53.9	60.2	4.25	65.9	72.3	4.38
Near Launcher		134.9	115.6	120.3	2.98	99.7	104.7	3.14	109.6	114.3	2.97
3 November 2011: Dual Medusa (first missile)											
Dos Coves	3.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Near Launcher		121.3	101.1	99.9	0.77	77.8	76.7	0.77	96.6	92.4	0.38
3 November 2011: Dual Medusa (second missile)											
Dos Coves	3.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Near Launcher		121.3	100.8	99.7	0.78	78.4	75.5	0.51	95.9	91.4	0.36
3 November 2011: Dual Medusa (live warhead impact ~ 2 km offshore)											
Dos Coves	3.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Near Launcher		96.8	86.6	74.5	0.06	N/A	N/A	N/A	N/A		
16 December 2011: Dual GQM (first missile)											
Dos Coves	0.5	99.4	82.2	89.5	5.4	71.5	78.7	5.3	79.2	86.5	5.4
Near Launcher		141.8	117.1	120.	2.1	96.6	100.5	2.5	107.3	111.0	2.3
16 December 2011: Dual GQM (second missile)											
Dos Coves	0.5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Near Launcher		137.8	115.4	119.	2.4	95.0	99.8	3.0	104.3	109.1	3.0

Note: Peak levels (Pk) and SPLs are in dB relative to 20 µPa. SELs or energy levels are in dB re 20 $\mu Pa^2 \cdot s$. Durations (Dur) are in seconds. N/A = data not available.

2.5 Discussion and Summary

During the September 2011 to September 2012 period, the sound levels received from the 11 missiles launched were comparable to those recorded from previous launches at SNI (see Holst et al. 2008). The highest measured sound levels on pinniped haul-out beaches were 119.8 dB re 20 µPa^2•s SEL on a flat-weighted basis, 115.3 dB re 20 µPa^2•s on an M_{pa}-weighted basis, and 107.6 dBA SEL (Table 2.2). Sounds of 130.6 dB re 20 µPa^2•s SEL-M and 130.5 dB re 20 µPa^2•s SEL-M were recorded near the launcher during the two Terrier-Lynx launches. These two launches exceeded 129 dB re 20 µPa^2•s SEL-M, the energy level at which TTS onset may occur in the Pacific harbor seal (Southall et al. 2007) by 1.6 and 1.5 dB respectively, but only near the launch pad. None of the sounds recorded near haul-outs exceed 129 dB re 20 µPa^2•s SEL-M and none exceeded the SEL-M (144 dB) or peak pressure (149 dB) at which a slight PTS may occur (Southall et al. 2007). Therefore, it is unlikely that any pinnipeds experienced launch sounds that could have caused TTS and nearly impossible that any experienced sounds that could have caused PTS. The possibility of TTS and PTS occurring in pinnipeds hauled out on SNI during missile launches is further discussed in Chapter 4.

TABLE 2.3. Ambient broadband (10–20,000 Hz) sound levels (in dB re 20 µPa) as recorded before launches.

Date	Missile	Site	Flat-weighted	A-weighted	M_{pa}-weighted
29 September 2011	Dual GQM*	Dos Coves	70.6-70.7	58.5	64.0
		Phoca Reef	63.5	55.3	60.0
		Near Launcher	44.5-45.5	23.1-23.7	32.4-33.5
3 November 2011	Dual Medusa*	Dos Coves	N/A	N/A	N/A
		Near Launcher	50.9-51.5	20.9-21.0	30.5-30.8
7 December 2011	GQM (1st of 2)	Dos Coves	59.6	50.4	54.0
		Near Launcher	64.7	27.4	32.8
7 December 2011	GQM (2nd of 2)	Dos Coves	61.6	47.4	50.8
		Near Launcher	49.8	20.0	27.4
16 December 2011	Dual* GQM	Dos Coves	73.8	48.3	53.5
		Near Launcher	71.2-71.6	32.7-33.0	43.3-44.7
11 March 2012	Terrier-	Dos Coves	72.8	53.9	60.0
		Pirates Cove	70.1	45.9	62.9
		West Balloon	N/A	N/A	N/A
		Near Launcher	73.1	46.0	56.2
28 March 2012	Terrier-	Dos Coves	59.4	50.8	55.5
		West Balloon	N/A	N/A	N/A
		Near Launcher	60.2	44.9	54.8
12 June 2012	MSST	Dos Coves	65.5	66.3	64.2
		Phoca Reef	47.4	37.7	43.0
		Near Launcher	84.2	83.9	83.8

N/A = data not available. * Two measurements were made, one during each missile launch.

3. PINNIPED BEHAVIOR DURING MISSILE LAUNCHES

3.1 Introduction

Three species of pinnipeds are common on SNI beaches – California sea lion, Pacific harbor seal, and northern elephant seal. Northern elephant seals have shown little reaction to previous missile launches and monitoring for elephant seals is not required by the current LOA. Therefore this report only includes reactions of Pacific harbor seals and California sea lions. Elephant seals were present on some of the monitored haul-outs along the other species and were included in the camera's FOV. On these occasions, reactions were similar to those in the past (generally no movement or very minor movement down the beach) reconfirming their lack of reaction to missile launches. No other pinniped species were recorded during this or previous monitoring since August 2001 (Holst et al. 2008).

California sea lions often show startle responses to launches and movement along the beach. In most cases, sea lion behavior returns to pre-launch levels within seconds or minutes following the launches (e.g., Holst et al. 2008). Behavior as well as numbers of sea lions hauled-out several hours after a launch appears similar to the behavior and numbers observed before a launch. In contrast, when Pacific harbor seals react to launches, they commonly leave their haul-out sites to enter the water and do not return for several hours or the next tide cycle (Holst et al. 2008). Nonetheless, Holst and Lawson (2002) noted that the behavior and numbers of Pacific harbor seals hauled out on the day following a launch were similar to those on the day of the launch.

Due to operational needs, launches in June 2012 occurred during California sea lions pupping/breeding season, launches in November and December 2011 occurred during northern elephant seal pupping/breeding season, and launches in March occurred during Pacific harbor seal pupping season. No evidence of injury, mortality, or pup abandonment was observed on the day of any launch during the monitoring period, nor was any launch-related injury or mortality expected based on prior monitoring results.

3.2 Field Methods

The launch monitoring program is based primarily on remote video recordings and later analysis. Remote cameras are essential because, during missile launches, safety requirements prevent personnel from being present in many of the areas of interest. Video data were obtained via portable cameras that can be set up temporarily at any location. In addition, trained biologists made notes on the status of pinnipeds on monitored beaches as well as other locations around the island prior to and following launches.

During the launches described in this report, use of video methods theoretically allowed observations of up to three pinniped species during the same launch. The actual number of species observed depended on the number of video systems deployed during each launch and on the number of species hauled out at those sampling sites (Table 3.1). During the monitoring period, only California sea lions and Pacific harbor seals were targeted for monitoring, though northern elephant seals were present at some monitored locations.

Navy biologists usually place three cameras at locations overlooking haul-out sites prior to each launch. However, on two occasions only two cameras were used and on one occasion only one camera was used due to an absence of animals in the area of potential impact. Cameras were placed in a manner to minimize disturbance to pinnipeds. The entire haul-out aggregation at a given site cannot be recorded, as the wide-angle view necessary to encompass an entire beach will not allow detailed behavioral observations. Thus, cameras are set to record a focal subgroup within the haul-out aggregation. Prior to selecting a focal subgroup, however, video pans of the entire area are made to allow computation of total animals in the area. Video pans were repeated after the launch to provide information on changes in total numbers of animals present.

Video and audio recordings are usually attempted at up to three locations with varying distances from the missile flight path, depending upon the presence of pinnipeds at haul-outs. Figure 3.1 shows the monitoring locations relative to the launch azimuths for September 2011 – September 2012.

TABLE 3.1. Video monitoring locations.

	Launch Date / Vehicle Type						
Video Recording Location by Species*	**29 Sept 2011 GQM**	**03 Nov 2011 Medusa**	**07 Dec 2011 GQM**	**16 Dec 2011 GQM**	**11 Mar 2012 Terrier-Lynx**	**28 Mar 2012 Terrier-Lynx**	**12 Jun 2012 MSST**
California Sea Lion							
Dos Coves	X[+]	X[+^]	X	X[+]	X	X[^]	X[+^]
Pacific Harbor Seal							
Phoca Reef	X[†]						X
Pirates Cove					X	X[^]	
W. Balloon Launch					X	X[†]	

*Multiple Species may be monitored on the same camera at one location.
X = recording obtained
[+] Two Cameras in this location
[†] No pinnipeds present in field of view at time of launch
[^] Camera failed (two cameras on 03 November and 28 March and one of two on 12 June)

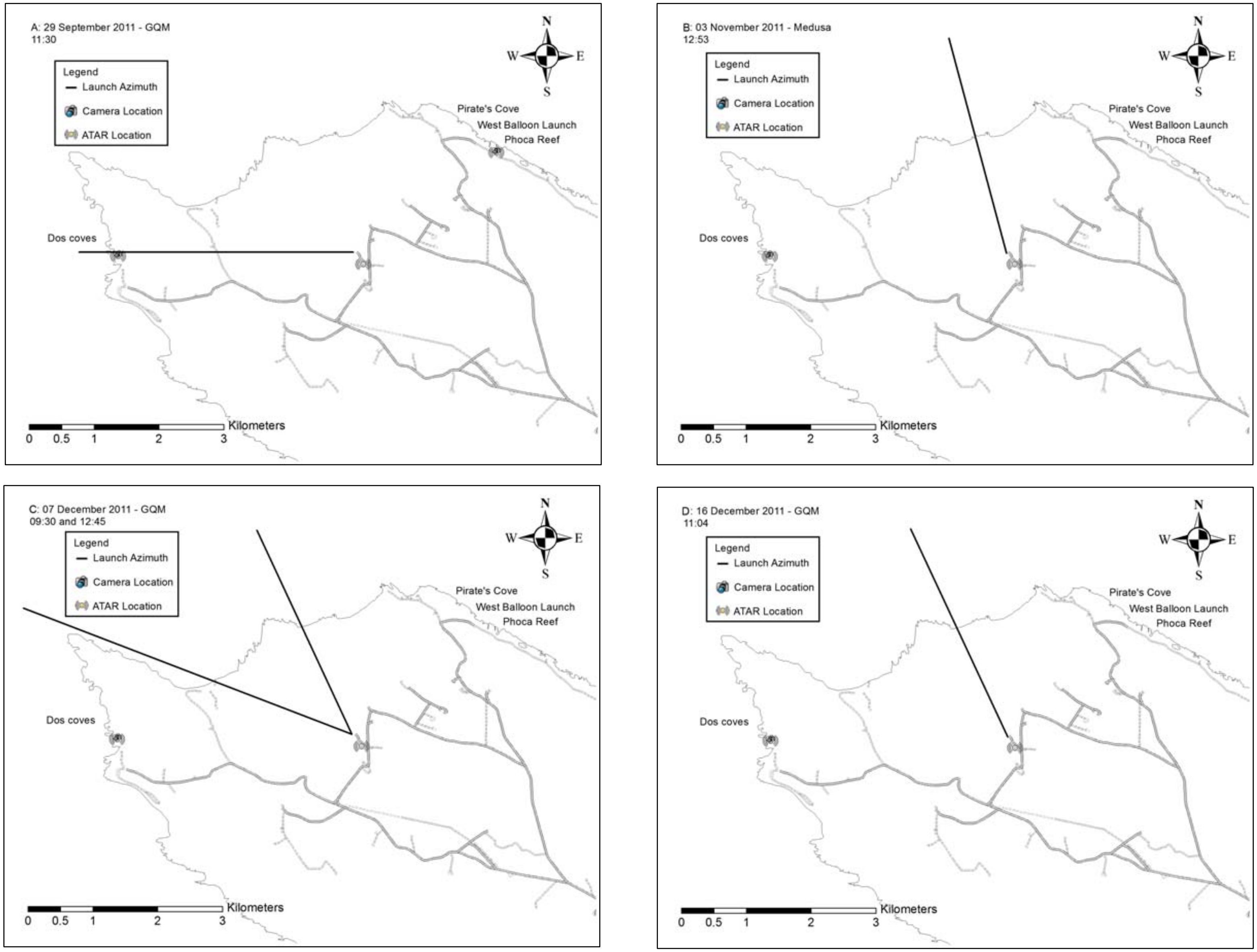


FIGURE 3.1. Launch azimuths, acoustic recording sites (ATARs), and video recording sites.

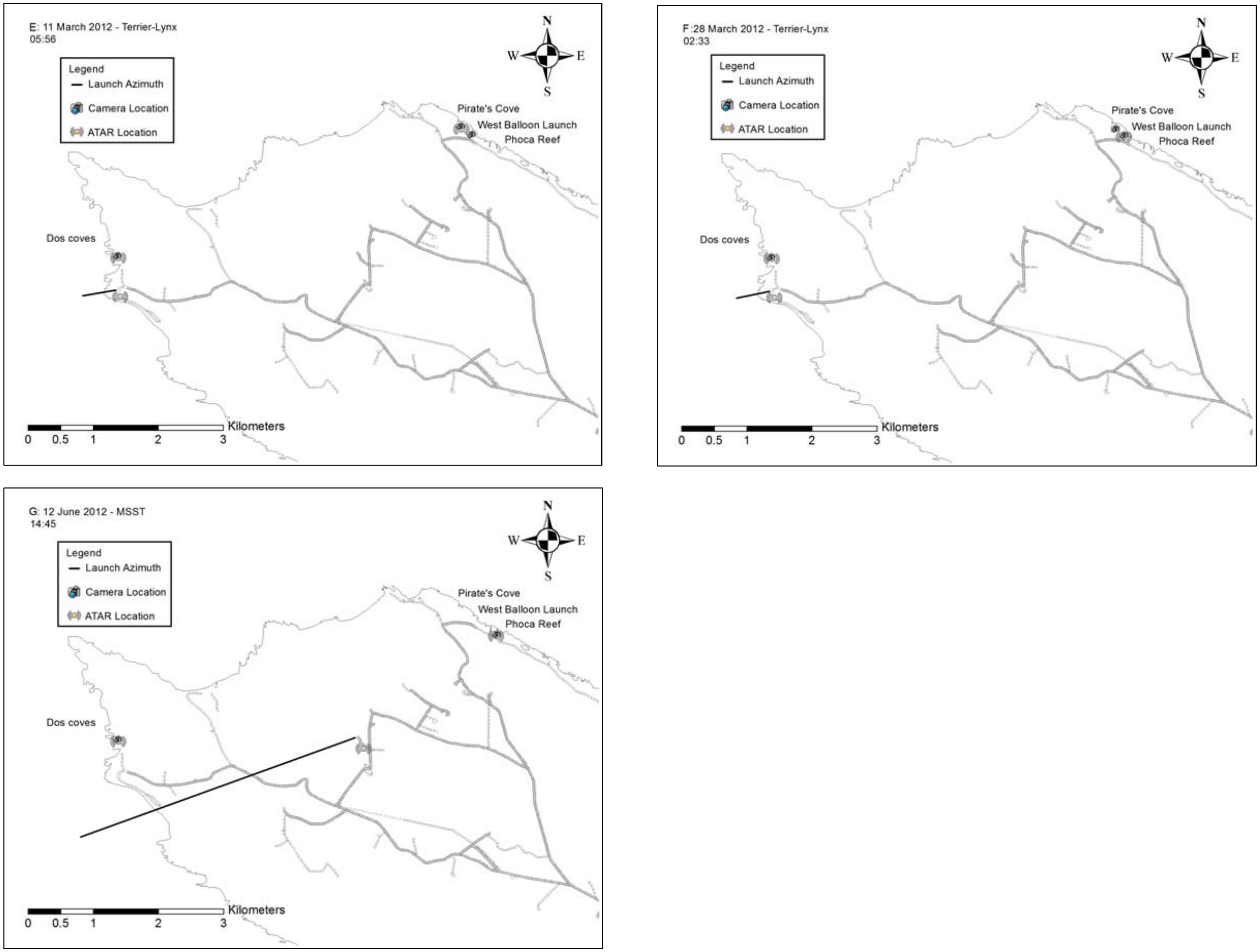


FIGURE 3.1 (Cont.)

3.2.1 Visual Observations

Video observations are obtained before, during, and after each missile launch. Navy biologists also make direct visual observations of the pinniped groups prior to deployment of the cameras and ATARs and after the launch when collecting equipment. Records from these visual observations include the local weather conditions, the type of launch activity planned, types and locations of any pinnipeds hauled out and notable impacts if any, as well as notes on tidal changes or other confounding factors.

Video recordings continue for approximately 15–60 min or more after the launch. If any reactions to the launch occur, recordings during the after-launch period are used to determine how quickly animals returned to pre-launch behaviors. These recordings also help determine whether the relative numbers of pinnipeds at the haul-out site had changed, and if there was obvious evidence of recent injury or mortality. In addition, Navy biologists performed visual scans while retrieving video equipment to determine the relative number of hauled-out pinnipeds compared to pre-launch numbers.

3.2.2 Digital Video Cameras

To monitor daytime launches, Navy biologists place up to three portable Sony high definition digital video cameras (HDR-CX160) on tripods overlooking haul-out sites. Missile and other sounds detected by the microphones built into these cameras are also recorded. The audio data are used during behavioral analyses (e.g., to confirm the exact time when the missile passed), but are not calibrated and not of sufficient quality to provide launch sound information.

3.2.3 FLIR Cameras

To monitor nighttime launches, Navy biologists place up to three FLIR Systems HS-324 Command thermal imaging cameras on tripods overlooking haul-out sites. The thermal imaging cameras have a FOV of 24°×18°. When a 2X extender lens is used with the cameras, the FOV is reduced to 12°×9°. The cameras record video data internally onto a Secure Digital (SD) card and can store more than 5 hr of video but do not collect or record audio data.

3.3 Video Monitoring Analysis

Digital video data are reviewed by an experienced biologist on a high-resolution color monitor. The data several hours before, during, and up to 60 min after each launch were reviewed in order to document the types and numbers of pinnipeds present, the nature of any overt responses to the launch, and the number of pinnipeds that responded overtly. The number, proportion and (where determinable) age class (adult or juvenile) of the individuals that responded in various ways were determined from the video, along with comparable data for those that did not respond. Following NMFS [2002], subtle behavioral reactions that persisted for only a few minutes were considered unlikely to have biologically significant consequences for the pinnipeds. To relate pinniped behavior to the proximity of the missile launch, the 3-D distance from the recording site to the CPA of the missile was calculated

The following variables were determined from the videotape or from direct observations at the site:

1. Study location;
2. Local time;
3. Weather, including an estimate of wind strength and direction, and presence of precipitation; and
4. Tide state - exact time for local high tide was determined from relevant tide tables.

3.4 Descriptions of Pinniped Behavior during Specific Launches

The following subsections provide overall descriptions of pinniped responses and notable reactions during each launch during the monitoring period. Video recordings of pinniped behavior during launches from September 2011 to September 2012 were successfully collected on five dates for California sea lions and on three dates for Pacific harbor seals (Table 3.1). California sea lions were monitored at one haul-out due to their absence from other beaches in the potential area of impact during launch events. Pacific harbor seals were monitored at three different haul-outs. The video recordings generally provided data on the responses of a sample of the total pinnipeds present on a given beach, though on some occasions all animals in the area were recorded.

3.4.1 Dual GQM Launch, 29 September 2011

The two GQM missiles were launched at approximately 11:30 Pacific time in quick succession (within 5 s) from the Alpha Launch Complex, with a 14º elevation angle and an azimuth of 270º (Fig. 3.1a). Video recordings of California sea lions were made from two different sites at Dos Coves Cliff (CPA ≈ 0.8 km) (Table 3.1); one site was located at the cliff edge whereas the other site was above the cliff edge. A video recording of Pacific harbor seals was attempted at Phoca Reef, but no seals were present on the beach during the launch.

ATARs were deployed at two sites where video recordings of pinnipeds were attempted (Dos Coves Cliff and Phoca Reef), as well as near the launcher (Fig. 3.1a; Tables 2.2 and 2.3). The sounds from the launch were audible on the audio channel of video recordings at Dos Coves, and they were barely audible at Phoca Reef.

California sea lions. Approximately 100 sea lions were monitored near the cliff edge. During the launches, all monitored sea lions startled and moved. More animals moved following the second launch, with movements of all animals increasing. Some animals moved towards the water (>100 m away) and likely entered the water at Dos Coves, but this could not be determined from the video recording due to topography. In addition, several hundred animals (~313) entered and left the FOV of the camera. Although the sea lions were starting to settle down after 2 - 5 min, some sea lions were still moving in and out of the FOV 8 min after the launch. At the site above the cliff edge, approximately 78 sea lions were monitored. All startled and showed prolonged movement during the launch. Several hundred animals (~305) entered and left the FOV of the camera. Although the sea lions were starting to settle down after 2 - 5 min, some sea lions were still moving in and out of the FOV 8 min after the launch. Based on the observations made, it is likely that nearly all the animals observed at the site above the cliff edge moved towards the site at the cliff edge in response to the launch. The animals that entered and left the site above the cliff edge were likely the same ones as were seen entering and leaving the site at the cliff edge. Therefore, it is estimated that 313 California Sea Lions were affected in total.

Pacific harbor seals. No harbor seals were hauled out on SNI at the time of the launch in the area where missiles sounds were audible. Therefore, no harbor seals were affected.

3.4.2 Dual Medusa Launch, 3 November 2011

The two Medusa missiles were launched at approximately 12:53 Pacific time from the Alpha Launch Complex in quick succession (within 14 s), with a 2º elevation angle and an azimuth of 345º (Fig. 3.1b). Video recordings of California sea lions were attempted at two sites at Dos Coves (CPA ≈ 3.0 km), but the cameras failed prior to the launch (Table 3.1). However, observations by Navy personnel noted that sea lions hauled at both Dos Coves sites were still present immediately following the launch in the same numbers as were present prior to the launch. No pinnipeds were present prior to the launch between Dos Coves and Phoca Reef. Thus, it appears that no pinnipeds were affected during the dual Medusa launch.

ATARs were deployed at Dos Coves and at the Alpha Launch Complex (Fig. 3.1b; Tables 2.2 and 2.3); the event was not captured at Dos Coves, likely due to the missiles' path and type of booster used. This supports the assumption that pinnipeds at Dos Coves were not affected. Both missile flights and the impact of the live warhead ~2 km offshore were analyzed from the ATAR recording near the launcher.

3.4.3 Two GQM Launches, 07 December 2011

The two GQMs were launched at approximately 09:30 and 12:45 Pacific time from the Alpha Launch Complex. The missiles were launched with a 14º elevation angle and an azimuth of 291º and 335º respectively (Fig. 3.1c). Video recordings of California sea lions were made at Dos Coves (CPA ≈ 1.4 km and 2.9 km respectively) (Table 3.1).

ATARs were deployed at Dos Coves where video recording of pinnipeds were made and near the launcher (Fig. 3.1c; Tables 2.2 and 2.3). The sounds from the launch were audible on the audio channel of video recordings at Dos Coves, though the second launch was far quieter likely due to the azimuth change.

California sea lions. Approximately 220 sea lions were in the vicinity of Dos Coves during both launches. During the first launch 188 were in the camera's FOV and during the second launch 163 were in the camera's FOV. During the first launch, nearly all monitored sea lions startled and moved (180 animals. Many of these animals (125) entered the water at a distance of approximately 3-5 m. Most sea lions were returning to normal behaviors and exiting the water after approximately 5 min. During the second launch, a relatively small number of sea lions (42) startled or moved. Of these, only 10 entered the water at a distance of approximately 3-5 m. The sea lions had all returned to normal behaviors after less than 5 min. Based on the observations made, it is estimated that 147 sea lions were affected in the entire area for the first launch and 14 for the second. While it is highly likely that the second launch affected some of the same animals as the first, the total estimate for affected sea lions is 161.

Pacific harbor seals. No harbor seals were hauled out on SNI at the time of the launch in the area where missiles sounds were audible. Therefore, no harbor seals were affected

3.4.4 Dual GQM Launch, 16 December 2011

The two GQMs were launched at approximately 11:04 Pacific time from the Alpha Launch Complex in quick succession (within 3 s). The missiles were launched with a 14º elevation angle and an azimuth of 335º (Fig. 3.1d). Video recordings of California sea lions were made from two sites at Dos Coves (CPA ≈ 0.5 km) (Table 3.1).

ATARs were deployed at Dos Coves where video recording of pinnipeds were made and near the launcher (Fig. 3.1d; Tables 2.2 and 2.3). The sounds from the launch were audible on the audio channel of video recordings at Dos Coves.

California sea lions. Approximately 225 sea lions were in the vicinity of Dos Coves during the launches. One camera was aimed to the south part of the beach with 66 sea lions in the camera's FOV. The second camera was aimed at the western portion of the beach with 65 animals in the camera's FOV. The first focal group all alerted to the missile launch sounds, but none moved in response. All of the sea lions in the second focal group alerted to the missile launch sounds and approximately 60 moved a short distance. Of these, 35 entered the water at a distance of approximately 2-3 m away and are considered to have been harassed. Sea lions began moving back towards their original locations after less than 5 minutes and all sea lions were returning to normal behaviors after approximately 10 min. Based on the observations made, it is estimated that 43 sea lions were affected in the entire area.

Pacific harbor seals. No harbor seals were hauled out on SNI at the time of the launches in the area where missiles sounds were audible. Therefore, no harbor seals were affected

3.4.5 Terrier-Lynx Launch, 11 March 2012

The Terrier-Lynx missile was launched at approximately 05:56 Pacific time from Building 807. The missile was launched with an 83º elevation angle and an azimuth of 260º (Fig. 3.1e). FLIR Video recordings of California sea lions were made Dos Coves (CPA ≈ 0.7 km) and of Pacific harbor seals at Pirates Cove (CPA ≈ 5.1 km) and West of the Balloon Launch building (CPA ≈ 5.1 km) (Table 3.1).

ATARs were deployed at all three sites where video recording of pinnipeds were made and near the launcher (Fig. 3.1e; Tables 2.2 and 2.3). The sounds from the launch were audible on all audio channels of video recordings.

California sea lions. Approximately 300 sea lions were in the vicinity of Dos Coves during the launch. The camera was aimed to the southwest part of the beach with 30 sea lions in the camera's FOV. All of the sea lions moved into the water (approximately 5-10 m) in response to the missile launch sounds. In addition approximately 50 sea lions moved into the camera's FOV and continued into the water. Sea lions were still vigilant and agitated after 30 minutes when the recording ended. Given the large reactions, all animals (300) were considered to be harassed by the event.

Pacific harbor seals. Eleven harbor seals were hauled out at Pirate's Cove and five at the West Balloon Launch area at the time of the launch. Harbor seals were absent from other beaches within the area of potential impact. At Pirate's cove, two Mother and pup pairs and one adult female moved out of the camera's FOV and likely into water (approximately 10-15 m). One Mother and pup pair moved a short distance but did not enter water. At West Balloon Launch, One mother and pup pair entered the water (approximately 1 m) and one mother moved 2 m then returned to her pup within 2 minutes. Based on these observations, and the lack of hauled out harbor seals in other areas potentially impacted, seven harbor seals were considered to be harassed by the event.

3.4.6 Terrier-Lynx Launch, 28 March 2012

The Terrier-Lynx missile was launched at approximately 02:33 Pacific time from Building 807. The missile was launched with an 85º elevation angle and an azimuth of 258º (Fig. 3.1f). FLIR Video recordings of California sea lions were attempted at Dos Coves (CPA ≈ 0.7 km) and of Pacific harbor seals at Pirates Cove (CPA ≈ 5.1 km) and West of the Balloon Launch building (CPA ≈ 5.1 km) (Table 3.1). The cameras at both Dos Coves and Pirate's Cove failed. While the camera at West Balloon Launch successfully recorded through the launch period, all harbor seals moved off the beach prior to the event as the tide came in.

ATARs were deployed at all three sites where video recording of pinnipeds were made and near the launcher (Fig. 3.1f; Tables 2.2 and 2.3). Launch sounds were barely audible (not above ambient noise) at West Balloon Launch.

California sea lions. Approximately 85 sea lions were in the vicinity of Dos Coves during the launch. The camera failed prior to the launch event. Based on the fact that all animals were considered harassed during the 11 March Terrier-Lynx launch, it is estimated that all 85 animals were affected by this launch.

Pacific harbor seals. Twelve harbor seals were hauled out at Pirate's Cove and none at the West Balloon Launch area at the time of the launch. Harbor seals were absent from other beaches within the area of potential impact. The camera failed at Pirate's cove prior to the launch. At West Balloon Launch, initially three harbor seals were present in the camera's FOV. Prior to the launch, however, the tide came in and all animals departed the beach. A conservative estimate was made that all animals at Pirate's cove were affected by the launch (12 animals).

3.4.6 MSST Launch, 12 June 2012

The MSST missile was launched at approximately 14:45 Pacific time from the Alpha Launch complex. The missile was launched with a 20º elevation angle and an azimuth of 250º (Fig. 3.1g). Video recordings of California sea lions were attempted at Dos Coves (CPA ≈ 1.3 km) and of Pacific harbor seals at Phoca Reef (CPA ≈ 2.4 km) (Table 3.1). One of two cameras at Dos Coves failed.

ATARs were deployed at Dos Coves and Phoca Reef where video recording of pinnipeds were made and near the launcher (Fig. 3.1g; Tables 2.2 and 2.3). Launch sounds were barely audible (not above ambient noise) at Dos Coves.

California sea lions. Approximately 187 sea lions were in the vicinity of Dos Coves during the launch. One camera was aimed to the south part of the beach but failed to record the event. The second camera was aimed at the western portion of the beach with 65 animals in the camera's FOV. All of the sea lions in the second focal group alerted to the missile launch sounds but none moved from their original positions and normal behavior resumed immediately after the event. Based on the observations made, it is estimated that no sea lions were affected in the entire area.

Pacific harbor seals. Forty-five harbor seals were hauled out at Phoca Reef at the time of the launch. Harbor seals were absent from other beaches within the area of potential impact. Thirteen harbor seals were in the camera's FOV at the time of the missile launch. All animals alerted to the missile launch sound, but none moved from their resting positions. Based on the observations made, it is estimated that no harbor seals were affected in the entire area.

3.5 Implementation of Mitigation Measures

Table 3.2 shows a summary of the mitigation measures that were specified by NMFS in the LOA, and how they were implemented during the June 2010–November 2011 monitoring period.

TABLE 3.2. Implementation of mitigation measures.

Mitigation Measure	Implementation
No personnel at haul-out sites 2 hr before launch	Personnel were prohibited from accessing the haul-out sites at least 2 hr before all launches.
Avoid launches during Pacific harbor seal pupping season	Two launches occurred during Pacific Harbor Seal pupping season (March 11 and 28, 2012). These launches had to occur at this time due to operational need. No harbor seal pups were abandoned and no pinniped injury or mortality occurred.
Limit launch activities during other pinniped pupping season	One launch occurred at the start of California sea lion pupping season, and two launches occurred at the start of northern elephant seal pupping season. These launches had to occur at this time due to operational need. No sea lion or elephant seal pups were abandoned and no pinniped injury or mortality occurred.
No launches of missiles at low elevation from Alpha Launch Complex	All missiles that were launched successfully passed over haul-out beaches at altitudes of approximately 1,500 Feet.
Avoid multiple launches in quick succession, especially when pups present	The dual launches of GQMs in December 2011 occurred at the start of elephant seal pupping season and pups were not present on the beaches in large numbers. No pups were abandoned and no pinniped injury or mortality occurred.
Limit launches during nighttime	Two launches occurred during nighttime due to operational need. While California sea lions reacted more strongly to these launches, no lethal takes occurred and total numbers harassed were within allowed takes.
Ensure aircraft maintain an altitude of 1000 ft from haul outs	No aircraft were flown near haul-out areas.
Review launch procedure and monitoring methods with NMFS if pinniped injury or mortality are discovered.	No injured or dead pinnipeds were seen during the monitoring period.

4. ESTIMATED NUMBERS OF PINNIPEDS AFFECTED

4.1 Pinniped Behavioral Reactions to Noise and Disturbance

Some of the pinnipeds on the beaches at SNI showed disturbance reactions to missile launches, but others do not. The levels, frequencies, and types of noise that elicit a response are known or expected to vary between and within species, individuals, locations, and seasons. Also, it is possible that pinnipeds hauled out on land may react to the sight (light at night), or the combined sight plus sound, of a missile launch. Furthermore, pinnipeds may, at times, react to the sight and sound of seabirds reacting to a launch. Thus, responses are not expected to be a direct function of received sound level. However, some correlation between pinniped responses and received sound level has been shown, at least for California sea lions and elephant seals, based on data from previous monitoring periods (Holst et al. 2008).

For pinnipeds hauled out on land, behavioral changes range from a momentary alert reaction or an upright posture to movement – either deliberate or abrupt – into the water. Previous studies indicate that the reaction threshold and degree of response are related to the activity of the pinniped at the time of the disturbance. In general, there is much variability and pinnipeds often show considerable tolerance of noise and other forms of human-induced disturbance, though at other times certain pinnipeds can be quite responsive (Richardson et al. 1995; Reeves et al. 1996; Lawson et al. 1998).

Although it is possible that pinnipeds exposed to launch noise might “stampede” from the haul-out sites in a manner that causes injury or mortality, this was judged unlikely prior to the monitoring program. Review of video records of pinnipeds during launches at SNI indicates that this assumption was generally correct. However, monitoring conducted during 2002 - 2003 showed that, in some cases, several Pacific harbor seal pups were knocked over by adult seals as both pups and adults moved toward the water in response to the launch (Holst 2004a) though no injuries were observed. Similarly, during the 2004 - 2005 monitoring period, several California sea lion pups were knocked over by adult sea lions as the adults moved along the beach in response to a launch (Holst and Greene 2006b). The pups were momentarily startled, but did not appear to be injured. No such cases have been observed since 2005.

Since no injuries or deaths were observed during the monitored launches in either this monitoring period or earlier monitoring dating back to August 2001, determining disturbance level, rather than injury or mortality, is the primary monitoring objective. The numbers of pinnipeds on the monitored beaches that might have been affected significantly by the launches were estimated. Estimates were always conservative, assuming the highest possible level of impact. The Navy, consistent with NMFS (2002), assumes that a pinniped blinking its eyes, lifting or turning its head, or moving a few feet along the beach as a result of a human activity is not significantly affected (i.e., not harassed).

In this report, consistent with previous related reports (Holst et al. 2005, 2008; Holst and Greene 2006a, b), it is assumed that only those animals meeting the following criteria are affected by launches:

1. Pinnipeds that were injured or killed during launches (e.g., by stampedes);
2. Pinnipeds exposed to launch sounds strong enough to cause TTS; and
3. Pinnipeds that left the haul-out site, or exhibited prolonged movement or prolonged behavioral changes (such as pups separated from mothers) relative to their behavior immediately prior to the launch.

In practice, no pinnipeds are known or suspected to have been injured or killed during the monitored launches since August 2001, no pups have been separated from mothers, and few if any are believed to have received sounds strong enough to elicit TTS (see §4.2, below). Thus, the number of pinnipeds counted as potentially affected during the monitoring period was based on criterion (3) – the number that left the haul-out site, or exhibited prolonged movement.

The numbers of such affected pinnipeds were calculated for the 11 launches on 7 separate days occurring between September 2011 and September 2012. Disturbance reactions were short-lived for California sea lions and did not appear to extend into subsequent days. Some Pacific harbor seals left their haul-out site during the launch, but the same site held similar numbers of animals on subsequent days.

4.2 Possible Effects on Pinniped Hearing Sensitivity

Temporary or perhaps permanent hearing impairment is a possibility when pinnipeds are exposed to very strong sounds in air. Based on data from terrestrial mammals, the minimum sound level necessary to cause PTS is presumed to be higher, by a variable and generally unknown amount, than the level that induces barely-detectable TTS. Given what is known about the thresholds for TTS and PTS in terrestrial mammals and humans, the PTS threshold is expected to be well above the TTS threshold for non-impulsive sounds. For impulsive sounds, such as sonic booms and artillery shots, the difference may be smaller (Kryter 1985; Southall et al. 2007).

4.2.1 Temporary Threshold Shift

There are few published data on TTS thresholds for pinnipeds in air exposed to impulsive or brief non-impulsive sounds. J. Francine, quoted in NMFS (2001: 41837), has mentioned evidence of mild TTS in captive California sea lions exposed to a 0.3 s transient sound with an SEL of 135 dBA re 20 $\mu Pa^2 \cdot s$ (see also Bowles et al. 1999). However, mild TTS may occur in harbor seals exposed to received levels lower than 135 dB SEL (A. Bowles, pers. comm., 2003). Initial evidence from more prolonged (non-pulse) exposures suggests that the TTS threshold on an SEL basis may actually be around 129–131 dB re 20 $\mu Pa^2 \cdot s$ (M_{pa}-weighted) for harbor seals, within their frequency range of good hearing (Kastak et al. 2004; Southall et al. 2007). The same research teams have found that the TTS thresholds of California sea lions and northern elephant seals exposed to strong sounds are higher as compared to harbor seals (Kastak et al. 2005). Based on these studies and other available data, Southall et al. (2007) propose that sounds may induce mild TTS if the received peak pressure is ~143 dB re 20 µPa, or if received SEL-M is ~129 dB re 20 $\mu Pa^2 \cdot s$ (for pulses) or 131 dB re 20 $\mu Pa^2 \cdot s$ (for non-pulses received in air). Those levels apply specifically to harbor seals; those levels are not expected to elicit TTS in elephant seals or California sea lions (Southall et al. 2007).

The sounds received from missile launches on SNI are sometimes impulse sounds (e.g., when there is a sonic boom or near the launcher). At other times and locations they are non-impulsive. During past monitoring of missile launches from SNI during 2001–2009, few if any pinnipeds were exposed to sound levels above 122 dB SEL-M (Holst et al. 2008; Holst and Greene 2010). In addition, peak pressure levels at pinniped haul-out beaches were generally <143 dB re 20 µPa, although for some launches that produced a sonic boom (impulse), peak pressure levels were as high as 150 dB (Holst et al. 2008). Thus, it is possible that a few pinnipeds, particularly Pacific harbor seals, may incur TTS during some missile launches (especially of larger missiles and targets) from SNI. Because of their higher TTS thresholds, it is likely that fewer California sea lions and northern elephant seals may incur TTS as compared to Pacific harbor seals.

During the 2011–2012 monitoring period, SEL-M at pinniped beaches reached up to 115.3 dB, and peak pressure levels were as high as 144.4 dB re 20 µPa. Near the launcher at the B807 Launch Complex, SEL-M reached 130.6 dB, and the peak pressure level was 146.3 dB. However, pinniped haul-out beaches are located at least 0.8 km from the B807 Launch Complex and the peak pressure recorded for one event at Dos Coves was recorded on open ground on a cliff above the beach. Pinnipeds present in the area were below this cliff and sheltered by it and harbor seals are not know to occur at Dos Coves. Thus, it is unlikely that any animals incurred TTS during the 2011–2012 monitoring period.

4.2.2 Permanent Threshold Shift

Southall et al. (2007) estimate that received SELs would need to exceed the TTS threshold by at least 15 dB for pulses and 13.5 dB for non-pulses in air for there to be risk of PTS. In the harbor seal, the SEL-M that is estimated to result in onset of PTS is 144 dB re 20 $\mu Pa^2 \cdot s$ (Southall et al. 2007). As already noted above, the SEL-M measurements nearshore did not exceed the SEL-based TTS threshold let alone the PTS threshold. Even measurements taken close to the launcher were <144 dB re 20 $\mu Pa^2 \cdot s$.

However, there is some possibility that a few pinnipeds at SNI might receive peak pressures exceeding those that elicit onset of TTS or perhaps even PTS. In animals (or humans) exposed to strong impulsive sound (e.g., close to an artillery shot), there is a possibility of PTS as a result of the high peak pressure even if the received energy did not exceed the SEL criterion for PTS onset. When considering peak pressures rather than energy levels, PTS onset may occur when the received level is as little as 6 dB higher than the TTS threshold, or 149 dB re 20 µPa in the case of the harbor seal (Southall et al. 2007). During the 2001–2010 monitoring period, peak pressure levels received near pinniped beaches close to the missile trajectory were generally less than 149 dB re 20 µPa (Holst et al. 2008; Holst and Greene 2010). However, during three launches that produced a sonic boom (impulse), peak pressure levels were 149–150 dB (Holst et al. 2008). During the 2011-2012 monitoring period, peak pressure never exceeded 149 dB re 20 µPa (maximum 146.3 dB) in any location.

Given the higher TTS thresholds in northern elephant seals and California sea lions than in harbor seals, PTS thresholds in those other species are also expected to be higher than in the harbor seal. Thus, it is unlikely that PTS occurred in California sea lions or northern elephant seals during those launches. Pacific harbor seal haul-out sites are located at least 1.5 km from the launch complexes at SNI, so peak levels at haul-out locations will be lower than near the launcher. Thus, Pacific harbor seals are also unlikely to incur PTS during launches at SNI. During the 2011 - 2012 monitoring period, none of the sounds were strong enough at pinniped haul-out sites or at the launchers themselves to have induced PTS in any pinniped species.

4.2.3 Conclusions Regarding Effects on Pinniped Hearing Sensitivity

Overall, the results to date indicate that there is little potential for appreciable TTS or especially PTS in pinnipeds hauled out on SNI near the missile launch paths during the launch operations. This conclusion is necessarily speculative given the limited TTS data (and lack of PTS data) for pinnipeds in air exposed to strong sounds for brief periods. In the event that levels are occasionally sufficiently high to cause TTS, these levels probably would be only slightly above the presumed thresholds for mild TTS. Thus, in the event that TTS did occur, it would typically be mild and reversible (i.e., no PTS). Given the relatively infrequent launches from SNI, the low probability of TTS during any one launch, and the fact that a given pinniped is not always present on land, there appears to be no likelihood of PTS from the cumulative effects of multiple launches.

If there is any reason to be concerned about auditory effects, it would be during either of two types of launches: (1) When artillery shots occur at beach locations and pinnipeds are present nearby, should this ever occur, and (2) When a large missile travels at supersonic speed over a pinniped beach at relatively low altitude. These types of events did not occur during the current monitoring period.

4.3 Estimated Numbers of Pinnipeds Affected by Launches

The approach to estimating the numbers of pinnipeds affected by launches between September 2011 and September 2012 was based on video observations of pinnipeds, combined with estimates of the numbers of hauled out pinnipeds in the same general vicinity not videotaped but exposed to the same launches. The latter animals are presumed to have reacted in the same manner as those whose responses were videotaped. For pinniped groups that extended farther along the beach than encompassed by the FOV of the video camera, an estimate of the total number of individuals that were hauled out was made based on a pre-launch video pan of the area.

The proportions of animals in the focal subgroups that were affected during each launch (based on the disturbance criteria listed in §4.1) were then extrapolated to the estimated total number of individuals hauled out in this area (Table 4.1). It was not possible to extrapolate the proportions of animals affected on the monitored beaches to the entire island as not all beaches could be observed on the day of a launch. However, whenever possible surveys of surrounding beaches were conducted during monitoring set up to determine if additional pinniped were in the area. Additionally, individual pinnipeds may have been affected on more than one occasion, but are counted here as separate individuals. Thus, the overall estimate of pinnipeds affected may be over- or underestimated.

Navy biologists did not observe any northern fur seals (*Callorhinus ursinus*) or Guadalupe fur seals (*Arctocephalus townsendi*) on SNI during the 2012–2012 monitoring period, and none were evident in the video segments that were analyzed.

Observations from the 2001–2002 monitoring period showed that all of the haul-out sites continued to be occupied on subsequent days following the launches (Holst and Lawson 2002).

There was no evidence of injury or mortality during any of the launches.

TABLE 4.1. Estimated numbers of pinnipeds harassed by launches from the Navy's SNI missile launch program between September 2011 and September 2012.

Launch Date	Missile Type	Monitoring Site	# of Focal Animals Potentially Affected	Total # Potentially Affected in Area
Number of California sea lions potentially harassed				
29 September 2011	Dual GQM	Dos Coves	178	*313*
3 November 2011	Dual Medusa	Dos Coves	0	0
07 December 2011	Dual GQM	Dos Coves	135	*161*
16 December 2011	Dual GQM	Dos Coves	35	*43*
11 March 2012	Terrier-Lynx	Dos Coves	80	*300*
28 March 2012	Terrier-Lynx	Dos Coves	85	85
12 June 2012	MSST	Dos Coves	0	0
	Total number of sea lions potentially affected			**902**
Number of Pacific harbor seals potentially affected				
29 September 2011	Dual GQM	Phoca Reef	None Present	0
3 November 2011	Dual Medusa	None Present	None Present	0
07 December 2011	Dual GQM	None Present	None Present	0
16 December 2011	Dual GQM	None Present	None Present	0
11 March 2012	Terrier-Lynx	Pirates Cove	5	5
11 March 2012	Terrier-Lynx	West Balloon	2	2
28 March 2012	Terrier-Lynx	Pirate's Cove	12	12
12 June 2012	MSST	Phoca Reef	0	0
	Total number of Pacific harbor seals potentially affected			**19**

Note: Numbers in italics are estimates based upon the proportion of pinnipeds affected within a focal group and expanded to the entire number of animals present in the area.

4.4 Summary

No evidence of pinniped injuries or fatalities related to launch noises or other launch operations was evident, nor was it expected. Few if any pinnipeds were exposed to received levels of sound energy above 118 dB re $(20\ \mu Pa)^2 \cdot s$ M_{pa}-weighted. The specific received levels of transient airborne sound that cause the onset of TTS in pinnipeds are not well documented. However, on two occasions near the B807 launch pad, the peak pressure level exceeded the estimated values at which mild TTS may occur in the Pacific harbor seal (130.6 dB re 20 µPa dB). Pacific harbor seal haul-out sites are located at least 0.8 km from the B807 Launch Complex and they are not know to haul out at Dos Coves; thus, TTS is considered to have been unlikely during the 2011–2012 monitoring period. In the unlikely event that TTS did occur, it would have been presumably mild and quickly recoverable.

Approximately 902 California sea lions, 19 Pacific harbor seals, and no northern elephant seals were estimated to have been affected during the monitoring period. These figures are very approximate, because they (a) include extrapolations for pinnipeds on beaches that were not monitored on any given launch day, (b) very likely count some of the same individuals more than once, and (c) also exclude pinnipeds on some beaches that were not monitored. The pinnipeds included in these estimates left the haul-out site in response to the launch, or exhibited prolonged movement or behavioral changes relative to their behavior immediately prior to the launch.

The results from the 2011 - 2012 monitoring period (and those from previous monitoring periods) suggest that any effects of the launch operations were minor, short-term, and localized, at least for northern elephant seals and California sea lions. Some Pacific harbor seals may have left their haul-out site until the following low tide, but numbers occupying haul-out sites shortly after a launch or the next day, are generally similar to pre-launch levels. It is not likely that any of the pinnipeds on SNI were adversely impacted by such behavioral reactions.

5. ACKNOWLEDGEMENTS

Lisa Thomas-Barnett and Grace Smith provided critical support collecting the audio and video recordings from SNI along with ancillary visual observations, weather data, and other information. Steve Schwartz provided comments on the draft monitoring report.

Bob Norman and Clay Rushing, consultants to Greeneridge, were largely responsible for the design of the ATARs, and continue to improve their operation. Bob Norman of Greeneridge analyzed the recordings and prepared the figures of launch-by-launch acoustic results.

Previous video monitoring analyses and report preparation was completed by Meike Holst and staff of LGL Ltd., environmental research associates. LGL's long-term assistance in the Navy's SNI pinniped monitoring program is greatly appreciated.

We are grateful to all concerned.

6. LITERATURE CITED

Bowles, A.E., L. Wolski, E. Berg and P.K. Yochem. 1999. Measurement of impulse noise-induced temporary threshold shift in endangered and protected animals—two case studies. J. Acoust. Soc. Am. 105(2, Pt. 2):932.

Gentry, R., A. Bowles, W. Ellison, J. Finneran, C. Greene, D. Kastak, D. Ketten, J. Miller, P. Nachtigall, W.J. Richardson, B. Southall, J. Thomas and P. Tyack. 2004. Noise exposure criteria. Presentation to U.S. Mar. Mamm. Comm. Advis. Commit. on Acoustic Impacts on Marine Mammals, Plenary Meeting 2, Arlington, VA, April 2004. http://mmc.gov/sound/plenary2/pdf/gentryetal.pdf.

Greene Jr., C.R. 1999. Vandal missile target launch sound measurements recorded at San Nicolas Island on 22 and 26 August 1999. Greeneridge Rep. 231-01. Rep. from Greeneridge Sciences Inc., Santa Barbara, CA, for Naval Air Warfare Cent., Weapons Div., Point Mugu, CA. 8 p.

Greene, C.R., Jr. and C.I. Malme. 2002. Acoustic measurements of missile launches. p. 2-1 to 2-54 *In*: J.W. Lawson, E.A. Becker, and W.J. Richardson (eds.), Marine mammal and acoustical monitoring of missile launches on San Nicolas Island, August 2001 – July 2002. LGL Rep. TA2630-3. Rep. from LGL Ltd., King City, Ont., and Greeneridge Sciences Inc., Santa Barbara, CA, for Naval Air Weapons Station, China Lake, CA, and Nat. Mar. Fish. Serv., Silver Spring, MD. 103 p.

Harris, F.J. 1978. On the use of windows for harmonic analysis with the discrete Fourier transform. Proc. IEEE 66(1):51-83.

Holst, M. 2004a. Behavior of pinnipeds during missile launches. p. 3-1 to 3-26 *In*: M. Holst and C.R. Greene Jr., Marine mammal and acoustical monitoring of missile launches on San Nicolas Island, August 2001–August 2003. LGL Rep. TA2665-3. Rep. from LGL Ltd., King City, Ont., and Greeneridge Sciences Inc., Santa Barbara, CA, for Naval Air Weapons Station, China Lake, CA, and Nat. Mar. Fish. Serv., Silver Spring, MD. 119 p.

Holst, M. 2004b. Estimated numbers of pinnipeds affected by missile launches., Aug. 2001–Aug. 2003. p. 4-1 to 4-5 *In*: M. Holst and C.R. Greene Jr., Marine mammal and acoustical monitoring of missile launches on San Nicolas Island, August 2001–August 2003. LGL Rep. TA2665-3. Rep. from LGL Ltd., King City, Ont., and Greeneridge Sciences Inc., Santa Barbara, CA, for Naval Air Weapons Station, China Lake, CA, and Nat. Mar. Fish. Serv., Silver Spring, MD. 119 p.

Holst, M. and C.R. Greene Jr. 2006a. Marine mammal and acoustical monitoring during vehicle launches on San Nicolas Island, California, February – September 2006. LGL Rep. TA2665-7. Rep. from LGL Ltd., King City, Ont., and Greeneridge Sciences Inc., Santa Barbara, CA, for Naval Air Warfare Center Weapons Division, Point Mugu, CA, and Nat. Mar. Fish. Serv., Silver Spring, MD, and Long Beach, CA. 60 p.

Holst, M., and C.R. Greene Jr. 2006b. Marine mammal and acoustical monitoring during vehicle launches on San Nicolas Island, California, October 2004 – October 2005. LGL Rep. TA2665-6. Rep. from LGL Ltd., King City, Ont., and Greeneridge Sciences Inc., Santa Barbara, CA, for Naval Air Warfare Center Weapons Division, Point Mugu, CA, and Nat. Mar. Fish. Serv., Silver Spring, MD, and Long Beach, CA. 139 p.

Holst, M., and C.R. Greene Jr. 2010. Marine mammal and acoustical monitoring during vehicle launches on San Nicolas Island, California, June 2009 – June 2010. LGL Rep. TA4896-2. Rep. from LGL Ltd., King City, Ont., and Greeneridge Sciences Inc., Santa Barbara, CA, for Naval Air Warfare Center Weapons Division, Point Mugu, CA, and Nat. Mar. Fish. Serv., Silver Spring, MD, and Long Beach, CA. 59 p.

Holst, M. and J.W. Lawson. 2002. Behavior of pinnipeds during missile launches. p. 3-1 to 3-27 *In*: J.W. Lawson, E.A. Becker, and W.J. Richardson (eds.), Marine mammal and acoustical monitoring of missile launches on San Nicolas Island, August 2001–July 2002. LGL Rep. TA2630-3. Rep. from LGL Ltd., King City, Ont., and Greeneridge Sciences Inc., Santa Barbara, CA, for Naval Air Weapons Station, China Lake, CA, and Nat. Mar. Fish. Serv., Silver Spring, MD. 103 p.

Holst, M. and C.R. Greene Jr., with W.J. Richardson, T.L. McDonald, K. Bay, R.E. Elliott, and V.D. Moulton. 2005. Marine mammal and acoustical monitoring of missile launches on San Nicolas Island, California, August 2001–May 2005. LGL Rep. TA2665-5. Rep. from LGL Ltd., King City, Ont., Greeneridge Sciences Inc., Santa Barbara, CA, and West Inc., Cheyenne, WY, for Naval Air Warfare Center Weapons Station, Point Mugu, CA, and Nat. Mar. Fish. Serv., Silver Spring, MD, and Long Beach, CA. 165 p.

Holst, M. and C.R. Greene, Jr., with W.J. Richardson, T.L. McDonald, K. Bay, R.E. Elliott, and R. Norman. 2008. Marine mammal and acoustical monitoring of missile launches on San Nicolas Island, California, August 2001 – March 2008. LGL Rep. TA4617-1. Rep. from LGL Ltd., King City, Ont., and Greeneridge Sciences Inc., Santa Barbara, CA, for Naval Air Warfare Center Weapons Division, Point Mugu, CA, and Nat. Mar. Fish. Serv., Silver Spring, MD, and Long Beach, CA. 116 p.

Kastak, D., B. Southall, M. Holt, C. Reichmuth Kastak, and R. Schusterman. 2004. Noise-induced temporary threshold shifts in pinnipeds: effects of noise energy. J. Acoust. Soc. Am. 116(4, Pt. 2):2531-2532, plus oral presentation at 148th Meeting, Acoust. Soc. Am., San Diego, CA, Nov. 2004.

Kastak, D., B. Southall, R. Schusterman, and C. Reichmuth. 2005. Underwater temporary threshold shift in pinnipeds: Effects of noise level and duration. J. Acoust. Soc. Am. 118(5):3154-3163.

Kinsler, L.E., A.R. Frey, A.B. Coppens, and J.V. Sanders. 1982. Fundamentals of Acoustics. John Wiley & Sons, New York, NY. 480 p.

Kryter, K.D. 1985. The Effects of Noise on Man. Academic Press, Orlando, FL. 688 p.

Lawson, J.W. 2002. Estimated numbers of pinnipeds affected by missile launches. p. 4-1 to 4-5 *In*: J.W. Lawson, E.A. Becker, and W.J. Richardson (eds.), Marine mammal and acoustical monitoring of missile launches on San Nicolas Island, August 2001 – July 2002. LGL Rep. TA2630-3. Rep. from LGL Ltd., King City, Ont., and Greeneridge Sciences Inc., Santa Barbara, CA, for Naval Air Weapons Station, China Lake, CA, and Nat. Mar. Fish. Serv., Silver Spring, MD. 103 p.

Lawson, J.W., W.R. Koski, W.J. Richardson, D.H. Thomson, and C.I. Malme. 1998. Biological consequences for marine mammals. p. 183-279 (plus Appendices) *In:* Point Mugu Sea Range marine mammal technical report. Rep. from LGL Ltd., King City, Ont., for Naval Air Warfare Cent., Weapons Div., Point Mugu, CA. 322 p.

NMFS. 2000. Small takes of marine mammals incidental to specified activities; oil and gas exploration drilling activities in the Beaufort Sea. Fed. Regist. 65(197, 11 Oct.): 60407-60411.

NMFS. 2001. Small takes of marine mammals incidental to specified activities; missile launch operations from San Nicolas Island, California. Fed. Regist. 66(154, 9 Aug.): 41834-41841.

NMFS. 2002. Small takes of marine mammals incidental to specified activities; missile launch operations from San Nicolas Island, CA. Fed. Regist. 67(170, 3 Sep.): 56271-56276.

NMFS. 2010. Taking and importing marine mammals; taking marine mammals incidental to missile launch operations from San Nicolas Island, CA. Fed. Regist. 75(226, 24 Nov.): 71672-71674.

Reeves, R.R., R.J. Hofman, G.K. Silber, and D. Wilkinson (eds.). 1996. Acoustic deterrence of harmful marine mammal-fishery interactions: proceedings of a workshop held in Seattle, Washington, 20-22 March 1996. NOAA Tech. Memo NMFS-OPR-10. U.S. Dep. Commerce, Nat. Mar. Fish. Serv. 70 p.

Richardson, W.J., C.R. Greene Jr., C.I. Malme, and D.H. Thomson. 1995. Marine Mammals and Noise. Academic Press, San Diego, CA. 576 p.

Southall, B.L., A.E. Bowles, W.T. Ellison, J.J. Finneran, R.L. Gentry, C.R. Greene Jr., D. Kastak, D.R. Ketten, J.H. Miller, P.E. Nachtigall, W.J. Richardson, J.A. Thomas and P.L. Tyack. 2007. Marine mammal noise exposure criteria: initial scientific recommendations. Aquatic Mammals 33(4):i-iv, 411-522.

Welch, P.D. 1967. The use of FFT for the estimation of power spectra: a method based on time averaging over short modified periodograms. IEEE Trans. Audio Electroacoust. AU 15(2):70-73.

APPENDIX A:
LETTER OF AUTHORIZATION
1 DECEMBER 2011 – 30 NOVEMBER 2012

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
1315 East-West Highway
Silver Spring, Maryland 20910
THE DIRECTOR

Letter of Authorization

The Department of the Navy, Naval Air Warfare Center Weapons Division, Point Mugu, 1 Administration Circle, China Lake, California 93555 is hereby authorized to take marine mammals incidental to missile launch activities from San Nicolas Island, California, in accordance with 50 CFR 216, Subpart N – Taking of Marine Mammals Incidental to Missile Launch Activities from San Nicolas Island, CA, subject to the provisions of the Marine Mammal Protection Act (16 U.S.C. 1361 *et seq.*) and the following conditions:

1. This Authorization is valid from December 1, 2011, through November 30, 2012.

2. This Authorization is valid only for activities associated with the launching of a maximum of 40 Coyote (or similar sized and smaller) missiles per year from San Nicolas Island, California.

3. General Conditions:

(a). The taking, by Level B harassment only, is limited to the species listed under condition 5 below. The taking by Level A harassment, serious injury (injury that is likely to lead to mortality) or death of these species and the taking by harassment, injury or death of any other species of marine mammal is prohibited and may result in the modification, suspension, or revocation of this Authorization.

(b). The taking of any marine mammal in a manner prohibited under this Authorization must be reported immediately to the Permits and Conservation Division, Office of Protected Resources, National Marine Fisheries Service (NMFS) at 301-427-8401 and to the Southwest Regional Office, NMFS at 562-980-3232.

(c). If a freshly dead or seriously injured pinniped is found during post-launch monitoring, it must be reported immediately to the parties listed above in 3(b). Additionally, the National Stranding Network must be notified immediately (telephone: 526-980-4017). Every attempt will be made to collect pinniped carcasses discovered within 48 hours following a launch, provided that the collection does not result in the disturbance (flushing) of other animals on the site. Any carcasses collected will be transferred to Long Marine Laboratory in Santa Cruz, California for complete necropsy.

4. Cooperation:

THE ASSISTANT ADMINISTRATOR
FOR FISHERIES

The holder of this Authorization is required to cooperate with NMFS and any other Federal, state or local agency monitoring the impacts of the activity on marine mammals. The holder must notify the Administrator, Southwest Regional Office, NMFS, by letter, e-mail, or telephone (562-980-3232) at least one (1) week prior to launches (unless constrained by the date of issuance of this Authorization).

5. The marine mammal species authorized for taking by incidental harassment are: 467 Pacific harbor seals (*Phoca vitulina*); 474 northern elephant seals (*Mirounga angustirostris*); and 1606 California sea lions (*Zalophus californianus*).

6. Mitigation Requirements: The Holder of this Authorization must ensure the least practicable adverse impacts on Pacific harbor seals, northern elephant seals, and California sea lions, by:

(a). Prohibiting personnel from entering pinniped haul-out sites below the missile's predicted flight path for two (2) hours prior to planned missile launches.

(b). Avoiding launch activities during harbor seal pupping season (February through April), unless constrained by factors including, but not limited to, human safety, national security, or for launch trajectory necessary to meet mission objectives.

(c). Limiting launch activities during other pinniped pupping seasons, unless constrained by factors including, but not limited to, human safety, national security, or for launch trajectory necessary to meet mission objectives.

(d). Not launching missiles from the Alpha Complex at low elevation (less than 1,000 ft [305 m]) on launch azimuths that pass close to pinniped haul-out site(s) when occupied.

(e). Avoiding the launch of multiple missiles in quick succession over haul-out sites, especially when young pups are present, except when required by mission objectives.

(f). Limiting launch activities during nighttime hours, except when required by mission objectives.

(g). Ensuring that aircraft and helicopter flight paths maintain a minimum altitude of 1,000 ft (305 m) from pinniped haul-outs and rookeries, except in emergencies or for real-time security incidents (e.g., search-and-rescue, fire-fighting, adverse weather conditions), which may require approaching pinniped haul-outs and rookeries closer than 1,000 ft (305 m).

(h). Reviewing the launch procedure and monitoring methods, in cooperation with NMFS, if any incidents of injury or mortality of a pinniped discovered during post-launch surveys or indications of affects to the distribution, size, or productivity of the affected pinniped populations as a result of the authorized activities are thought to have occurred. If necessary, appropriate changes must be made through modification to this Authorization prior to conducting the next launch of the same vehicle.

7. Monitoring Requirements:

(a). General:

(1). The holder of this Authorization must designate biologically-trained, on-site individual(s), approved in advance by NMFS, to record the effects of the launch activities and the resulting noise on pinnipeds.

(2). NMFS must be informed immediately of any changes or deletions to any portions of the proposed monitoring plan.

(b). Visual Land-Based Monitoring:

(1). Prior to each missile launch, an observer(s) will place three (3) autonomous digital video cameras overlooking chosen haul-out sites located varying distances from the missile launch site. Each video camera will be set to record a focal subgroup within the larger haul-out aggregation for a maximum of four (4) hours or as permitted by the videotape capacity.

(2). Systematic visual observations, by those individuals described in condition 7(a)(1) above, on pinniped presence and activity will be conducted and recorded in a field logbook or recorded on digital video for subsequent analysis for no less than one (1) hour prior to the estimated launch time and for up to one (1) hour immediately following each missile launch.

(3). Documentation, both via autonomous video camera and human observer, will consist of:

(i). numbers and sexes of each age class in focal subgroups;
(ii). description and timing of launch activities or other disruptive event(s);
(iii). movements of pinnipeds, including number and proportion moving, direction and distance moved, and pace of movement;
(iv). description of reactions;
(v). minimum distances between interacting and reacting pinnipeds;
(vi). study location;
(vii). local time;
(viii). substratum type;
(ix). substratum slope;
(x). weather condition;

(xi). horizontal visibility; and
(xii). tide state.

(c). Acoustic Monitoring:

(1). During all missile launches, calibrated recordings of the levels and characteristics of the received launch sounds will be obtained from three (3) different locations of varying distances from the missile's flight path. To the extent practicable, these acoustic recording locations will correspond with the haul-out sites where video monitoring is done.

(2). Acoustic recordings will be supplemented by the use of radar and telemetry systems to obtain the trajectory of target missiles in three (3) dimensions, whenever data coverage allows.

(3). Acoustic equipment used to record launch sounds will be suitable for collecting a wide range of parameters, including the magnitude, characteristics, and duration of each missile.

8. Reporting:

(a). For each missile launch, the lead contractor or lead observer for the holder of this Authorization must provide a status report by telephone to the Southwest Regional Office, NMFS (562-980-3232), providing reporting items found under condition 8(b), unless other arrangements for monitoring are agreed in writing.

(b). An initial report must be submitted to the Office of Protected Resources, NMFS, and the Southwest Regional Office, NMFS, at least 60 days prior to the expiration of this Letter of Authorization. This report must contain the following information:

(1). Timing and nature of launch operations;

(2). Summary of pinniped behavioral observations;

(3). Estimate of the amount and nature of all takes by harassment or by other means; and

(4). Evidence of compliance with mitigation measures.

(c). A draft comprehensive technical report will be submitted to the Office of Protected Resources, NMFS, and the Southwest Regional Office, NMFS, 180 days prior to the expiration of the regulations providing full documentation of the methods, results, and interpretation of all monitoring tasks for launches to date plus preliminary information for missiles launches planned during the first six (6) months of the final Letter of Authorization.

(d). A revised final comprehensive technical report, including all monitoring results during the entire period of the Letters of Authorization will be due 90 days after the end of the period of effectiveness of the regulations contained in 50 CFR 216.150 through 216.159.

(e). The draft and final reports will be subject to review and comment by NMFS. Any recommendations made by NMFS must be addressed in the final comprehensive report prior to acceptance by NMFS.

(f). The draft final technical report must contain documentation on the effectiveness of the implementation of the mitigation measures described in condition 6 of this Authorization, including a description of launch activity during the harbor seal pupping season (February through April).

9. Activities related to the monitoring described in this Authorization and as described in the holders application, do not require a separate scientific research permit issued under section 104 of the Marine Mammal Protection Act.

10. Failure to comply with the terms and conditions contained in Subpart N – Taking of Marine Mammals Incidental to Missile Launch Operations from San Nicolas Island, CA (50 CFR 216.150-216.159) may result in the modification, suspension or revocation of this Authorization

11. A copy of this Authorization must be in the possession of each observer or group operating under the authority of this Letter of Authorization.

Helen M. Golde
Deputy Director
Office of Protected Resources
National Marine Fisheries Service

11/22/11
Date

APPENDIX B:
ACOUSTIC DATA
FOR MISSILE LAUNCHES BETWEEN SEPTEMBER 2011 – SEPTEMBER 2012

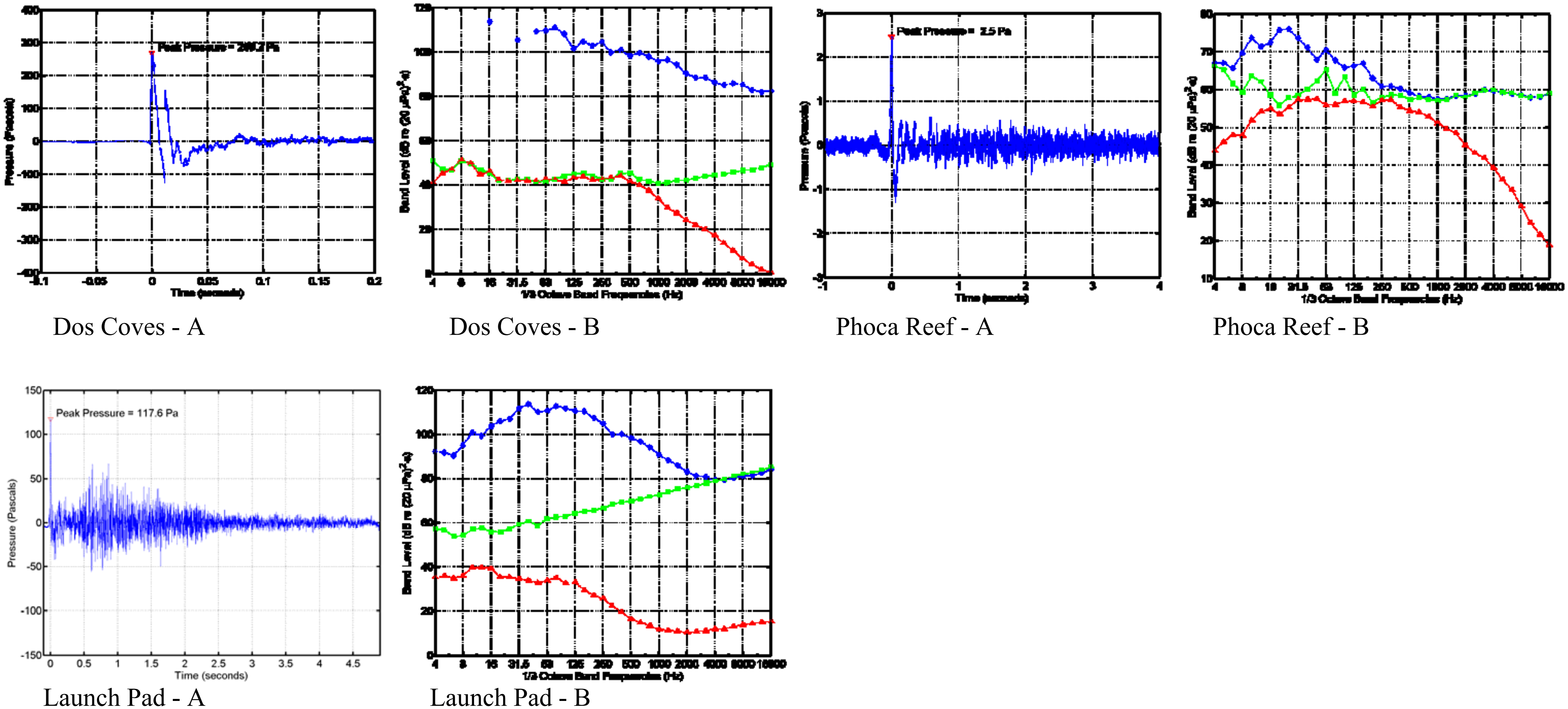
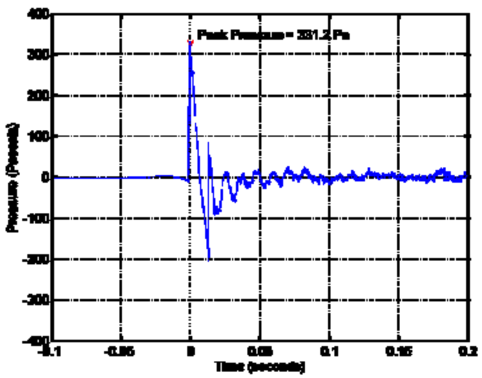
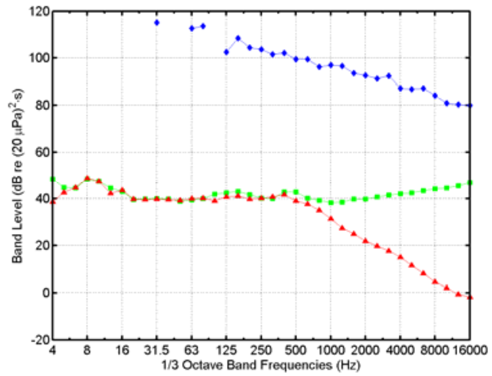


FIGURE B-1. (A) Pressure waveform and (B) one-third octave band levels for a GQM flight (first missile of a dual launch) at 11:30:00 on 29 September 2011.

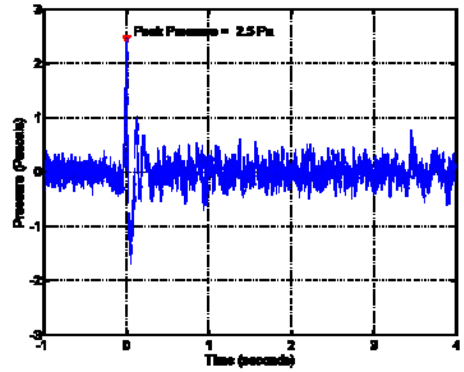
In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).



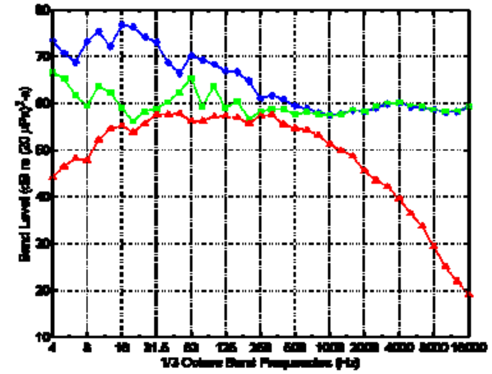
Dos Coves - A



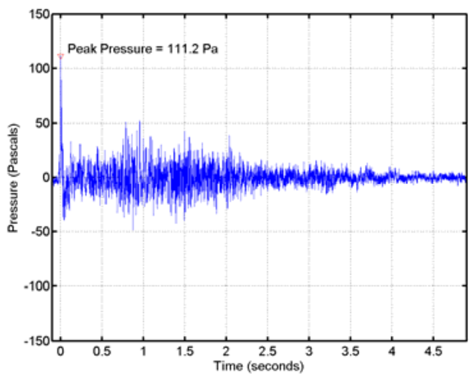
Dos Coves - B



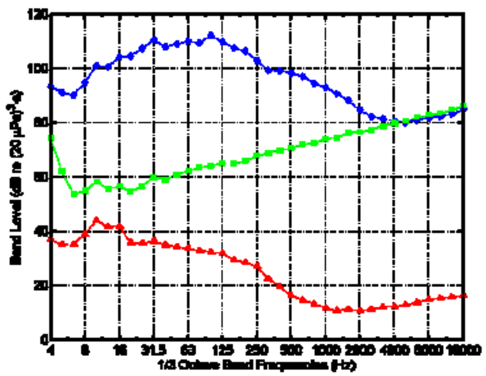
Phoca Reef - A



Phoca Reef - B



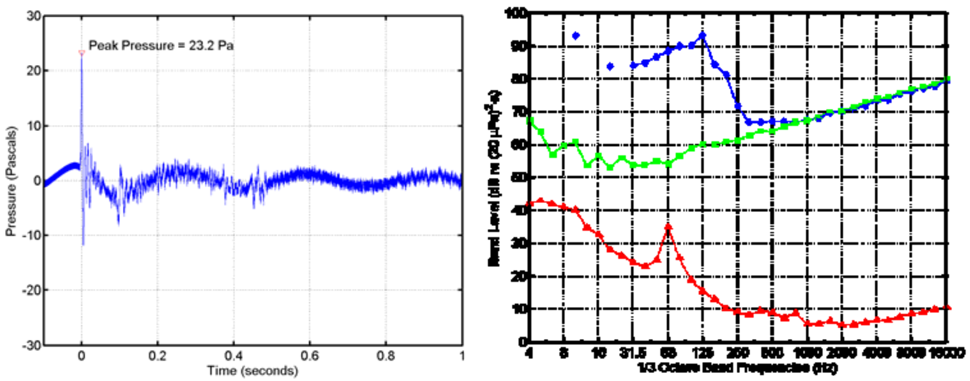
Launch Pad - A



Launch Pad - B

FIGURE B-2. (A) Pressure waveform and (B) one-third octave band levels for a GQM flight (second missile of a dual launch) at 11:30:05 on 29 September 2011.

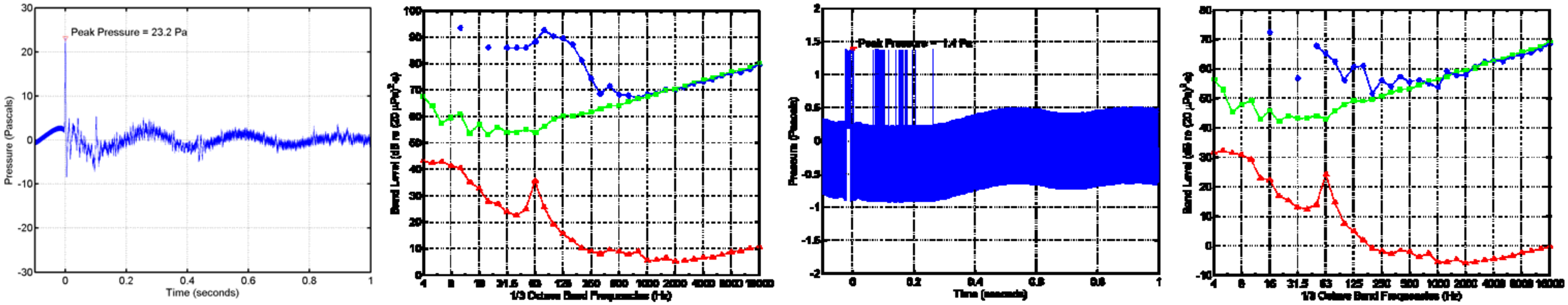
In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).



Launch Pad - A Launch Pad - B

FIGURE B-3. (A) Pressure waveform and (B) one-third octave band levels for a Medusa flight (first missile of a dual launch) at 12:53:00 on 3 November 2011.

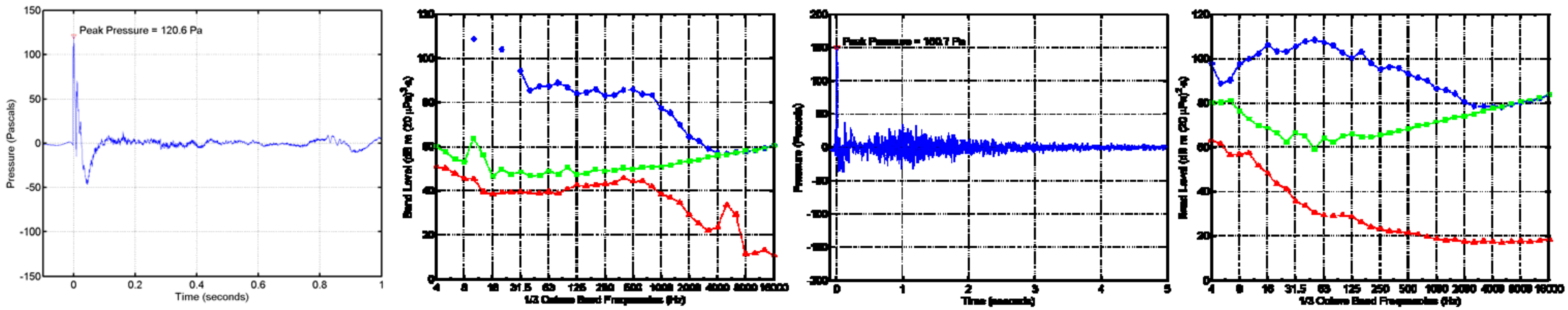
In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).



Launch Pad - A   Launch Pad – B   Impact – A   Impact – B

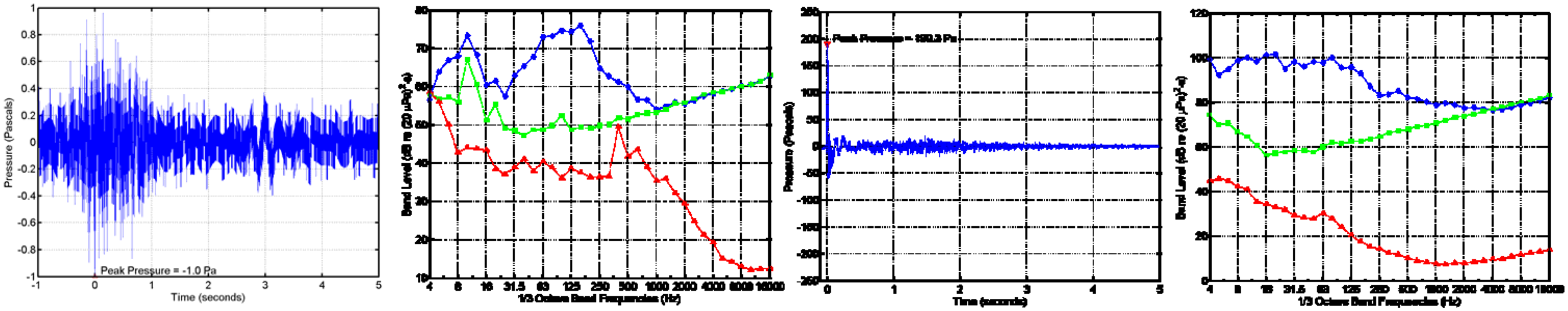
FIGURE B-4. (A) Pressure waveform and (B) one-third octave band levels for a Medusa flight (second missile of a dual launch) and live warhead impact (~2 km offshore) at 12:53:15 on 3 November 2011.

In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).



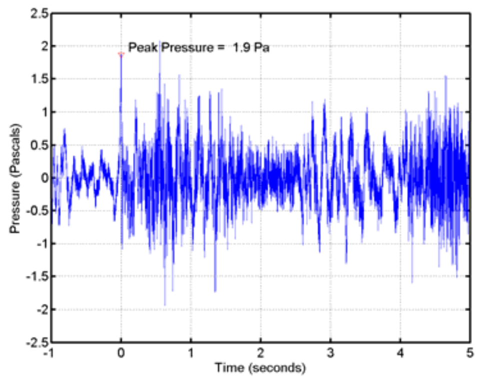
Dos Coves - A Dos Coves - B Launch Pad - A Launch Pad - B

FIGURE B-5. (A) Pressure waveform and (B) one-third octave band levels for a GQM flight at 09:30 on 7 December 2011. In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

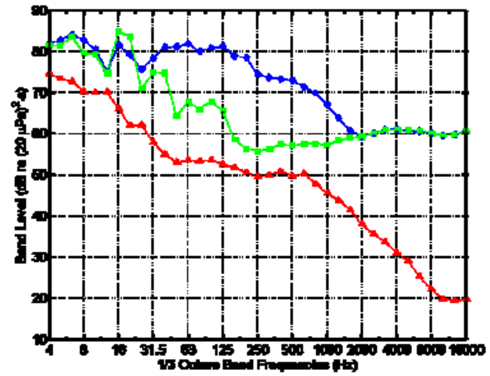


Dos Coves - A | Dos Coves - B | Launch Pad - A | Launch Pad - B

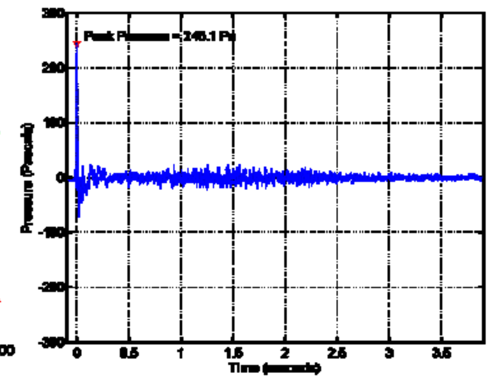
FIGURE B-6. (A) Pressure waveform and (B) one-third octave band levels for a GQM flight at 12:45 on 7 December 2011.
In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).



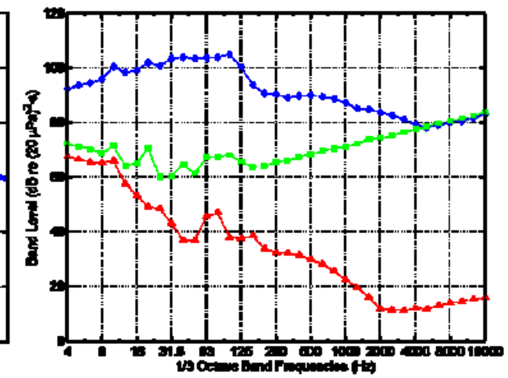
Dos Coves - A



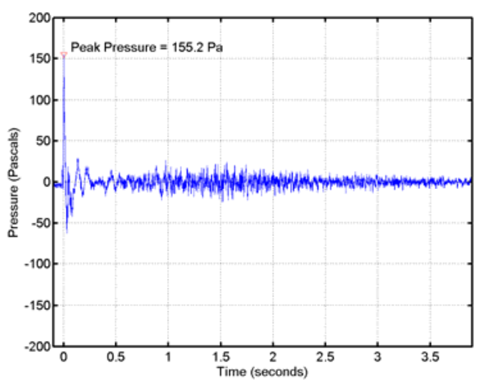
Dos Coves - B



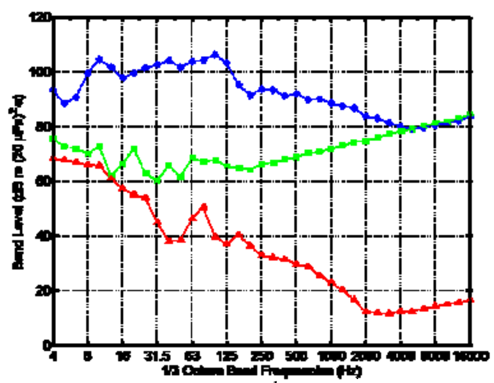
Launch Pad (1st missile) - A



Launch Pad (1st missile) - B



Launch Pad (2nd missile) - A



Launch Pad (2nd missile) – B

FIGURE B-7. (A) Pressure waveform and (B) one-third octave band levels for a Dual GQM flight at 11:02 on 16 December 2011.
In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

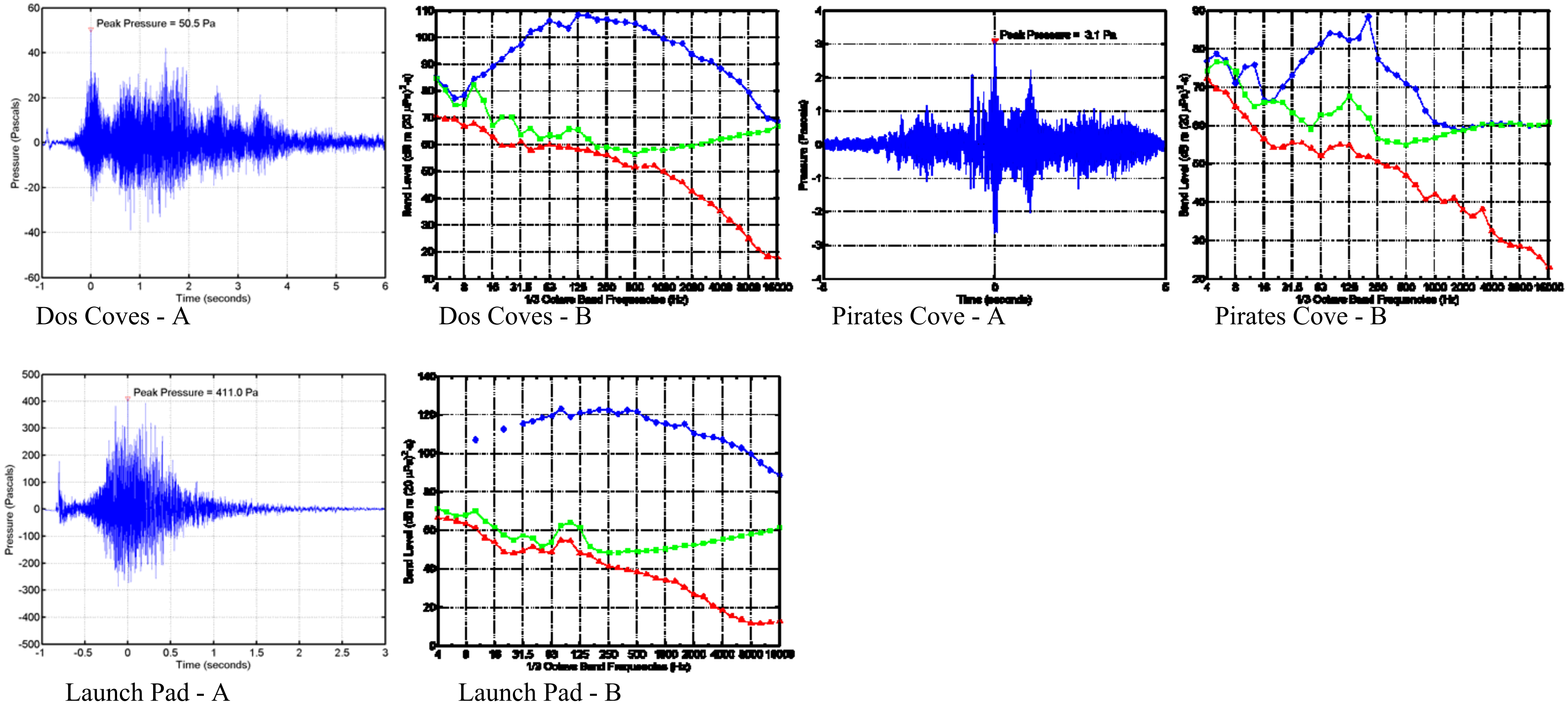
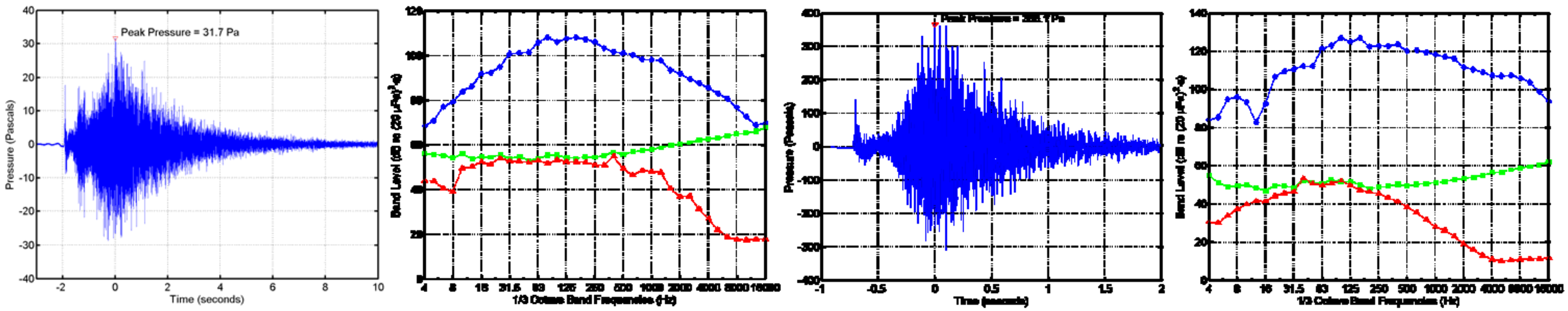
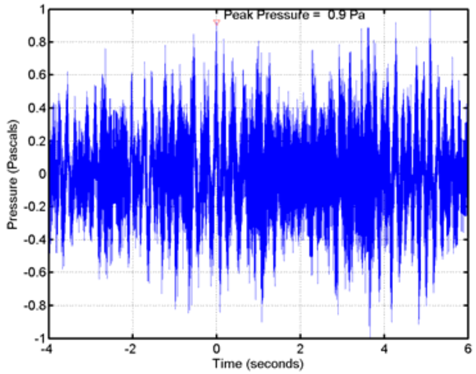


FIGURE B-8. (A) Pressure waveform and (B) one-third octave band levels for a Terrier-Lynx flight at 05:56 on 11 March 2012. In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

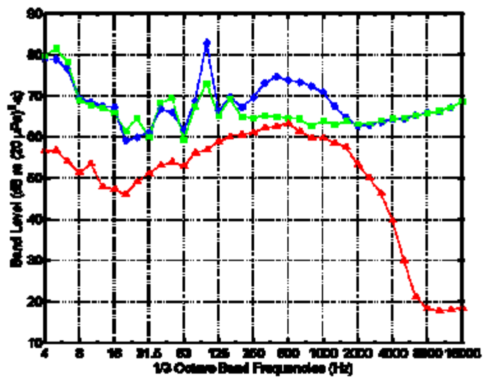


Dos Coves - A Dos Coves - B Launch Pad - A Launch Pad - B

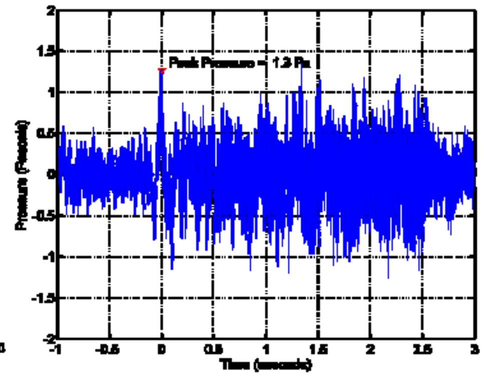
FIGURE B-9. (A) Pressure waveform and (B) one-third octave band levels for a Terrier-Lynx flight at 02:33 on 28 March 2012.
In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).



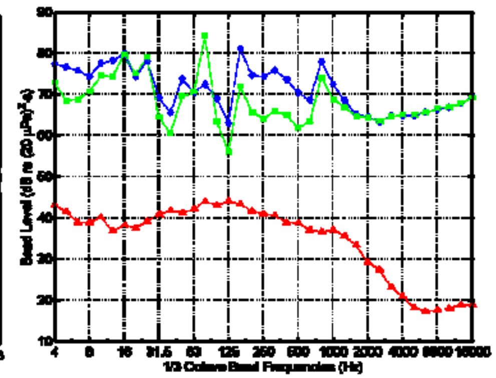
Dos Coves - A



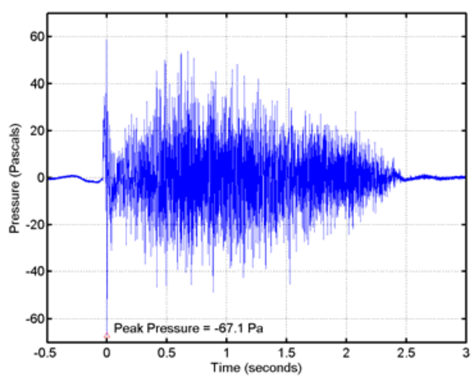
Dos Coves - B



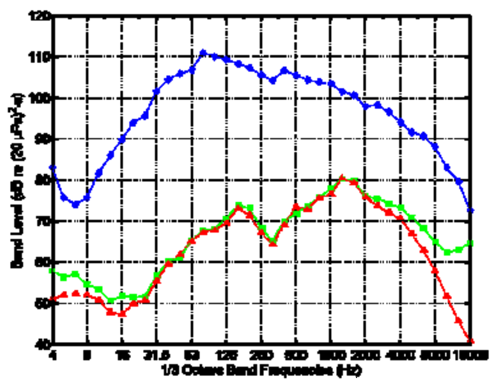
Phoca Reef - A



Phoca Reef - B



Launch Pad - A



Launch Pad - B

FIGURE B-10. (A) Pressure waveform and (B) one-third octave band levels for an MSST flight at 14:45 on 12 June 2012.
In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).