Marine Mammal and Acoustical Monitoring during Missile Launches on San Nicolas Island, California, June 2010 – February 2011

LGL Report TA4896-3

submitted by

LIMITED
environmental research associates

In Association with

Epsilon Systems Solutions, Inc.
9242 Lightwave Ave., Suite 100
San Diego, CA 92123-6404

Under Contract
N68936-07-D-0005
Delivery Order 78

Prepared For

Naval Air Warfare Center Weapons Division
Point Mugu, California

For Submittal To

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

Submitted
June 1 2011

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by

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Suggested format for citation:

Holst, M. and C.R. Greene, Jr. 2011. Marine mammal and acoustical monitoring during missile launches on San Nicolas Island, California, June 2010 – February 2011. LGL Rep. TA4896-3. 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. 63 p.

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ACRONYMS AND ABBREVIATIONS

3-D	3-dimensional
ASL	above sea level
ATAR	Autonomous Terrestrial Acoustic Recorder
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
FOV	field of view (of video camera)
ft	feet
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)
kt	knots or nautical miles per hour
lb	pounds
LOA	Letter of Authorization
m	meter
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)
NAWCWD	Naval Air Warfare Center Weapons Division
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
SEL-M	M_{pa}-weighted sound pressure level
TTS	Temporary Threshold Shift
µPa	micropascal

EXECUTIVE SUMMARY

Naval Air Warfare Center Weapons Division (NAWCWD) currently holds a Letter of Authorization (LOA) issued by the National Marine Fisheries Service (NMFS) on 18 November 2010 allowing non-lethal takes of pinnipeds incidental to the Navy's missile launch operations on San Nicolas Island (SNI), California. The LOA is valid from 1 December 2010 through 30 November 2011. 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 in 2009 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.

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, and June 2010 to June 2011. 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). Three launches occurred between June 2010 and the issuance of the new LOA beginning December 2010. This report includes launches occurring between June 2010 and February 2011. Before any LOAs were issued, two separate Incidental Harassment Authorizations (IHAs) were issued by NMFS; those provided similar incidental take authorization for the periods August 2001 to July 2002 and August 2002 to August 2003.

In the Navy's Petition for Regulations that led to promulgation of 50 CFR 216.151–158, a Marine Mammal 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 monitoring that took place during 2001–2008. Pinniped species that were monitored at 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 reaction to most missile launches at SNI. NMFS accepted this proposed change to the Monitoring Plan (Federal Register vol.75, No. 226 11/24/2010) and issued the new LOA to acknowledge the change; thus, no elephant seals were monitored during June 2010–February 2011.

This report describes the results of the marine mammal and associated acoustic monitoring program for missile launches from SNI during the June 2010–February 2011 period. It includes results from three single launches at SNI in 2010 (9 June, 8 July, and 8 December) and two launches in 2011 (21 and 24 February). Holst et al. (2008) provided corresponding results concerning 77 launches during the period 2001–2008, and Holst and Greene (2010) reported on three launches in 2009 and one launch in May 2010.

The following subsections briefly summarize the monitoring program during the June 2010–February 2011 period. Details are provided in subsequent chapters of this report.

Description of Missile Launches and Monitoring Program

During the June 2010–February 2011 period, five single launches occurred from SNI on five different days. A single Coyote missile was launched during daytime on each of 9 June 2010, 8 July 2010, 8 December 2010, and 24 February 2011, and an Arrow was launched at nighttime on 21 February 2011. Missiles were launched from the Alpha Launch Complex located 190.5 meters (m) above sea level

(ASL) on the west-central part of SNI. The Coyotes were launched at an elevation angle of 14–20º above horizontal and crossed the west end of SNI at altitudes of 914–1036 m. The launch elevation angle for the Arrow is classified and cannot be reported here.

The launch azimuths caused the missiles to pass over or near various pinniped monitoring and acoustic measurement sites where Autonomous Terrestrial Acoustic Recorders (ATARs) and video systems had been 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.

Acoustic Measurements during Missile Launches

Missile flight sounds were measured as received at various locations on the periphery of SNI or near the launcher during the launches conducted during the monitoring period. Recordings of received sound levels were attempted at up to four different locations during each of the launches. For the Coyote launches, flat-weighted sound pressure levels (SPL-f), measured over the 3–20,000 hertz (Hz) bandwidth, were 80.0–132.2 decibels (dB) reference 20 micropascals (re 20 μPa) at sites located 0.8–2.4 kilometers (km) from the closest point of approach (CPA) of the launched missile. The M-weighted (for pinnipeds in air, M_{pa}) sound exposure level (SEL-M) values ranged from 79.1 to 118.4 dB reference 20 micropascal squared second (re 20 $\mu Pa^2 \cdot s$) at those same sites. For the Arrow launch, SPL-f values were 69.2–88.4 dB re 20 μPa, and SEL-M values ranged from 74.7–97.1 re 20 $\mu Pa^2 \cdot s$.

Behavior of Pinnipeds during Missile Launches

Behavior of pinnipeds around the periphery of SNI 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 typically attempted at three sites during each launch, with launch-to-launch variation in the locations monitored. Acoustic measurements were obtained at many of the same locations and times. For each launch, the number, proportion, and (where determinable) ages of the individual pinnipeds that responded in various ways were extracted from the video, along with comparable data for those that did not respond overtly. No evidence of injury or mortality was observed during or immediately succeeding the launches for the monitored pinniped species.

California sea lions

California sea lions were observed during all five launches (total of 12 site-date-launch combinations). During all video recordings of sea lions at sites 0.8–1.8 km from the CPA, most animals observed exhibited startle responses and moved along the beach. Although sea lions showed increased vigilance for a short period after each launch, all age classes settled back to pre-launch behavior patterns within 1 or 2 min of the launch time. At a site 8.8 km from the CPA, sea lions did not show any responses to the launch.

Pacific harbor seals

Pacific harbor seals were monitored at one site during three of the five launches; a fourth recording was attempted, but no Pacific harbor seals were hauled out during the launch. All missiles were launched from the Alpha Launch Complex, situated at least 2 km away from the nearest Pacific harbor seal haul-out site. At a site located 2.4 km from the CPA, some Pacific harbor seals left their haul-out site, but individuals started hauling out again at the same site within 2 min after the launch. At a site 8.8 km from the CPA, Pacific harbor seals did not show any responses to the launch. During previous launch monitoring at sites with CPAs as great as 3.5 km, Pacific harbor seals commonly left their haul-out sites and did not return during the duration of the video-recording period (Holst et al. 2008). Nonetheless, Holst and Lawson (2002) noted that during post-launch monitoring on the days following launches, Pacific harbor seals were usually hauled out again at these sites.

Estimated Numbers of Pinnipeds Affected by Missile Launches

No evidence of pinniped injuries or fatalities related to missile launches was evident, nor was it expected, during the monitoring period. Few, if any, pinnipeds were exposed to SEL-M values above 118.4 dB re 20 $\mu Pa^2 \cdot s$ or peak sound pressure levels above 140.1 dB re 20 µPa. The maximum exposure levels at pinniped beaches were below the levels at which any of the three species would be expected to incur temporary or permanent hearing impairment (*cf.* Southall et al. 2007). Levels near the launcher reached a peak pressure of 144.6 dB re 20 µPa and a SEL-M of 125.8 dB. Although these levels would not be expected to elicit permanent threshold shift (PTS) in any pinniped species, temporary threshold shift (TTS) is possible at the recorded peak pressure level (but not the SEL-M level), particularly in Pacific harbor seals. However, pinniped haul-out beaches were located at least 2 km from the Alpha Launch Complex; thus, pinnipeds were unlikely to have incurred TTS. In the unlikely event that an animal did incur TTS, it would have been mild and reversible.

Pinniped groups generally extended farther along the beach than encompassed by the field of view of the video camera. In these cases, an estimate was made of the total number of individuals that were hauled out on the monitored beaches prior to the launch based on video pans of the area. The proportions of animals in the focal subgroups that were counted as affected during analysis of launch video records were extrapolated to the estimated total number of individuals hauled out in the area to derive a minimum estimate of the total number of pinnipeds affected. An attempt was also made to extrapolate the proportions of animals affected on the monitored beaches to unmonitored haul-out sites. However, this was not always possible, because it was generally unknown which beaches were used as haul-out sites on specific launch dates and how many animals were hauled out. In addition, data from previous launches were used to estimate the number of pinnipeds affected during launch days when no recordings of that species were possible. We considered pinnipeds that left the haul-out site, exhibited prolonged movement, or entered the water, as affected.

Approximately 1074 California sea lions, 16 Pacific harbor seals, and no elephant seals are estimated to have been affected by launches during the June 2010–February 2011 monitoring period. These estimates include animals that left the haul-out site in response to the launch or exhibited prolonged movement. These numbers may be underestimates, because not all pinniped beaches around SNI could be monitored during any given launch, even though extrapolation of data for other potential haul-out sites was attempted. However, it is also possible that some proportion of individuals were affected by more than one launch and thus included more than once in the estimates. Although the behavior of some pinnipeds occurring near the launch azimuths was affected, the lack of evidence of any serious effects on pinnipeds at the monitored sites during this study and previous monitoring periods suggests that any effects of these launch operations were minor, short-term, and localized, with no consequences for local pinniped populations. Thus, it is unlikely that many (if any) pinnipeds on SNI were adversely impacted by the launches.

1. MISSILE LAUNCHES AND MONITORING PROGRAM DESCRIBED

San Nicolas Island (SNI) is located ~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: the 807 Launch Complex is located on the west coast of SNI, 11 meters (m) above sea level (ASL), and the Alpha Launch Complex is located 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 angus-tirostris*), Pacific harbor seals (*Phoca vitulina*), and California sea lions (*Zalophus californianus*).

Naval Air Warfare Center Weapons Division (NAWCWD) currently holds a Letter of Authorization (LOA) issued on 18 November 2010 by the National Marine Fisheries Service (NMFS) allowing non-lethal takes of pinnipeds incidental to the Navy's missile launch operations on SNI (Appendix A). This LOA is valid from 1 December 2010 through 30 November 2011. 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 2008 to October 2008, June 2009 to June 2010, and June 2010 to June 2011. 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 to 3 June 2009). Three launches occurred between June 2010 and the issuance of the new LOA for December 2010. These launches are included as part of this monitoring report. In addition, before any LOAs were issued, two separate Incidental Harassment Authorizations (IHAs) were issued by NMFS; those provided similar incidental take authorization for the periods August 2001 to July 2002 and August 2002 to August 2003. These authorizations, issued by NMFS under the Marine Mammal Protection Act (MMPA), allow the 'take by harassment' of small numbers of northern elephant seals, Pacific harbor seals, and California sea lions during routine launches from Navy-owned SNI.

A Marine Mammal Monitoring Plan was proposed in the Petition for Regulations under which the December 2010–November 2011 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 (Federal Register vol.75, No. 226 11/24/2010) and issued the new LOA to acknowledge the change; thus, no elephant seals were monitored during June 2010–February 2011.

This report describes the results of the marine mammal and associated acoustic monitoring program during the period from June 2010 to February 2011. During that period, a total of five launches of single missiles took place from SNI. Results concerning 77 previous launches during 2001–2008 were reported by Holst et al. (2008), and Holst and Greene (2010) reported on three launches in 2009 and one launch in May 2010.

This report describes the missiles and their launch processes, the associated monitoring program, and the monitoring results for the launches conducted by the Navy at SNI during June 2010–February 2011. This 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].

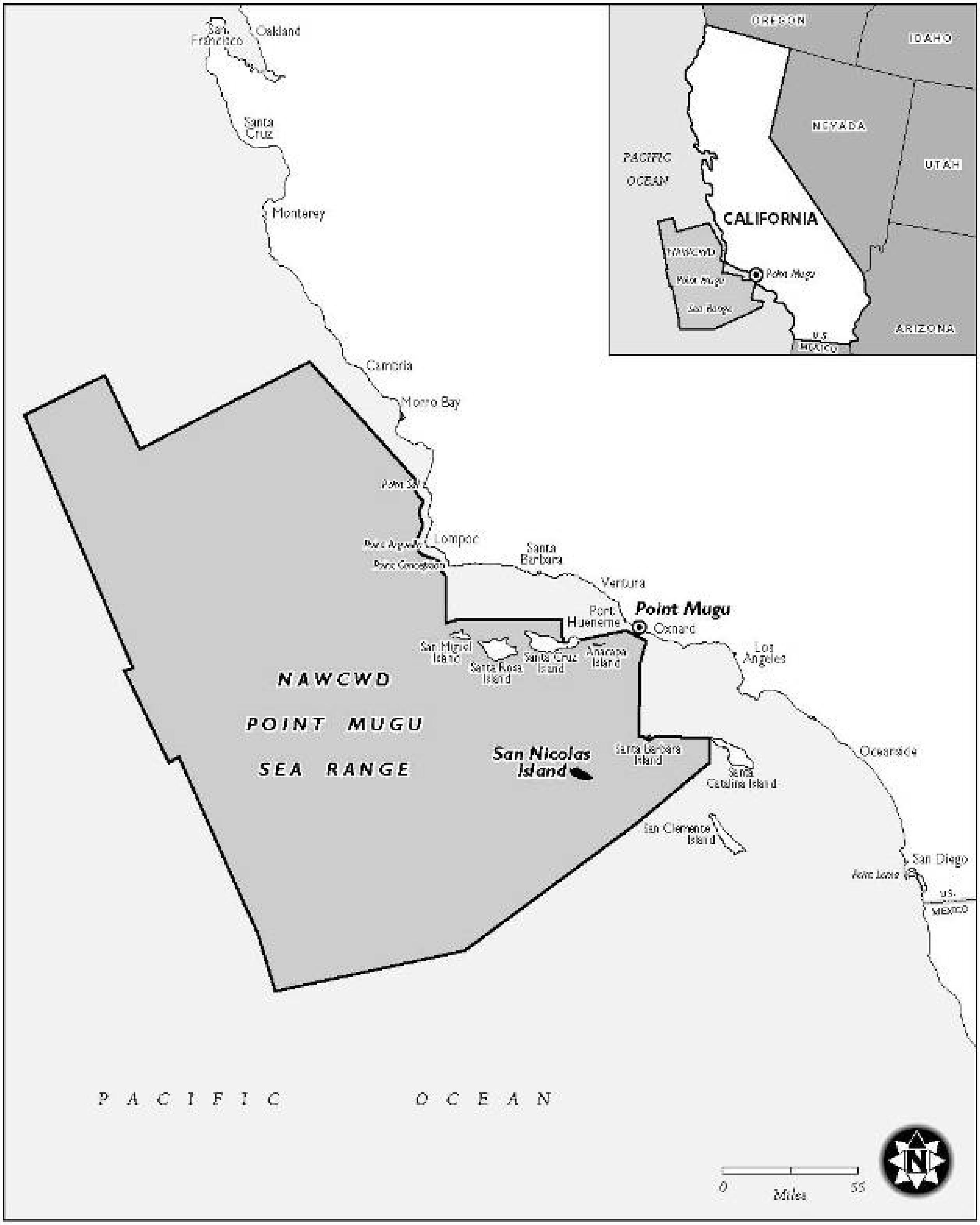

FIGURE 1.1. Regional site map of the Point Mugu Sea Range and San Nicolas Island (map by TEC).

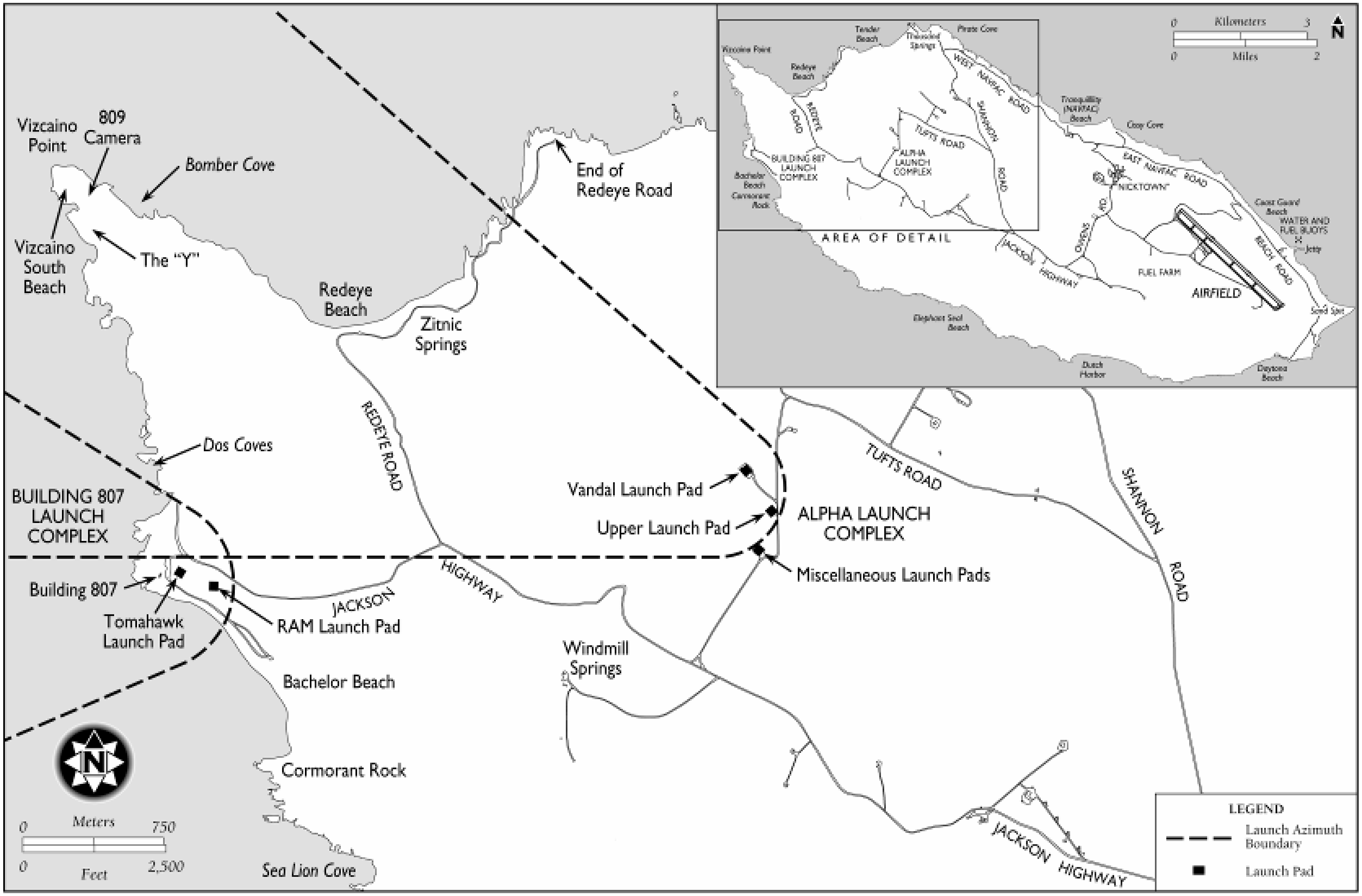

FIGURE 1.2. Map of San Nicolas Island, California, showing the Alpha Launch Complex, the 807 Launch Complex, and the names of adjacent beaches on which pinnipeds are known to haul out. Also shown are the anticipated launch azimuths (dashed lines) for each launch complex. These launch azimuths are typical, although occasionally launch paths could pass outside these boundaries.

1.2 GQM-163A "Coyote" Supersonic Sea-Skimming Target (SSST)

The Navy/Orbital Sciences Corp. GQM-163A "Coyote" SSST 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 SSST was developed to replace the Vandal missile target.

The SSST 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 Subassemblies, and the Front End Subsystem (FES). Included in the FES is an explosive destruct system to terminate flight if required.

The SSST utilizes the unmodified Vandal launcher, currently installed at the Alpha Launch Complex on SNI, with a Launcher Interface Kit (Fig. 1.3). A modified AQM-37C Aerial Target Test Set is utilized for target checkout, mission programming, verification of the missile's ability to perform the entire mission, and homing updates while the missile is in flight.

During a typical launch, booster separation would occur about 5.5 s after launch and about 1.4 nm(2.6 km) downrange, at which time the missile would have a speed of about Mach 2.35 (Orbital Sciences Corp; www.orbital.com). Following booster separation, the GQM-163A's DR ramjet ignites, the missile reaches its apogee, and then dives to 16 ft (5 m) altitude while maintaining a speed of Mach 2.5. During launches from SNI, the low-altitude phase occurs over water west of the island. The target performs pre-programmed maneuvers during the cruise and terminal phases, as dictated by the loaded mission profile, associated waypoints, and mission requirements. During the terminal phase, the SSST settles down to an altitude of 13 ft (4 m) and Mach 2.3 until DR burnout.

1.3 Arrow

The Arrow is a theater missile defense weapon, or anti-ballistic missile (ABM). It was developed in Israel and is designed to intercept tactical ballistic missiles. It is about 23 ft (7 m) long, 2.6 ft (0.8 m) in diameter, and weighs 2866 lbs (1300 kg). It travels at hypersonic speed, and it has high and low altitude interception capabilities. The Arrow consists of three main components: a phased array radar (known as Green Pine), a fire control center (called Citron Tree), and a high-altitude interceptor missile that contains a powerful fragmentation warhead. It also has two solid propellant stages, including a booster and sustainer. The array radar is capable of detecting incoming missiles at a distance of 310 mi (500 km). Once a missile is detected, the fire control center launches the interceptor missile. The interceptor travels at Mach 9 and reaches an altitude of 31 mi (50 km) in less than 3 min.

The first test of an Arrow in the United States was conducted at SNI on 29 July 2004, and another Arrow was launched on 26 August 2004. These missiles were launched at the Alpha Launch Complex, within the area labeled on Figure 1.2 as "Miscellaneous Launch Pads". Another Arrow was launched from SNI on the evening of 21 February 2011 as part of the Arrow System Improvement Program (ASIP); it was successful at intercepting a ballistic target missile.

FIGURE 1.3. GQM-163A SSST with booster and launcher at the Alpha Launch Complex on SNI (photograph by U.S. Navy).

1.4 Missile Launches during the Monitoring Period

During the period June 2010–February 2011 there were a total of five launches from SNI on five separate days (Table 1.1). Single Coyotes were launched during the daytime on 9 June 2010, 8 July 2010, 8 December 2010, and 24 February 2011. The temperature during these launches ranged from 12 to 18°C, with winds up to 15 km/h (Table 1.1). In addition, an Arrow was launched on the night of 21 February 2011.

All missiles were launched from the Alpha Launch Complex. The Coyotes were launched at an azimuth of 280–300º and an elevation angle of 14–20º; the azimuth and elevation angle for the Arrow are classified (Fig. 1.2; Table 1.1). The launch azimuths caused the missiles to pass over or near various acoustic measurement and pinniped monitoring sites where Autonomous Terrestrial Acoustic Recorders (ATARs) and video systems had been deployed. The latter consisted of tripod-mounted digital cameras.

1.5 Acoustical Monitoring of Missile Launches

Audio recordings were attempted to document launch sounds at several distances from the launch trajectories of the missiles; details are given in Chapter 2. 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.

TABLE 1.1. Details of the five launches at SNI during June 2010–February 2011. The weather data were collected at the SNI airport, which is located at an elevation of 152 m ASL toward the east end of the island; therefore weather conditions at pinniped haul-out sites may have differed somewhat.

Launch Date	Launch Time (local)	Missile Type	Launch Complex	Launch Azimuth (true)	Elevation Angle / Altitude Over Beach	Weather at SNI Airport	Video Quality	Audio Quality
9 June 2010	10:00	Coyote	Alpha	300°	14° / 914 m	12°C; winds WSW at 15 km/h	2 cameras ok; 1 poor	3 ATARs ok
8 July 2010	08:45	Coyote	Alpha	280°	20° / 1036 m	18°C; winds NW at 5.5-9 km/h	3 cameras ok	4 ATARs ok
8 December 2010	09:45	Coyote	Alpha	300°	14° / 914 m	Winds N at 13 km/h	2 cameras ok; 1 poor	3 ATARs ok
21 February 2011	22:35	Arrow	Alpha	Classified	Classified	N/A	2 of 2 cameras ok	2 of 2 ATARs ok
24 February 2011	14:36	Coyote	Alpha	300°	14° / 914 m	N/A	1 camera ok; 2 poor	1 of 2 ATARs ok

N/A = not available.

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 were monitored in the first year.

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 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 (Chapter 3) 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 sea lions and Pacific harbor seals 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}.

1.6 Visual Monitoring of Pinnipeds during Missile Launches

The Navy conducted video and visual monitoring of pinnipeds during five missile launches from SNI during the June 2010–February 2011 period, supplemented by simultaneous autonomous audio re-cording of launch sounds (see Chapter 2). The video and visual monitoring provided data on samples of the pinnipeds hauled out on SNI during launches. The accumulation of such data across numerous launches is providing the 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[1] for missile sounds under different launch conditions;
4. ascertain periods or launch conditions when pinnipeds are most and least responsive to launch activities, and
5. document numbers of pinnipeds affected by missile launches and, although unlikely, any mortality or injury.

During the June 2010–February 2011 period, there were four launches involving Coyotes and one launch of an Arrow missile (Table 1.1). 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).

1.7 Estimated Numbers of Pinnipeds Affected

The monitoring programs for the Navy's missile launches were 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, we have assumed that only those animals that met the following criteria would be counted as affected by launches:

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

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

was primarily based on criterion (3) — the number that left the haul-out site, or exhibited prolonged movement or other behavioral changes.

1.8 Summary

From June 2010 to February 2011, NAWCWD conducted five launches from SNI on five different days; the Arrow was launched at night as part of the ASIP. All launches occurred from the Alpha Launch Complex located inland on the central-west part of SNI. An acoustic and visual monitoring program took place during these launches to assess the effects of the operations on Pacific harbor seals and California sea lions. Monitoring procedures were consistent with those for previous launches during 2001–2008 (Holst et al. 2008) and 2009 (Holst and Green 2010). Monitoring procedures and results of the acoustic and visual monitoring for June 2010–February 2011 are described in Chapters 2 and 3.

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 the sounds of each missile, as well as background sounds, were attempted at up to four sites on the island during each missile flight. ATARs, described below, were developed for this purpose by the Navy's acoustical contractor, Greeneridge Sciences Inc. (Greeneridge) of Santa Barbara, California. The ATARs were used to record the launch sounds at places and times where launch safety considerations required that no operator could be present during launches. Maps of the launch azimuths and monitoring locations can be found in Chapter 3 (Fig. 3.1). A total of 14 recordings were attempted during June 2010–February 2011 monitoring period, but only 13 recordings were obtained and analyzed; for the other attempted recording, the event was not captured by the ATAR (Table 2.1).

2.2 Field Methods

2.2.1 Deployment of ATARs

During each launch within the monitoring period, the ATARs were positioned near pinniped haul out sites at varying distances from the planned launch azimuth, specifically at locations where pinniped responses were to be monitored by video methods as well as other locations closer to the launch on occasion (see Chapter 3). The audio 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 during each flight, 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. Additional data acquired during previous and ongoing monitoring will be needed in order to fully meet that objective.

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 the June 2010–February 2011 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 three pinniped haul-out sites (and/or a site near the launcher) at various distances from the launch site and launch trajectory. Over the period since monitoring started (August 2001), the Navy has distributed the ATARs such that, for types of missiles that are launched commonly at SNI, recordings have been made at a variety of different distances and locations relative to the flight trajectories and relative to the launcher itself.

TABLE 2.1. Missile launches and ATAR recording sites at SNI during June 2010–February 2011 (also see Fig. 3.1).

Launch Date	Missile	Elevation Angle (º)	ATAR Locations	# of Acoustic Recording Sites
9 June 2010	Coyote	14	B809, Dos Coves, Near Launcher	3 OK
8 July 2010	Coyote	20	Phoca Reef, Dos Coves, Redeye Beach, Near Launcher	4 OK
8 December 2010	Coyote	14	Phoca Reef, Dos Coves, Near Launcher	3 OK
21 February 2011	Arrow	Classified	Dos Coves, Coast Guard	2 of 2 OK
24 February 2011	Coyote	14	Dos Coves, Coast Guard*	1 of 2 OK

* Launch event ATAR recording not attempted due to classified nature of launch.

2.2.2 ATAR Design

The ATARs are designed to record continuously and unattended for up to 13 hours (hr). It was necessary to use autonomous extended-duration recorders because safety considerations required 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 if prolonged launch delays occur.

The ATARs are designed to 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 con-currently, 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.

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). These signal conditioners are kept in waterproof backpacks with the other equipment, excluding the microphones (Fig. 2.1 and 2.2).

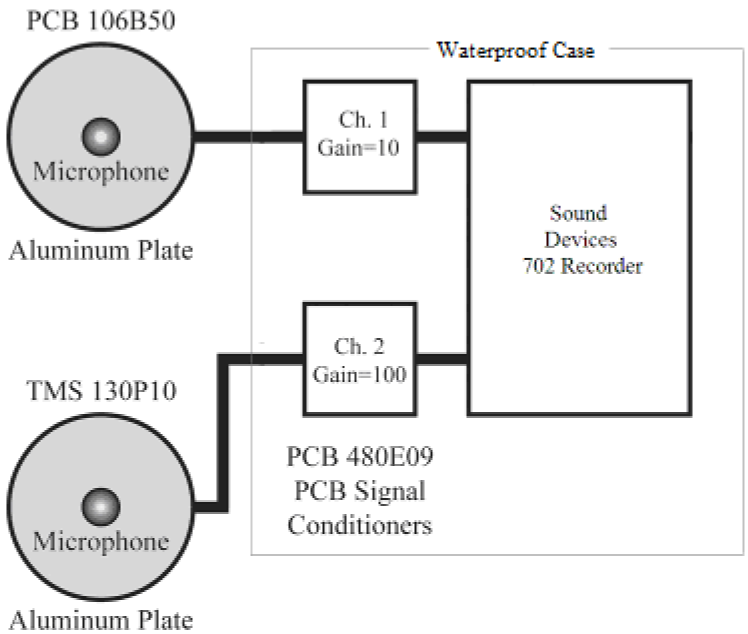

FIGURE 2.1. Block diagram of an Autonomous Terrestrial Acoustic Recorder (ATAR).

At each of the monitoring sites, the microphones were placed in hemispherical windscreens and positioned so they were 2–3 millimeters (mm) from the flat side of the hemisphere. Each windscreen was then affixed to the center of an aluminum base plate 6 mm thick and 56 cm in diameter. The two base plates were set on the ground or sand in an area generally free of vegetation (Fig. 2.3). The purpose of the aluminum base plates was 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).

Setting optimum recording levels presented a challenge, given that these had to be set in advance of the launch, with no opportunity to make adjustments based on initial results at that location. Setting recording levels too high would result in clipping the desired signal; setting them too low would lose the signal beneath recorder self-noise; and setting them dynamically by automatic gain control would result in uncalibrated, and hence useless, data.

During previous monitoring periods, it was observed that ATARs would sometimes not operate at certain sites despite repeated attempts, but after being moved a fraction of a kilometer away, they operated successfully on the first try. The ATARs did not fail when tested either in the laboratory at SNI or in Santa Barbara. We suggested that microwave or other electromagnetic radiation on the island, from the numerous radar and telemetry systems present there, may produce sporadic but potentially intense electromagnetic interference and cause the ATARs to fail at some times and places on SNI. Therefore, since 2004, shielding and grounding have been applied, and this has been successful in reducing the frequency of ATAR failures.

FIGURE 2.2. Photo of ATAR components in waterproof backpack (photograph by J. Ugoretz, U.S. Navy).

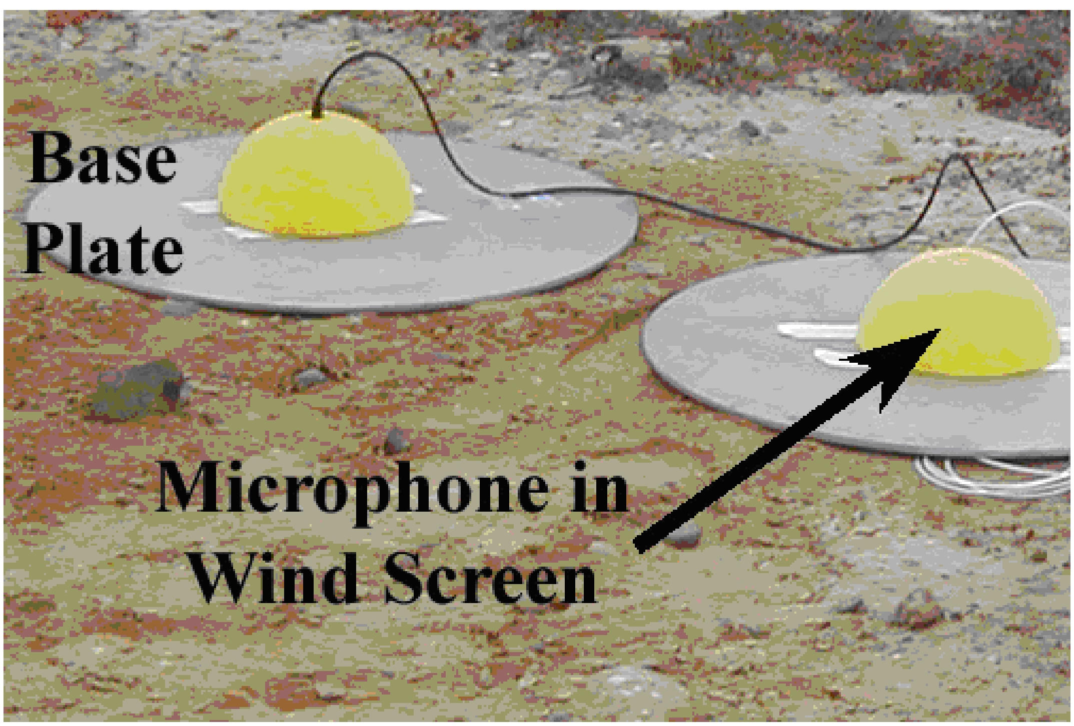

FIGURE 2.3. ATAR microphones at SNI, California (photograph by J. Lawson, LGL).

2.3 Audio and Data Analysis Methods

The ATARs recorded digital data directly onto a Sound Devices 702 recorder. The digital data were copied to a recordable CD-ROM after the recording period and returned to the acoustical contractor for sound analysis.

Both time-series and frequency-domain analyses were 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 recently-defined 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 2009 from the notebook computer 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 the recent recordings near the launch site, 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. We speculate that ignition at launch results 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, the earlier missile flight data recorded before the ATARs were changed in 2009 has been re-processed with the 3-Hz high pass filter.

All analyses required 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:

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

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 was defined as the times associated with the accumulation of 5% and 95% of E.

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

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

Sound pressure was 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 • log (sound pressure).

The **peak instantaneous pressure** was 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** was 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 we defined the "signal" 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 is a recent development that 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.[2] 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 was calculated for each launch date and sound monitoring site.

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[2] 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.

2.4 Results

2.4.1 Missile Flight Sounds

Acoustic monitoring results for all five 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 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.

2.5 Discussion and Summary

During the June 2010–February 2011 period, five missiles were launched from SNI. The sound levels received from the missiles were comparable to those recorded from previous launches at SNI (see Holst et al. 2008). During the current monitoring period, the highest measured sound levels on pinniped haul-out beaches were 118.9 dB re 20 $\mu Pa^2 \cdot s$ SEL on a flat-weighted basis, 118.4 dB re 20 $\mu Pa^2 \cdot s$ on an M_{pa}-weighted basis, and 116.8 dBA SEL (Table 2.2). Sounds of 125.8 dB re 20 $\mu Pa^2 \cdot s$ SEL-M were recorded near the launcher. None of the sounds recorded at haul-out sites or the launcher exceeded 129 dB re 20 $\mu Pa^2 \cdot s$ SEL-M, the energy level at which TTS onset may occur in the Pacific harbor seal (Southall et al. 2007). None of the recorded sounds exceeded the SEL-M (144 dB) or peak pressure (149 dB) at which a slight PTS may occur (Southall et al. 2007). The possibility of TTS and PTS occurring in pinnipeds hauled out on SNI during missile launches is further discussed in Chapter 4.

TABLE 2.2. Pulse parameters for flat-, A-, and M_{pa}-weighted sound from the missile launches at SNI during June 2010–February 2011.

Launch & Monitoring Site	CPA (m)	Flat-weighted sound Pk	Flat SPL	Flat SEL	Flat Dur	A-weighted sound SPL	A SEL	A Dur	M_{pa}-weighted sound SPL	M_{pa} SEL	M_{pa} Dur
9 June 2010: Coyote											
B809‡	1208	140.1	132.2	116.7	0.03	120.0	102.5	0.02	127.7	110.4	0.02
Dos Coves‡	1717	130.0	123.6	111.9	0.07	90.1	83.0	0.20	108.6	95.8	0.05
Near Launcher	96	144.6	123.6	125.2	1.45	104.7	106.0	1.36	114.2	116.2	1.59
8 July 2010: Coyote											
Phoca Reef‡	2416	101.0	81.1	89.8	7.41	62.8	70.5	5.90	70.7	79.1	6.89
Dos Coves‡	1014	138.0	129.1	118.0	0.08	103.4	99.3	0.40	118.4	107.4	0.08
Redeye Beach‡	822	139.0	117.7	118.9	1.34	115.4	116.8	1.39	117.1	118.4	1.35
Near Launcher	174	142.2	124.7	128.3	2.28	118.1	121.0	1.95	122.2	125.8	2.32
8 December 2010: Coyote											
Phoca Reef‡	2428	99.2	80.0	91.0	12.70	71.2	80.1	7.83	77.5	86.8	8.51
Dos Coves‡	1747	132.5	117.7	113.2	0.36	89.8	89.8	0.99	102.7	99.2	0.45
Near Launcher	176	141.0	116.7	120.1	2.19	99.0	101.7	1.86	108.8	111.8	2.00
21 February 2011: Arrow											
Dos Coves	N/A	107.0	88.4	99.6	13.4	81.2	90.7	8.90	86.7	97.1	11.01
Coast Guard	N/A	86.4	69.2	81.0	15.2	53.5	58.7	3.38	63.0	74.7	14.80
24 February 2011: Coyote											
Dos Coves‡	1748	137.7	117.0	116.7	0.93	113.8	117.1	2.12	116.4	118.2	1.53
Coast Guard	8801		N/A				N/A			N/A	

N/A = data not available. 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. ‡ Sonic boom evident.

TABLE 2.3. Broadband (10–20,000 Hz) sound levels (in dB re 20 μPa) as recorded before the launch by the high-sensitivity sensor designed to measure ambient sounds.

Date	Missile	Site	Flat-weighted	A-weighted	M_{pa}-weighted
9 June 2010	Coyote	B809	77.8	46.6	60.8
		Dos Coves	69.2	46.3	54.4
		Near Launcher	56.3	24.2	34.9
8 July 2010	Coyote	Phoca Reef	47.5	41.9	44.6
		Dos Coves	65.2	62.0	64.6
		Redeye Beach	87.4	74.1	79.1
		Near Launcher	61.4	21.9	35.0
8 December 2010	Coyote	Phoca Reef	63.6	51.8	58.6
		Dos Coves	70.7	56.8	60.9
		Near Launcher	79.4	58.8	68.3
21 February 2011	Arrow	Dos Coves	65.1	55.9	60.5
		Coast Guard	48.7	41.2	44.9
24 February 2011	Coyote	Dos Coves	79.3	51.6	56.6
		Coast Guard		N/A	

N/A = data not available.

3. BEHAVIOR OF PINNIPEDS DURING MISSILE LAUNCHES

3.1 Introduction

Three species of pinnipeds are common on the beaches of SNI – California sea lion, Pacific harbor seal, and northern elephant seal. As northern elephant seals have shown little reaction to previous missile launches at SNI and monitoring for elephant seals is not required by the current LOA, only Pacific harbor seals and California sea lions were monitored during the five launches that occurred from June 2010 through February 2011, although elephant seals were sometimes present during launches. No other pinniped species was recorded during the monitoring work, either during the monitoring period or during previous monitoring efforts since August 2001 (Holst et al. 2008).

Due to operation needs, launches in June and July took place when California sea lions were pupping/breeding, and launches in December and February occurred during the pupping/breeding season of elephant seals. The launches in late February occurred at the beginning of the Pacific harbor seal pupping/breeding season. No evidence of injury or mortality 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.

In most cases, sea lion behavior returns to pre-launch states 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 the launches appears similar to the behavior and numbers observed before launches. In contrast, Pacific harbor seals commonly leave their haul-out sites to enter the water and do not return during the duration of the video-recording (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.

3.2 Field Methods

The launch monitoring program was based primarily on remote video recordings. Remote cameras were 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 digital cameras that can be set up temporarily at any location.

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 during the launches, though northern elephant seals were present at some monitored locations.

TABLE 3.1. Video data collected for California sea lions and Pacific harbor seals during missile launches at SNI during June 2010–February 2011.

	Launch Date / Missile Type				
Video Recording Location	9 June 2010 Coyote	8 July 2010 Coyote	8 December 2010 Coyote	21 February 2011 Arrow	24 February 2011 Coyote
California Sea Lion					
Dos Coves West End			x		
Dos Coves East End			x*		
Dos Coves	x*	x		x+	x*
Dos Coves High on Shelf	x				
B809	x				
Redeye Beach		x			
Coast Guard above Borrow Pit				x+	x
Dos Coves – Cliff					x*
Pacific harbor seal					
Phoca Reef		x	x†		
Coast Guard above Borrow Pit				x+	x

'x' recording obtained; † No seals present at time of launch. * Lens fogged; poor recording. + Low-light conditions; nighttime launch.

Navy biologists placed up to three cameras at locations overlooking haul-out sites prior to each launch. Placement was such that disturbance to pinnipeds was minimized to the extent possible. The entire haul-out aggregation at a given site could not be recorded, as the wide-angle view necessary to encompass an entire beach would not allow detailed behavioral observations. Thus, the cameras were set to record a focal subgroup within the haul-out aggregation.

For the combined pinniped and acoustic monitoring, the Navy usually attempts to obtain video and audio records from three locations at different distances from the missile flight path during each launch from SNI. Figure 3.1 shows the monitoring locations relative to the launch azimuths for June 2010–February 2011. Combined pinniped and acoustic monitoring is important to ascertain the lateral extent of the disturbance effects and the "dose–response" relationship between sound levels and pinniped behavioral reactions. Given the variability in types of missiles launched at SNI, in sound propagation, and in pinniped behavioral reactions, this analysis requires data from a relatively large number of launches. The limited number of launches (of different types) during the current monitoring period did not, by itself, provide sufficient data for such an analysis. To investigate the dose–response relationships, acoustic and pinniped response data from the current monitoring period will need to be combined with corresponding data from previous monitoring; a preliminary analysis of dose–response relationships using data collected from 2001 to 2008 was presented by Holst et al. (2008).

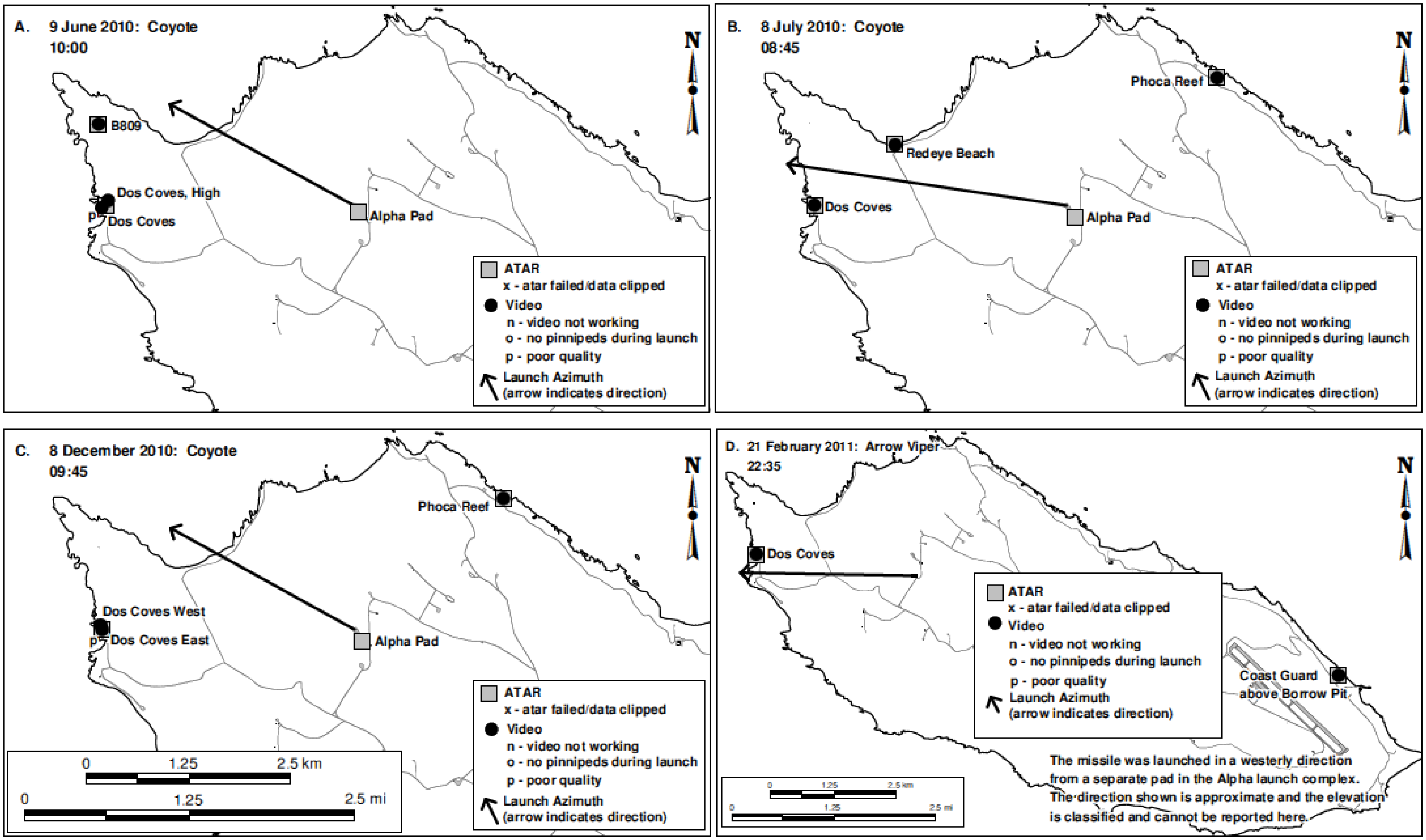

FIGURE 3.1. Launch azimuths, acoustic recording sites (ATARs), and video recording sites for launches at SNI during the June 2010–February 2011 monitoring period.

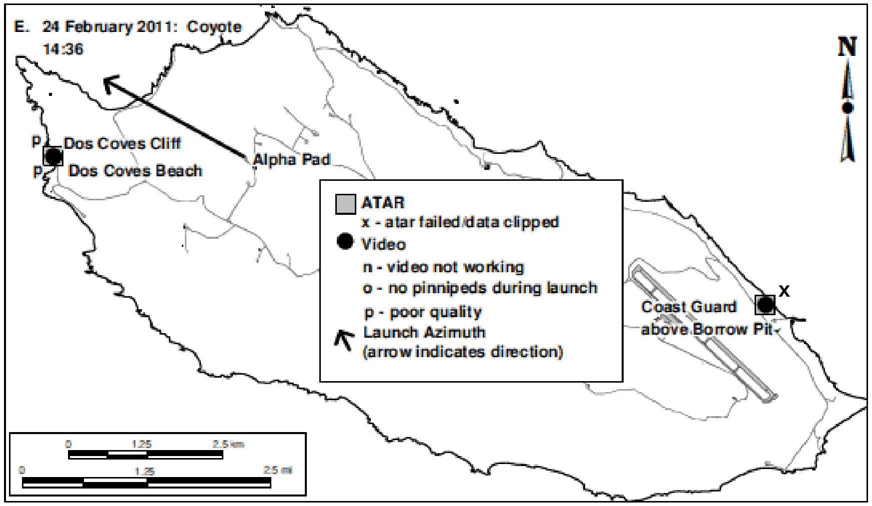

FIGURE 3.1. Continued.

3.2.1 Mobile Cameras

Prior to daytime launches, Navy biologists placed up to three portable Sony Handicam video cameras (DCR-SR100) on tripods that overlooked haul-out sites. Missile and other sounds detected by the microphones built into these cameras were also recorded. These audio data were used during behavioral analyses (e.g., to confirm the exact time when the missile passed), but were uncalibrated and not of sufficient quality to provide launch sound information.

3.2.2 FLIR Cameras

Prior to the nighttime launch, Navy personnel placed two FLIR Systems HS-324 Command thermal imaging cameras to overlook haul-out sites (Fig. 3.2). The thermal imaging cameras, made by FLIR Systems, Inc., have a field of view of 24°×18°. When a FLIR-HS-2X Extender 2X extender lens is used with the cameras, the field of view is 12°×9°. The cameras record video data internally onto a Secure Digital (SD) card and can store more than 5 hours of video but do not collect or record audio data.

3.2.3 Visual Observations

Video observations were obtained before, during, and after each missile launch. Navy biologists from NAWCWD, Point Mugu, Range Department, made 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 included the local weather conditions, types and locations of any pinnipeds hauled out, and the type of launch activity planned. The time (to the second) is shown superimposed on the video recordings. The video continued recording for ~15–60 min after the launch. Observations during that period were used to 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.

3.3 Video and Data Analysis

Digital video data were copied to DVD-ROMs to facilitate transport and playback and for backup. Video records were then transferred from the Navy to LGL Ltd., environmental research associates (LGL), for analysis. Subsequent to the launch, an experienced biologist (MH) reviewed and coded the video data on the DVD-ROMs as they were played back to 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) ages of the individuals that responded in various ways were extracted from the video, along with comparable data for those that did not respond overtly. (Following NMFS [2002], subtle behavioral reactions that persisted for only a few minutes were considered unlikely to have biologically significant consequences for the pinnipeds.)

The following variables concerning the circumstances of the observations were extracted from the videotape or from direct observations at the site:

1. study location;
2. local time;
3. substratum type—a categorical description of the substratum upon which the focal group of pinnipeds was resting (sand, cobble, rock ledges, or water less than 1 m deep);
4. substratum slope (0-15º, >15º, or irregular), estimated from the video records;

FIGURE 3.2. Photo of FLIR camera set-up at SNI (photograph by J. Ugoretz, U.S. Navy).

5. weather, including an estimate of wind strength and direction, and presence of precipitation; these data were made available by the Navy meteorological unit;
6. horizontal visibility—the average horizontal visibility (in m) around the focal subgroup of pinnipeds, as determined by meteorological conditions and/or physical obstructions; this was estimated by identifying the farthest visible object relative to the interacting pinnipeds, as evident from the known positions of local objects and accounting for obstructing terrain; and
7. tide state—exact time for local high tide was determined from relevant tide tables.

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.

3.4 Descriptions of Pinniped Behavior during Specific Launches

The following subsections provide overall descriptions of pinniped responses and notable reactions during each launch in the monitoring period. Corresponding descriptions concerning pinniped responses to launches in 2001–2008 and 2009–2010 were reported by Holst et al. (2008) and Holst and Greene (2010), respectively. Video recordings of pinniped behavior during launches from June 2010–February 2011 were 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 eight different sites (12 site-date-launch combinations), and Pacific harbor seals were observed at two different sites (three site-date-launch combinations; Table 3.1). The video recordings generally provided data on the responses of a sample of the total pinnipeds present on a given beach.

3.4.1 Coyote Launch, 9 June 2010

A Coyote missile was launched from the Alpha Launch Complex, with an azimuth of 300º and a 14º elevation angle (Fig. 3.1A). Video recordings of California sea lions were obtained at B809 (CPA = 1.2 km), Dos Coves (CPA = 1.8 km) and Dos Coves High on Cliff (CPA = 1.7 km) (Table 3.1). The video quality was poor at Dos Coves High on Shelf because the camera lens fogged before the launch.

ATARs were deployed at two sites (B809, Dos Coves) where video recordings of pinnipeds were attempted, as well as near the launcher (Fig. 3.1A; Tables 2.2 and 2.3). The sounds from the launch were clearly audible on the audio channel of all video recordings.

California Sea Lions.—Prior to the launch, as observed near B809, several hundred sea lions (mostly females, but some adult males and pups) were hauled out. During the launch, 46 sea lions (44 females, 1 adult male, and 1 pup) were observed on the beach. All sea lions startled and moved along the beach in response to the launch; 35 sea lions moved out of the field of view (FOV) of the camera (several meters; Table 3.2). Although it could not be determined whether these animals entered the water, it is unlikely, as they were hauled out on the ledge above the water. The remaining individuals settled within ~1 min.

High up on the shelf at Dos Coves, hundreds if not 1000 or more California sea lions were observed to be hauled out before the launch. During the launch, 32 sea lions were monitored. All 32 sea lions moved down the slope and left the FOV (~20 m) in response to the launch, and another 11 sea lions entered the FOV (Table 3.2). It was not possible to determine whether any sea lions entered the water in response to the launch.

Prior to the launch, hundreds of California sea lions were hauled out at Dos Coves, including females, pups, and adult males. In addition, ~20 elephant seals were hauled out. Just before the launch, the camera lens fogged, so detailed observations during the launch were not possible. However, hundreds of California sea lions were still hauled out during the launch. Most sea lions were startled during the launch and moved along the beach; ~100 of those individuals moved more than 10 m along the beach (Table 3.2). However, it was not possible to determine whether any sea lions entered the water. In addition, two northern elephant seals moved 3–5 m in response to the launch.

3.4.2 Coyote Launch, 8 July 2010

A Coyote missile was launched from the Alpha Launch Complex, with an azimuth of 280º and a 20º elevation angle (Fig. 3.1B). Video recordings of California sea lions were made at Dos Coves (CPA = 1.0 km) and Redeye Beach (CPA = 0.8 km), and Pacific harbor seals were observed at Phoca Reef (CPA = 2.4 km) (Table 3.1).

ATARs were deployed at three sites (Dos Coves, Phoca Reef, Redeye Beach) where pinnipeds were observed, and also near the launcher (Fig. 3.1B; Tables 2.2 and 2.3). The sounds from the launch were audible on the audio channel of all video recordings.

TABLE 3.2. Details of missile launches, SELs, and California sea lion reactions at SNI during June 2010–February 2011. All launches occurred from the Alpha Launch Complex.

Launch Date	Launch Time (local)	Missile Type	Launch Azimuth	Elevation Angle / Altitude Over Beach	Pinniped Monitoring Site	3-D CPA distance (m)	SEL [dB re 20 $\mu Pa^2 \cdot s$] flat-/ M_{pa}-weighted	Behavioral Reaction of Animals to Launch
9 June 2010	10:00	Coyote	300°	14° / 914 m	B809[s]	1206	117/110	46 sea lions monitored; all startled and moved along beach. 35 left FOV (several meters); remaining sea lions settled within ~1 min. Could not determine if any animals entered water.
“	“	“	“	“	Dos Coves[s]	1765	112/96	Poor video quality. Several hundred sea lions monitored. Most sea lion startled and moved along the beach; 100 moved >10 m. Could not determine if any animals entered water.
“	“	“	“	“	Dos Coves High on Shelf[s]	1662	112/96*	32 sea lions monitored; all startled and moved out of FOV (~20 m). Could not determine if any animals entered water. 11 entered FOV.
8 July 2010	08:45	Coyote	280°	20° / 1036 m	Dos Coves[s]	1015	118/107	170 sea lions monitored; all looked and moved along beach. 26 sea lions left FOV (~6 m). Could not determine if any animals entered water. Sea lions settled within ~2 min.
“	“	“	“	“	Redeye Beach[n]	822	119/118	14 sea lions monitored; all startled and moved along beach. 13 left FOV (6-10 m) and 2 entered FOV. Could not determine if any animals entered water, but seems very likely.
8 December 2010	09:45	Coyote	300°	14° / 914 m	Dos Coves West End[s]	1720	113/99	61 sea lions monitored; all startled and most moved along beach. 30 sea lions entered water, and another 40 entered FOV and subsequently entered water. Sea lions settled within ~2 min.
“	“	“	“	“	Dos Coves East End[s]	1747	113/99*	Poor video quality. About 110 sea lions hauled out during launch, ~60% moved, and 50% entered the water.

[n] monitoring site was located north of the launch azimuth. [s] monitoring site was located south of the launch azimuth. N/A = not available, FOV = field of view of camera.
* sound measured nearby.

TABLE 3.2. Continued….

Launch Date	Launch Time (local)	Missile Type	Launch Azimuth	Elevation Angle / Altitude Over Beach	Pinniped Monitoring Site	3-D CPA distance (m)	SEL [dB re 20 µ$Pa^2 \cdot s$] flat-/ M_{pa}-weighted	Behavioral Reaction of Animals to Launch
21 February 2011	22:35	Arrow	Classi -fied	Classified	Dos Coves[c]	N/A	100/97	Low-light conditions; 80 sea lions hauled out during launch. All startled during launch, 75 moved, and 27 entered water. An additional 40 sea lions entered the FOV and 21 of those entered the water. Remaining sea lions settled within ~1 min after launch.
"	"	"	"	"	Coast Guard[e]	N/A	81/75	Low-light conditions. About 15 sea lions hauled out during launch; did not respond to launch.
24 February 2011	14:36	Coyote	300°	14° / 914 m	Dos Coves Cliff[s]	1748	117/118*	Very poor video quality. About 100 sea lions hauled out, but could not make any observations during the launch.
"	"	"	"	"	Dos Coves[s]	1748	117/118	Poor video quality. About 150 sea lions hauled out; most if not all startled and ~90% moved along the beach, and 75% may have entered the water. Remaining sea lions settled within ~1 min.
"	"	"	"	"	Coast Guard[e]	8801	N/A	10 sea lions monitored; did not react to launch.

[n] monitoring site was located north of the launch azimuth. [s] monitoring site was located south of the launch azimuth. [c] monitoring site was located close to the launch azimuth (classified). [e] monitoring site was located far to the east, in the opposite direction of the launch azimuth. N/A = not available, FOV = field of view of camera. * sound measured nearby.

California Sea Lions.—Prior to the launch, >200 sea lions (including adult females, pups, and adults males) were hauled out at Dos Coves. During the launch, 170 sea lions (mostly adult females and pups, but 6 adult males) were observed on the beach, as well as one elephant seal. During the launch, nearly all sea lions startled and moved along the beach in response to the launch; 26 sea lions moved out of the FOV (~6 m) and likely entered the water, but this could not be confirmed (Table 3.2). Another 20 sea lions entered the FOV. Sea lions settled within ~2 min. The one observed elephant seal looked up during the launch, but did not move.

At Redeye Beach, 17 California sea lions were hauled out before the launch. During the launch, 14 California sea lions were observed, including adult males and females, but no pups. All sea lions startled and moved along the beach in response to the launch; 13 sea lions left the FOV (6–10 m) and likely entered the water although this could not be confirmed (Table 3.2). Two additional sea lions entered the FOV.

Pacific harbor seals.—Twenty-one Pacific harbor seals were monitored at Phoca Reef during the launch. All Pacific harbor seals looked up in response to the launch, and seven entered the water. In addition, one Pacific harbor seal left the FOV, and one Pacific harbor seal moved a short distance (0.5 m); the remaining 11 Pacific harbor seals did not move (Table 3.3). Pacific harbor seals started hauling out again at the same site 2 min. after the launch. After 35 min., the number of hauled out seals had reached pre-launch levels.

3.4.3 Coyote Launch, 8 December 2010

A Coyote missile was launched from the Alpha Launch Complex, with an azimuth of 300º and a 14º elevation angle (Fig. 3.1C). Video recordings of California sea lions were made at the east and west ends of Dos Coves (CPA = 1.7 km). A video recording of Pacific harbor seals was attempted at Phoca Reef, but no animals were hauled out during the launch (Table 3.1). The video quality was poor at Dos Coves East End because the camera lens fogged before the launch.

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

California Sea Lions.—Prior to the launch at Dos Coves West End, it was difficult to see how many sea lions were hauled out on the beach because of glare. During the launch, 61 sea lions (including adult females and pups) were monitored. All sea lions started in response to the launch and most moved along the beach. Thirty sea lions entered the water; pups entered the water first and some adults followed (Table 3.2). Forty additional sea lions entered the FOV and subsequently also entered the water. Sea lions settled within ~2 min.

The camera lens fogged during recording at Dos Coves East End, so it was difficult to observe sea lions on the beach. However, ~110 sea lions were likely hauled out during the launch, and 50% of those entered the water in response to the launch.

3.4.4 Arrow Launch, 21 February 2011

An Arrow missile was launched in a westerly direction from a separate pad in the Alpha Launch Complex. The exact direction and elevation are classified and cannot be reported here (Fig. 3.1D). Video recordings of California sea lions were made at Dos Coves; California sea lions and Pacific harbor seals were monitored at Coast Guard Beach above the Borrow Pit (Table 3.1). As this was a nighttime launch, lighting conditions were poor, but observations were made with relative ease using the FLIR infrared cameras.

TABLE 3.3. Details of missile launches, SELs, and Pacific harbor seal reactions at SNI during June 2010–February 2011. All launches occurred from Alpha Launch Complex.

Launch Date	Launch Time (local)	Missile Type	Launch Azimuth	Elevation Angle / Altitude Over Beach	Pinniped Monitoring Site	3-D CPA distance (m)	SEL [dB re 20 μPa^2 · s] flat-/ M_{pa}-weighted	Behavioral Reaction of Animals to Launch
8 July 2010	08:45	Coyote	280°	20° / 1036 m	Phoca Reef[a]	2417	90/79	21 Pacific harbor seals monitored; all looked up during launch and 7 entered water. 1 left FOV, and another moved a short (0.5 m) distance. Seals started hauling out again after 2 min.
8 December 2010	09:45	Coyote	300°	14° / 914 m	Phoca Reef[a]	2428	91/87	No Pacific harbor seals in FOV during launch, but were seen hauled out on beach later during the day.
21 February 2011	22:35	Arrow	Classi-fied	Classified	Coast Guard[e]	N/A	81/75	Low-light conditions. About 10 seals hauled out during launch; did not respond to launch.
24 February 2011	14:36	Coyote	300°	14° / 914 m	Coast Guard[e]	8801	N/A	45 seals monitored; did not respond to launch.

[e] monitoring site was located to far to the east, in the opposite direction of the launch azimuth. [a] monitoring site was located away from/opposite direction of azimuth. N/A = not available, FOV = field of view of camera.

ATARs were deployed at two sites (Dos Coves, Coast Guard) where video recordings of pinnipeds were made (Fig. 3.1d; Tables 2.2 and 2.3). The FLIR video recordings did not have an audio channel.

California Sea Lions.—Prior to the launch at Dos Coves, ~150 sea lions were hauled out in the area. Approximately 80 California sea lions were monitored during the launch. All startled in response to the launch, and most (75 of 80) moved during the launch; 27 of the sea lions that moved entered the water. Forty additional sea lions entered the FOV during the launch and 21 of those entered the water. In addition, six northern elephant seals were hauled out during the launch; five elephant seals moved a short distance during the launch, but it appeared that they reacted in response to the sea lion movements into the water rather than to the launch itself

Approximately 15 sea lions were monitored at the Coast Guard Beach during the launch. The sea lions showed no overt responses to the launch.

Pacific harbor seals.—Approximately 10 Pacific harbor seals were monitored at the Coast Guard Beach during the launch; the seals showed no overt responses to the launch.

3.4.5 Coyote Launch, 24 February 2011

A Coyote missile was launched from the Alpha Launch Complex, with an azimuth of 300º and a 14º elevation angle (Fig. 3.1E). Video recordings of California sea lions were made at two different locations at Dos Coves (CPA = 1.7 km); California sea lions and Pacific harbor seals were monitored at Coast Guard Beach above the Borrow Pit (CPA = 8.8 km) (Table 3.1). The video quality at Dos Coves and Dos Coves Cliff was poor, because the camera lens fogged prior to the launch.

ATARs were deployed at two sites (Dos Coves, Coast Guard) where video recordings of pinnipeds were made (Fig. 3.1E; Tables 2.2 and 2.3). The sounds from the launch were loudly audible on the audio channel of video recordings at Dos Coves and Dos Coves Cliff, but not at the Coast Guard site.

California Sea Lions.—Prior to the launch at Dos Coves Cliff, it was difficult to see how many sea lions were hauled out (due to topography), but there were probably ~100 sea lions. During the launch, it was impossible to make any observations, as the lens had fogged.

Prior to the launch at Dos Coves, there were ~100 sea lions hauled out and 5 elephant seals. During the launch, it was difficult to see detailed behavior, as the lens had fogged. However, at least 150 sea lions were monitored, all of which startled in response to the launch. Approximately 90% of sea lions moved along the beach when the missile was launched, and 85% showed prolonged movement on the beach or left the FOV of the camera. About 75% of animals may have entered the water, although this could not be confirmed by the video recording. The sea lions that remained within the FOV of the camera settled within ~1 min.

Approximately 10 sea lions were monitored at the Coast Guard Beach. These sea lions were quite active on the beach both before and after the launch. They showed no overt responses to the launch.

Pacific harbor seals.—Approximately 45 seals were monitored at the Coast Guard Beach during the launch. The Pacific harbor seals showed no overt responses to the launch.

3.5 Implementation of Mitigation Measures

Table 3.4 shows a summary of the mitigation measures that were specified by NMFS in the LOA, and how they were implemented during the June 2010–February 2011 monitoring period.

TABLE 3.4. Implementation of mitigation measures during the June 2010–February 2011 monitoring period.

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	None of the launches occurred during the peak pupping season of the Pacific harbor seal
Limit launch activities during other pinniped pupping season	Two launches occurred during the California sea lion pupping season, and three launches occurred during the northern elephant seal pupping season. These launches were time critical, so it was not possible to avoid the pupping seasons.
No launches of missiles at low elevation from Alpha Launch Complex	All missiles launched passed over haul out beaches at altitudes > 396 m.
Avoid multiple launches in quick succession, especially when pups present	No multiple launches in quick succession occurred during the current monitoring period.
Limit launches during nighttime	One launch occurred during nighttime – time critical. The missile was launched as part of the Arrow System Improvement Program.
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.

3.6 Summary

In general, pinniped responses to launches appeared to be similar to those observed during previous monitoring periods (see Holst et al. 2008); Pacific harbor seals and California sea lions reacted strongly to the launches and the few northern elephant seals that were observed during launches showed little reaction to the launches. At all monitored sites located 0.8-1.8 km from the CPA, all California sea lions that were observed during the launches exhibited startle responses and most, if not all, moved around on the beach. Monitoring effort for Pacific harbor seals was limited close to the missiles' CPA, but at a site located 2.4 km from the CPA, all Pacific harbor seals startled, and some individuals entered the water in response to the launch. In contrast to previous monitoring periods, Pacific harbor seals started to haul out again 2 min after the launch.

No evidence of injury or mortality was observed during or immediately succeeding the launches.

4. ESTIMATED NUMBERS OF PINNIPEDS AFFECTED BY MISSILE LAUNCHES DURING JUNE 2010–FEBRUARY 2011

This chapter provides estimates of the numbers of pinnipeds affected by the Navy's missile launches on SNI during June 2010–February 2011, based mainly on information provided in previous chapters of this report.

4.1 Pinniped Behavioral Reactions to Noise and Disturbance

Some of the pinnipeds on the beaches at SNI show 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. 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). However, no injuries were observed. Similarly, during the 2004–2005 monitoring period, several 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 the 2010–2011 monitoring period or earlier monitoring back to August 2001, disturbance rather than injury or mortality is the primary concern in this project. The minimum numbers of pinnipeds on the monitored beaches that might have been affected significantly by the launches were estimated. 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), we have assumed that only those animals that met the following criteria would be counted as affected by the 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 (i.e., since August 2001), and few if any are believed to have received sounds strong enough to elicit TTS (see §4.2, below) with none during this monitoring period. 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 or other behavioral changes.

The numbers of such affected pinnipeds were calculated for the periods during and immediately following the five launches on five separate days during June 2010–February 2011. Disturbance reactions were short-lived for California sea lions and did not appear to extend into subsequent days. Close to the missile CPA, some Pacific harbor seals left their haul-out site during the launch, but started to haul out again 2 min after the launch.

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 Pacific 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 Pacific 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 elephant seals exposed to strong sounds are higher as compared to Pacific 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 Pacific 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 2001–2010, 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 elephant seals may incur TTS as compared to Pacific harbor seals.

During the 2010–2011 monitoring period, SEL-M at pinniped beaches reached up to 118 dB, and peak pressure levels were as high as 139 dB re 20 μPa. Near the launcher, SEL-M reached 126 dB, and the peak pressure level was 145 dB. However, pinniped haul-out beaches are located at least 2 km from the Alpha Launch Complex. Thus, it is unlikely that any animals incurred TTS during the 2010–2011 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 Pacific 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 Pacific 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).

Given the higher TTS thresholds in elephant seals and California sea lions than in Pacific harbor seals, PTS thresholds in those other species are also expected to be higher than in the Pacific harbor seal. Thus, it is unlikely that PTS occurred in sea lions or elephant seals during those launches. Pacific harbor seal haul-out sites are located at least 1 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 2010–2011 monitoring period, none of the sounds were strong enough at pinniped haul-out sites to have induced TTS or 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 near the missile launch azimuths during the launch operations at SNI. 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 (i.e., when the elevation angle at launch was low). 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 during June 2010–February 2011 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. The total numbers of such affected pinnipeds were calculated for the periods during and immediately following the five launches. Disturbance reactions for most California sea lions and Pacific harbor seals appeared to be short-lived and were not expected to extend into subsequent days.

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 at the monitored site 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 unmonitored haul-out sites, because it was generally unknown which beaches were used as haul-out sites on specific launch dates and how many animals may have been hauled out. Thus, the estimates of the numbers of pinnipeds affected by launches are likely underestimates.

For pinniped species that were not monitored on certain launch dates but known to be hauled out on the island at the time of launch in locations close to the launch trajectory, the number of animals affected by launches was estimated based on data from the 2001–2010 monitoring periods. That is, the number of affected animals for the corresponding season and missile type was used, if possible.

Navy biologists did not observe any northern fur seals (*Callorhinus ursinus*) or Guadalupe fur seals (*Arctocephalus townsendi*) on SNI during the 2010–2011 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.

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 µPa)^2·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 one occasion near the launcher, the recorded peak pressure level exceeded the estimated values at which mild TTS may occur in the Pacific harbor seal (143 dB re 20 µPa dB). As Pacific harbor seal haul-out sites are located at least 2 km from the Alpha Launch Complex at SNI, TTS is considered to have been unlikely during the 2010–

2011 monitoring period. In the unlikely event that TTS did occur, it would have been presumably mild and quickly recoverable.

TABLE 4.1. Minimum estimated numbers of pinnipeds potentially affected by launches from the Navy's missile launch program on SNI, June 2010–February 2011. Some individuals were probably affected during more than one launch on a given day.

Launch Date	Missile Type	Monitoring Site	# of Focal Animals Potentially Affected	Total # Potentially Affected in Area
Number of California sea lions potentially affected				
9 June 2010	Coyote	Dos Coves	100	420
"	"	Dos Coves High	32	32
"	"	B809	35	35
8 July 2010	Coyote	Dos Coves	140	186
"	"	Redeye Beach	13	15
8 December 2010	Coyote	Dos Coves West	30	70
"	"	Dos Coves East	55	55
21 February 2011	Arrow	Dos Coves	27	48
"	"	Coast Guard	0	0
24 February 2011	Coyote	Dos Coves	128	128
	"	Dos Coves Cliff	-	*85*
	"	Coast Guard	0	0
	Total number of sea lions potentially affected			**1074**
Number of Pacific harbor seals potentially affected				
9 June 2010	Coyote	Unmonitored sites	-	8
8 July 2010	Coyote	Phoca Reef	8	8
8 December 2010	Coyote	Phoca Reef	0	0
21 February 2011	Arrow	Coast Guard	0	0
24 February 2011	Coyote	Coast Guard	0	0
	Total number of Pacific harbor seals potentially affected			**16**

Note: Numbers in italics are estimates derived from data previously collected during the 2001–2010 monitoring programs (Lawson 2002; Holst 2004b; Holst et al. 2005, 2008; Holst and Greene 2006a,b, 2010), as well as the 2010–2011 monitoring period, for launch dates when monitoring of certain pinniped species did not occur. A dash (-) shows that unknown numbers or were observed at that site during the launch.

Approximately 1074 California sea lions, 16 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 2010–2011 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. In the case of Pacific harbor seals, 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. In the unlikely case that any pinnipeds did incur TTS during launches at SNI, this would have presumably been mild and recoverable.

5. ACKNOWLEDGEMENTS

The 2010–2011 acoustical and marine mammal monitoring work was funded and in part conducted by NAWCWD, Point Mugu, California. It was done under the provisions of an LOA issued by NMFS for the period 1 December 2010 to 30 November 2011. We thank Steve Schwartz, John Ugoretz, Grace Smith, Gina Smith, Lisa Thomas-Barnett, Tony Parisi, and many others at Point Mugu and on SNI for their support, assistance, and very positive approach to the monitoring and mitigation effort. In particular, Grace Smith, Lisa Thomas-Barnett, John Ugoretz, and Steve Schwartz of NAWCWD are instrumental in acquiring and providing the sound and video recordings from SNI, and ancillary visual observations, weather data, and other information. Drs. Steve Schwartz and John Ugoretz of NAWCWD provided comments on the draft monitoring report, as did Rick Spaulding of TEC Inc.

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. Steve Schwartz, John Ugoretz, Grace Smith, Gina Smith, and Lisa Thomas-Barnett at SNI were responsible for setting out the ATARs and video cameras, and for transferring the sound and video data to Greeneridge and LGL, respectively.

At LGL, Ted Elliott assisted with mapping of launches and audio/video recording sites, and Valerie Moulton provided valuable advice on video analysis approaches. Dr. Jack Lawson was principally responsible for the project design and initial project reports. Dr. W. John Richardson of LGL helped with project design and administration.

We are grateful to all concerned.

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APPENDIX A:
LETTER OF AUTHORIZATION FOR
1 DECEMBER 2010 – 30 NOVEMBER 2011

Letter of Authorization[3]

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 at 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, 2010, through November 30, 2011.

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, Conservation, and Education Division, Office of Protected Resources, National Marine Fisheries Service (NMFS) at 301-713-2289 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 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).

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[3] This is a verbatim copy (retyped) of the LOA.

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 Pacific 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 feet [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 feet (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 feet (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 missile.

7. <u>Monitoring Requirements:</u>

(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 this Authorization 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 Pacific 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.

NOV 18 2010

James H. Lecky
Director
Office of Protected Resources
National Marine Fisheries Service

Date

APPENDIX B:
ACOUSTIC DATA FROM THE MISSILE LAUNCHES DURING JUNE 2010 – FEBRUARY 2011

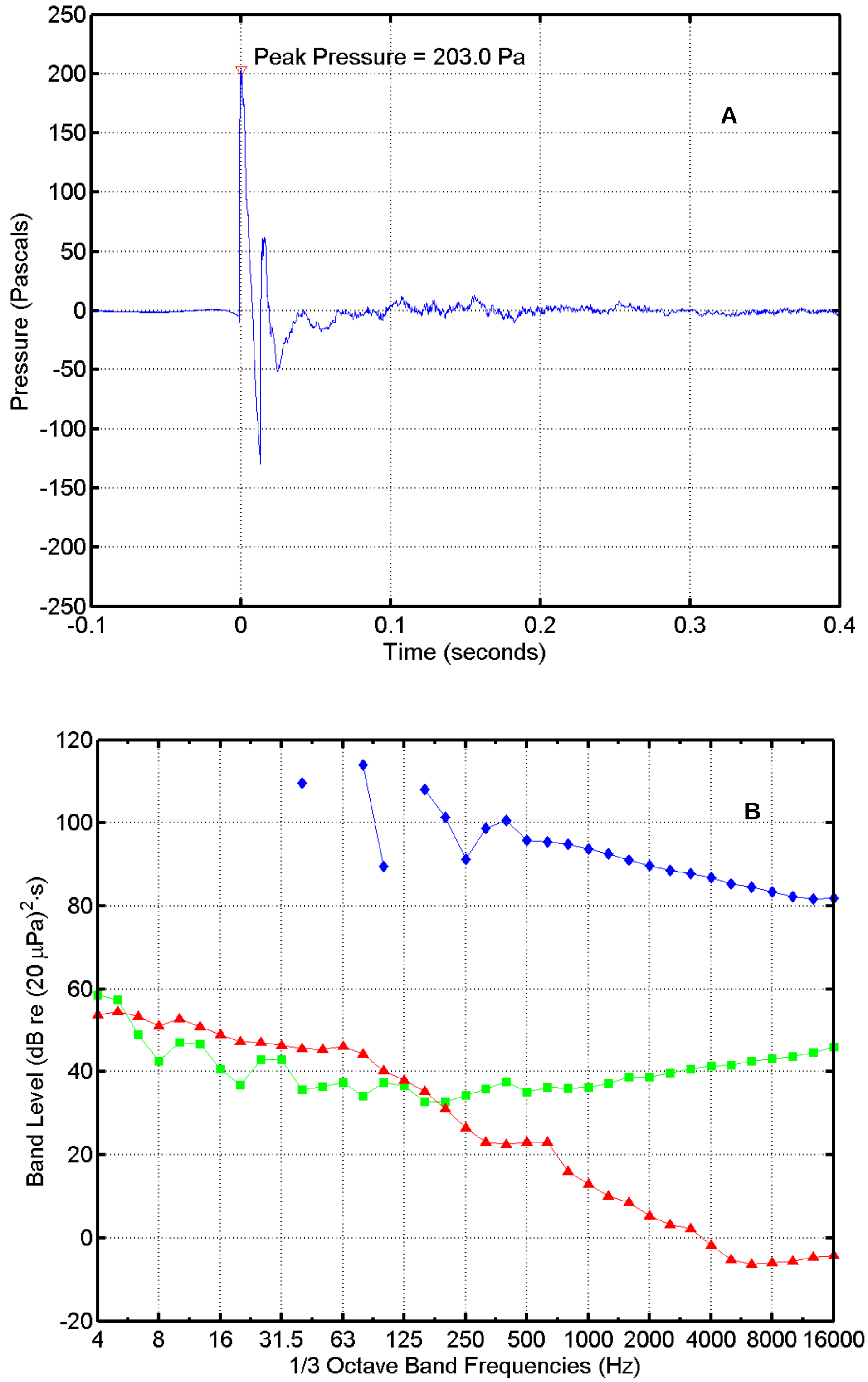


FIGURE B-1. (A) Pressure waveform and (B) one-third octave band levels for a Coyote flight at 10:00 on 9 June 2010 recorded at B809. In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

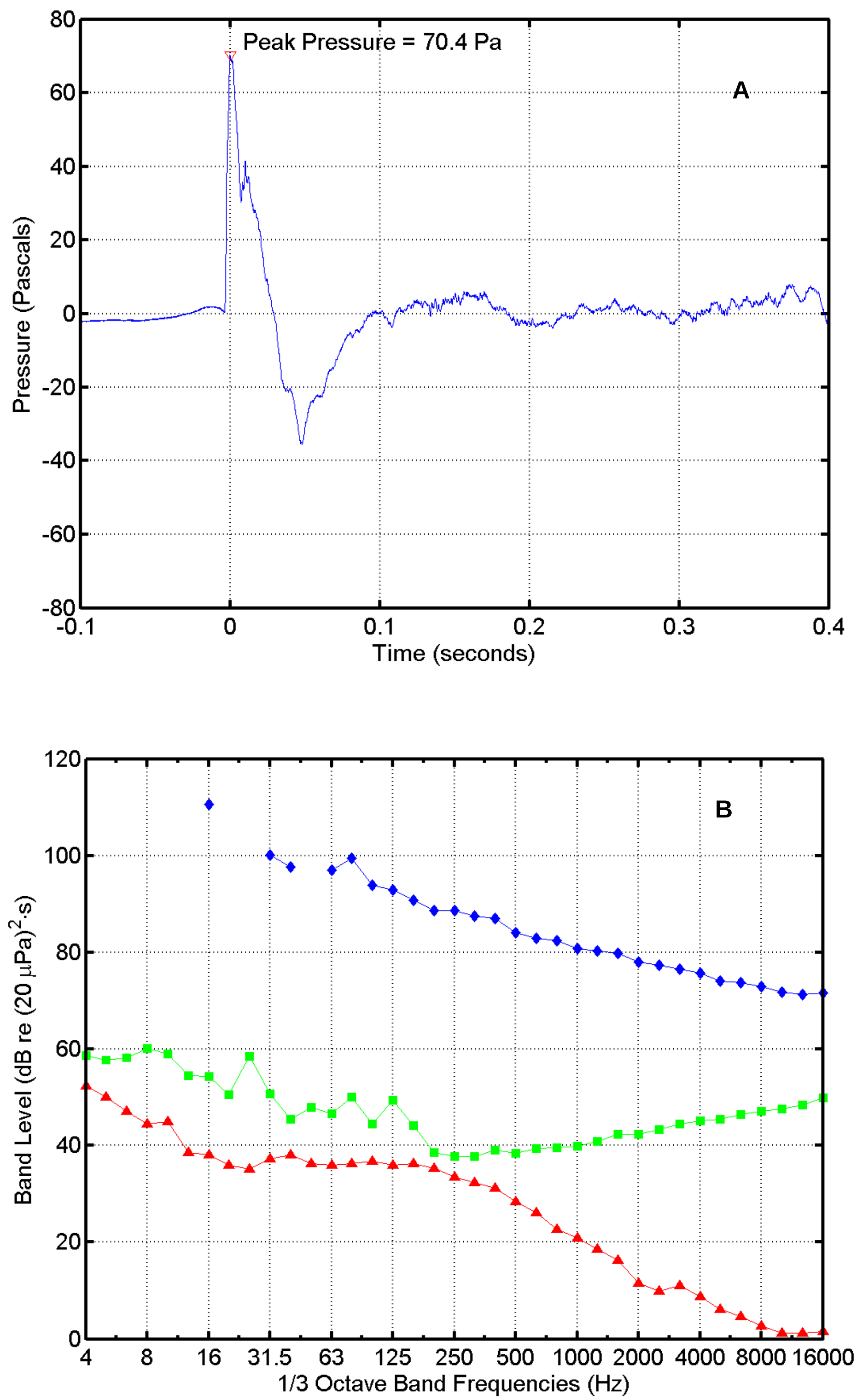
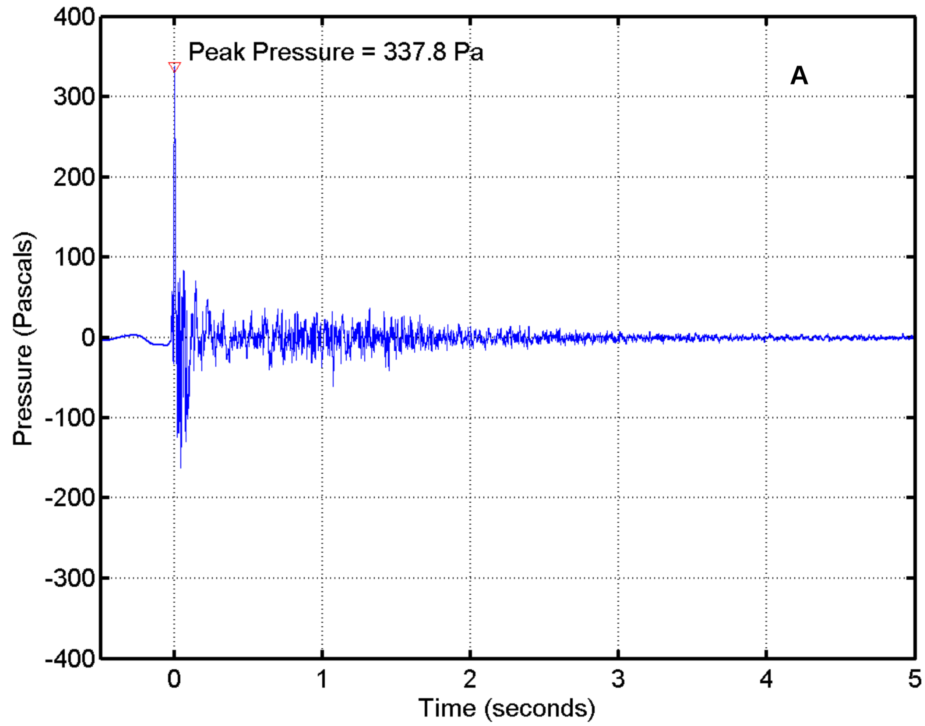


FIGURE B-2. (A) Pressure waveform and (B) one-third octave band levels for a Coyote flight at 10:00 on 9 June 2010 recorded at Dos Coves. In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).



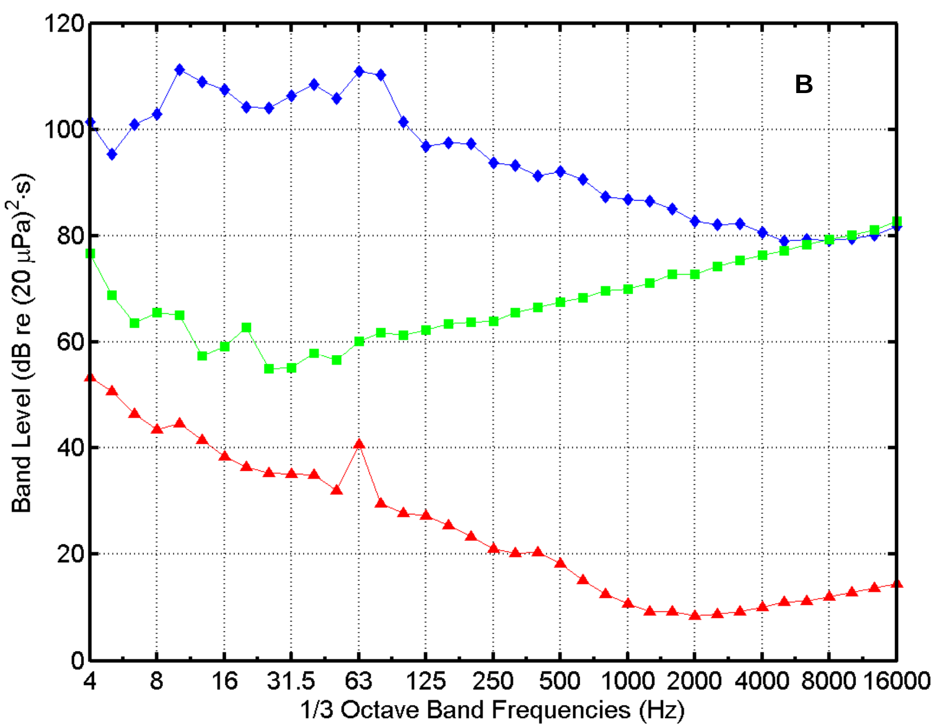


FIGURE B-3. (A) Pressure waveform and (B) one-third octave band levels for a Coyote flight at 10:00 on 9 June 2010 recorded near the Launcher. In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

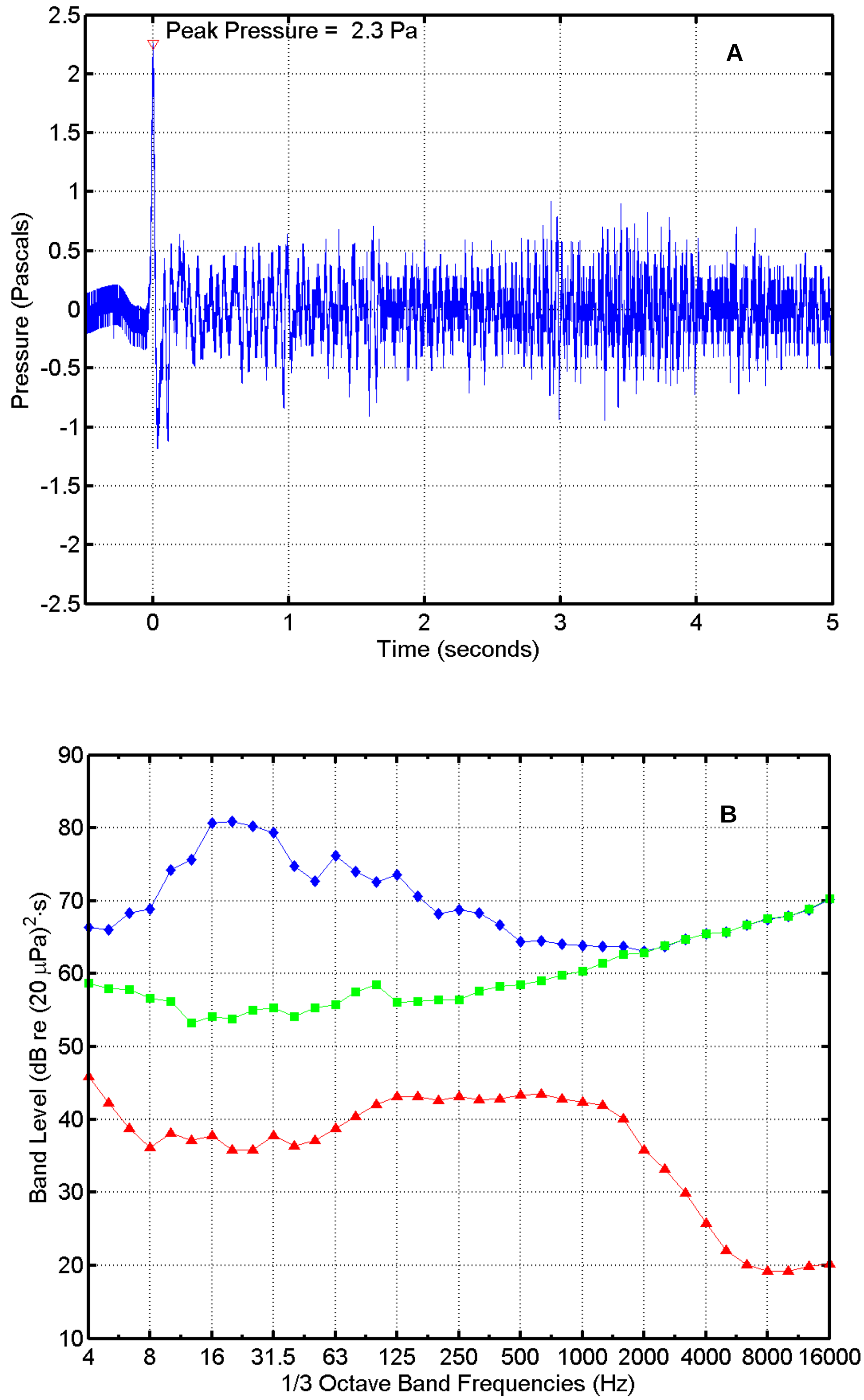
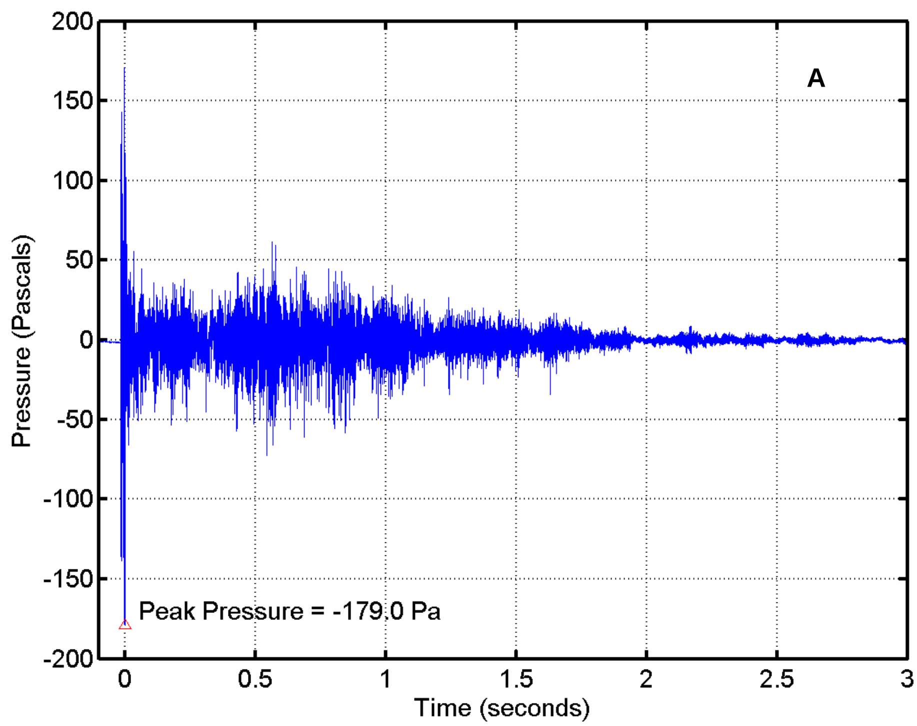


FIGURE B-4. (A) Pressure waveform and (B) one-third octave band levels for a Coyote flight at 08:45 on 8 July 2010 recorded at Phoca Reef. In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).



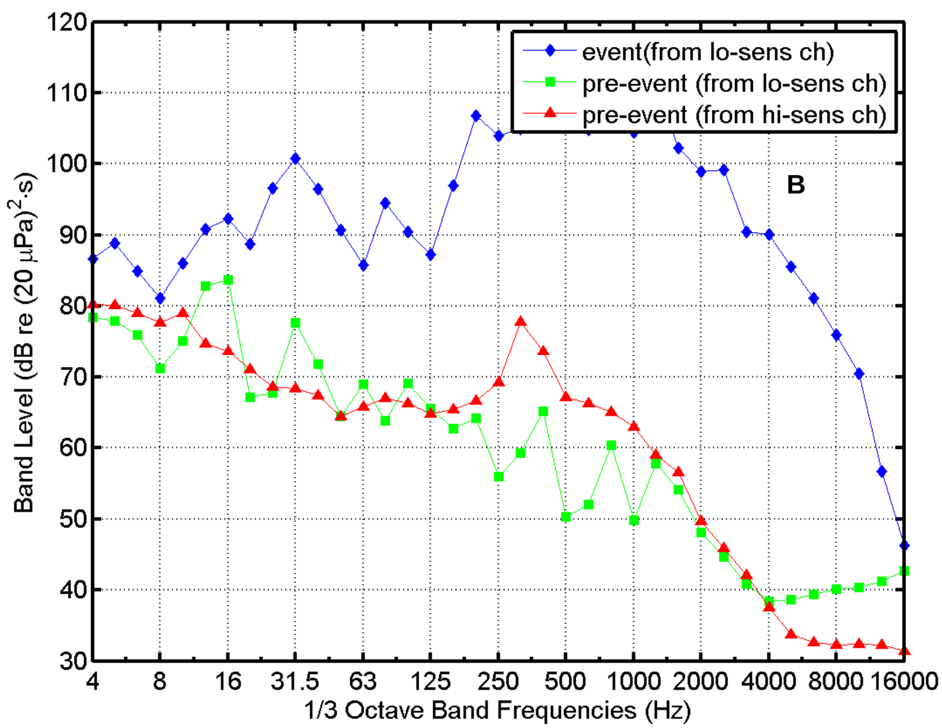


FIGURE B-5. (A) Pressure waveform and (B) one-third octave band levels for a Coyote flight at 08:45 on 8 July 2010 recorded at Redeye Beach. In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

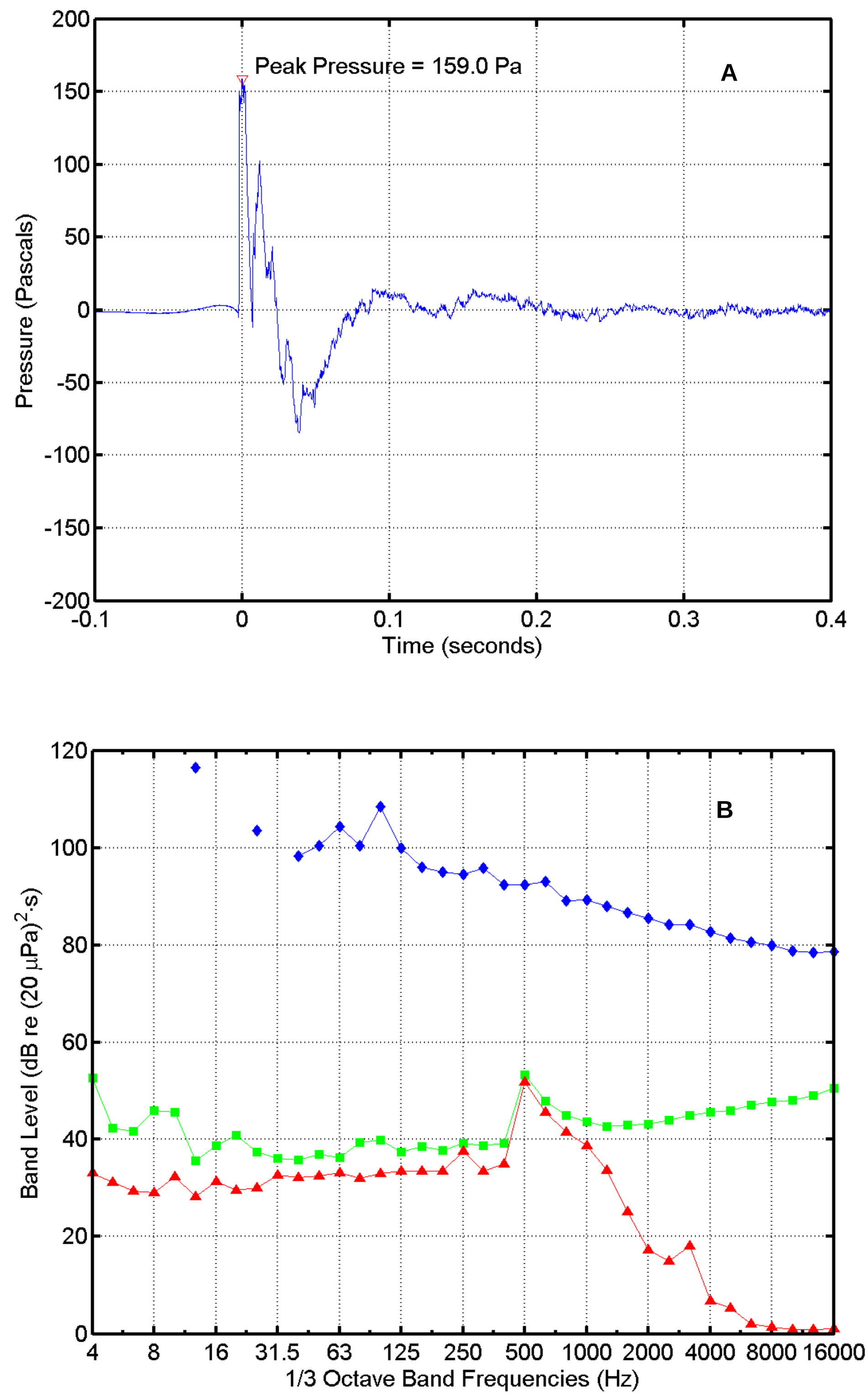
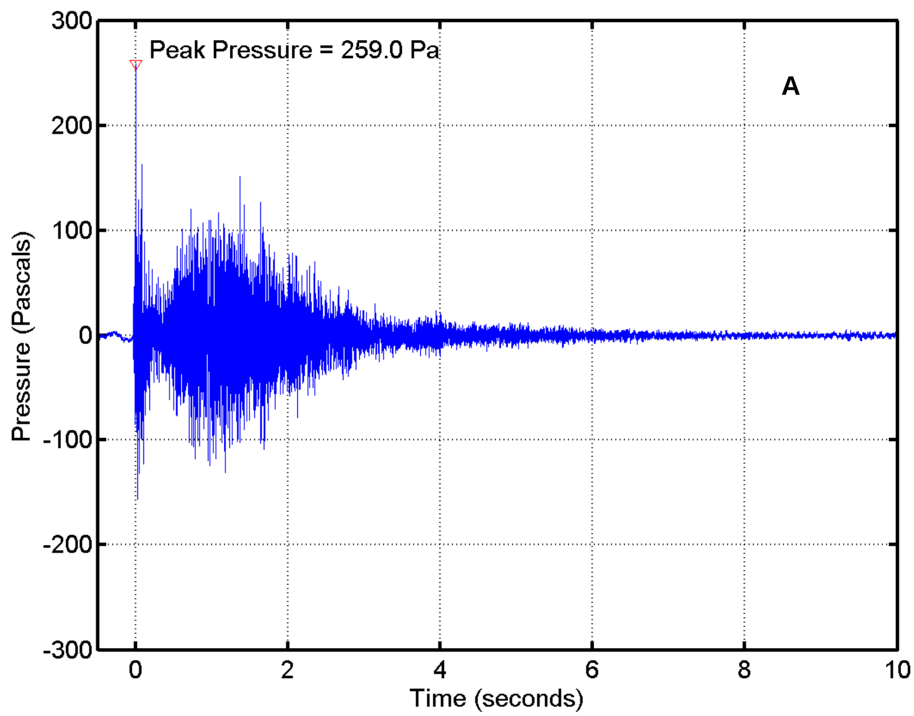


FIGURE B-6. (A) Pressure waveform and (B) one-third octave band levels for a Coyote flight at 08:45 on 8 July 2010 recorded at Dos Coves. In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).



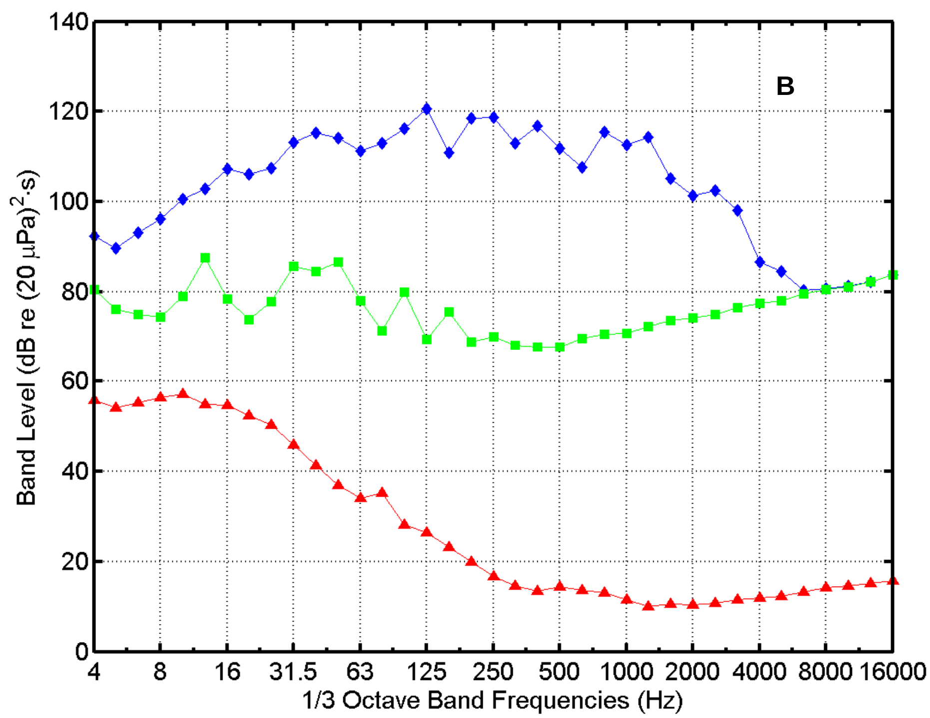


FIGURE B-7. (A) Pressure waveform and (B) one-third octave band levels for a Coyote flight at 08:45 on 8 July 2010 recorded near the Launcher. In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

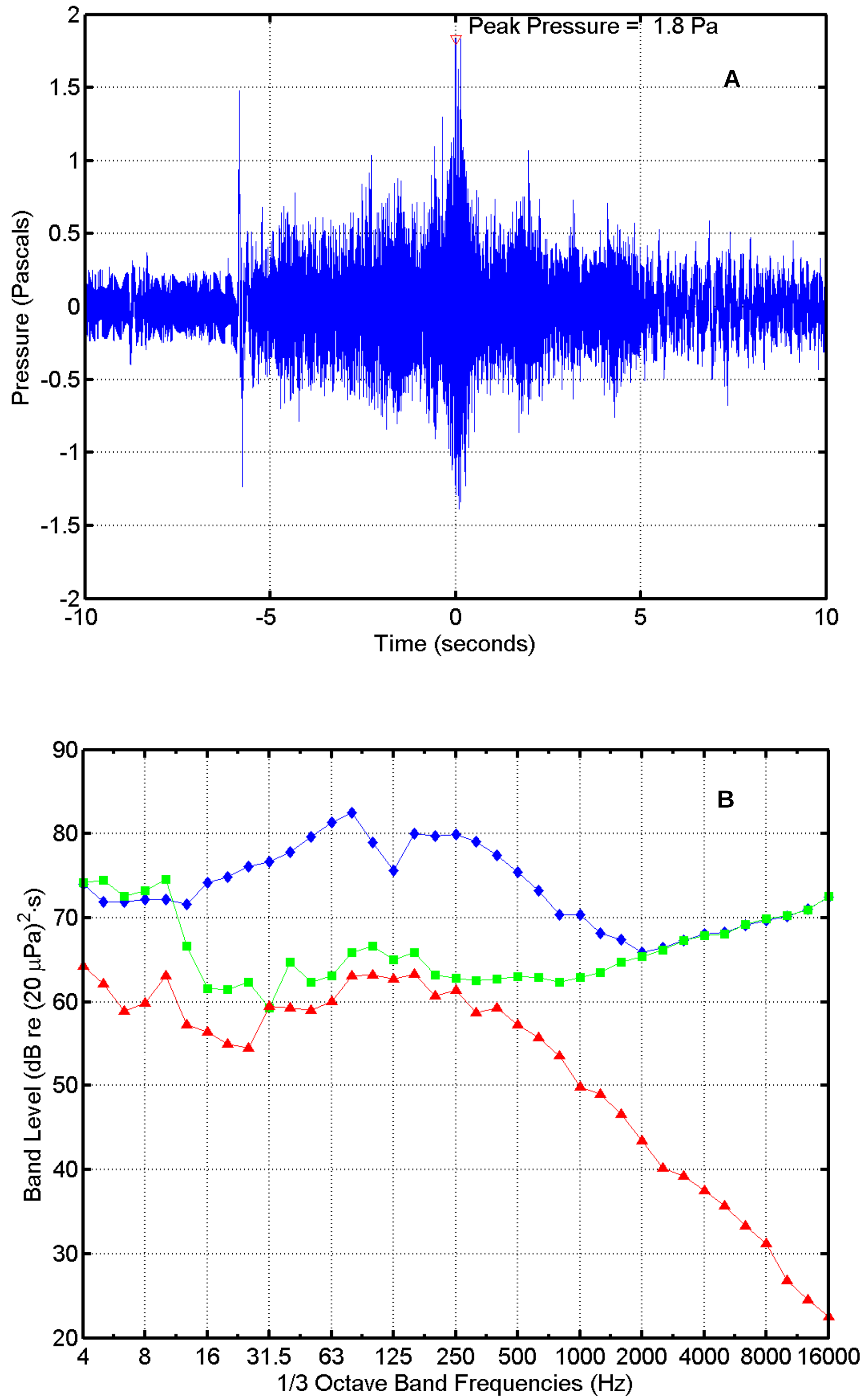
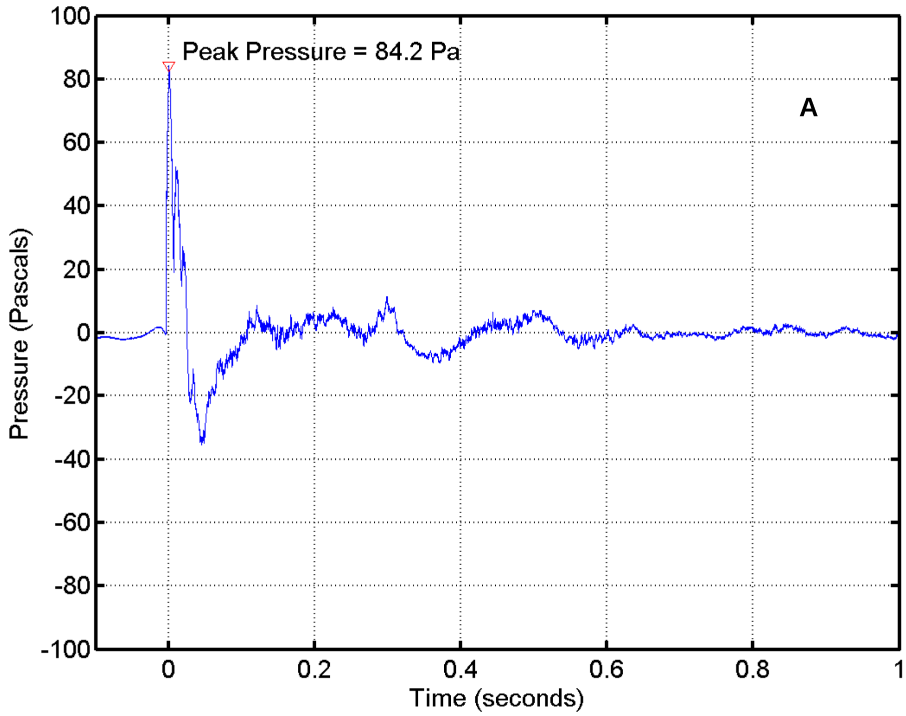


FIGURE B-8. (A) Pressure waveform and (B) one-third octave band levels for a Coyote flight at 09:45 on 8 December 2010 recorded at Phoca Reef. In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).



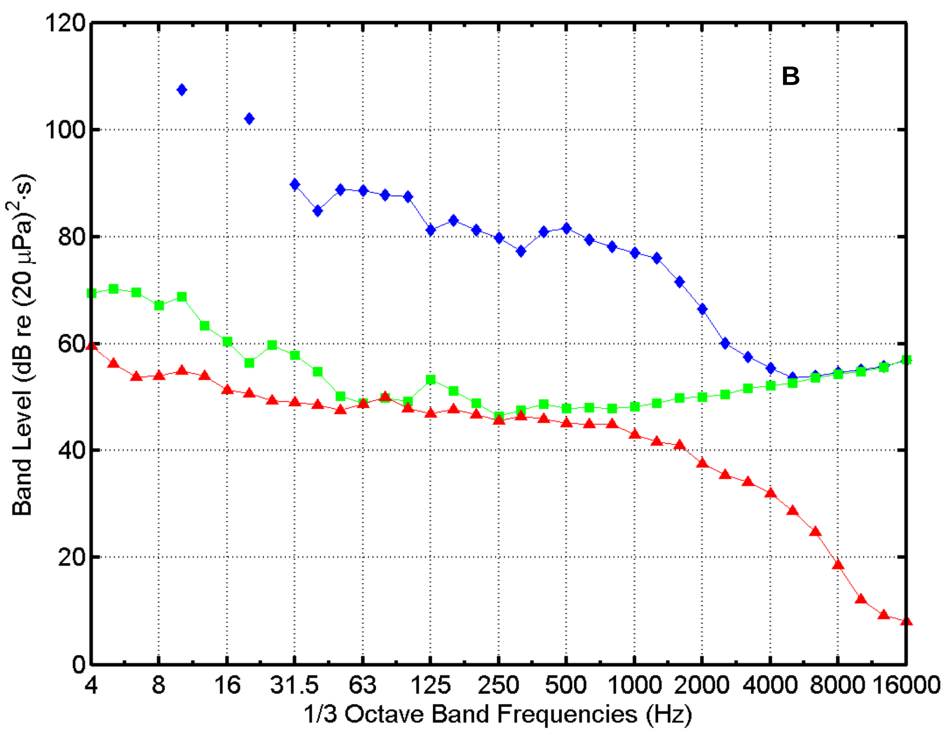


FIGURE B-9. (A) Pressure waveform and (B) one-third octave band levels for a Coyote flight at 09:45 on 8 December 2010 recorded at Dos Coves. In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

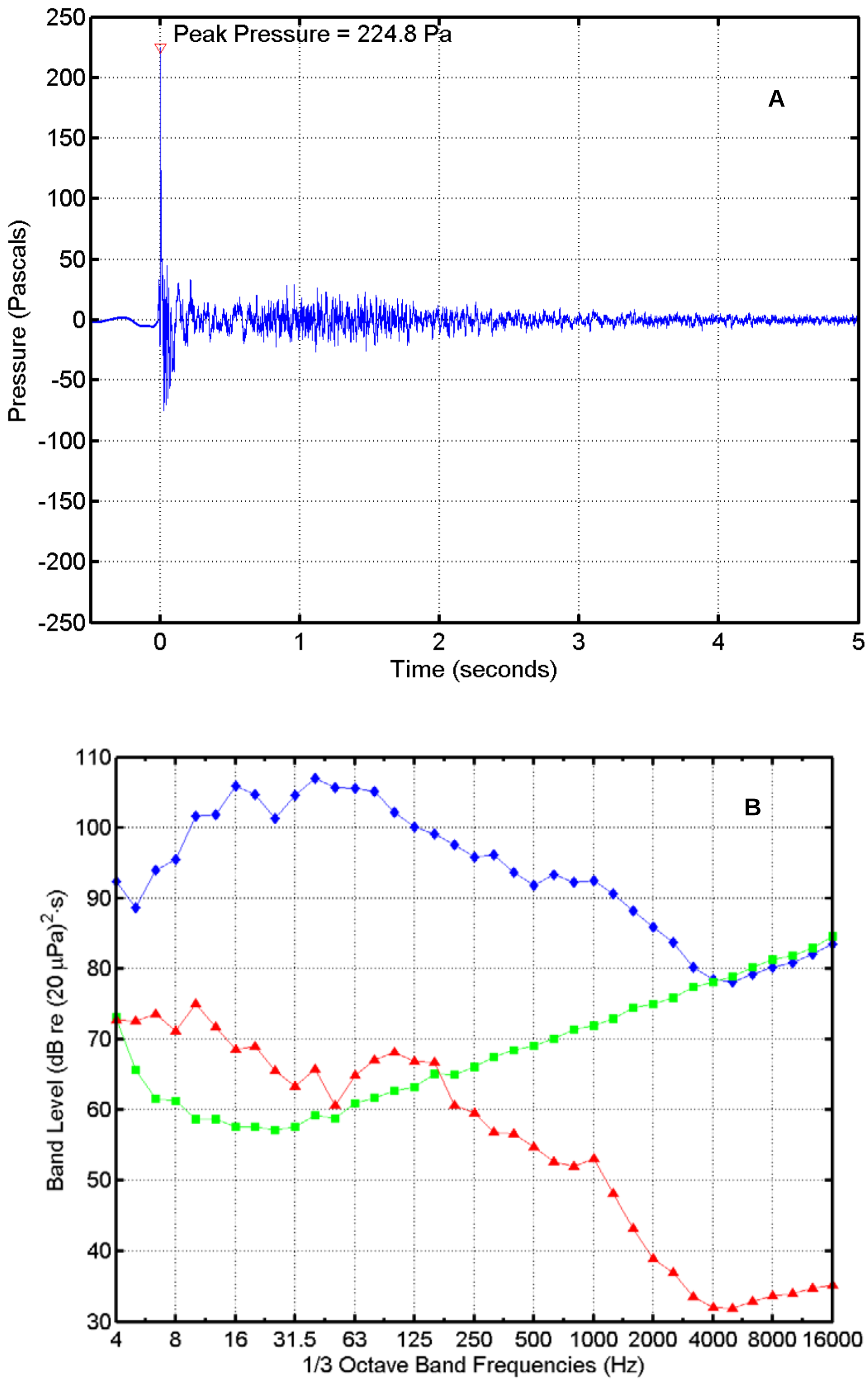


FIGURE B-10. (A) Pressure waveform and (B) one-third octave band levels for a Coyote flight at 09:45 on 8 December 2010 recorded near the Launcher. In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

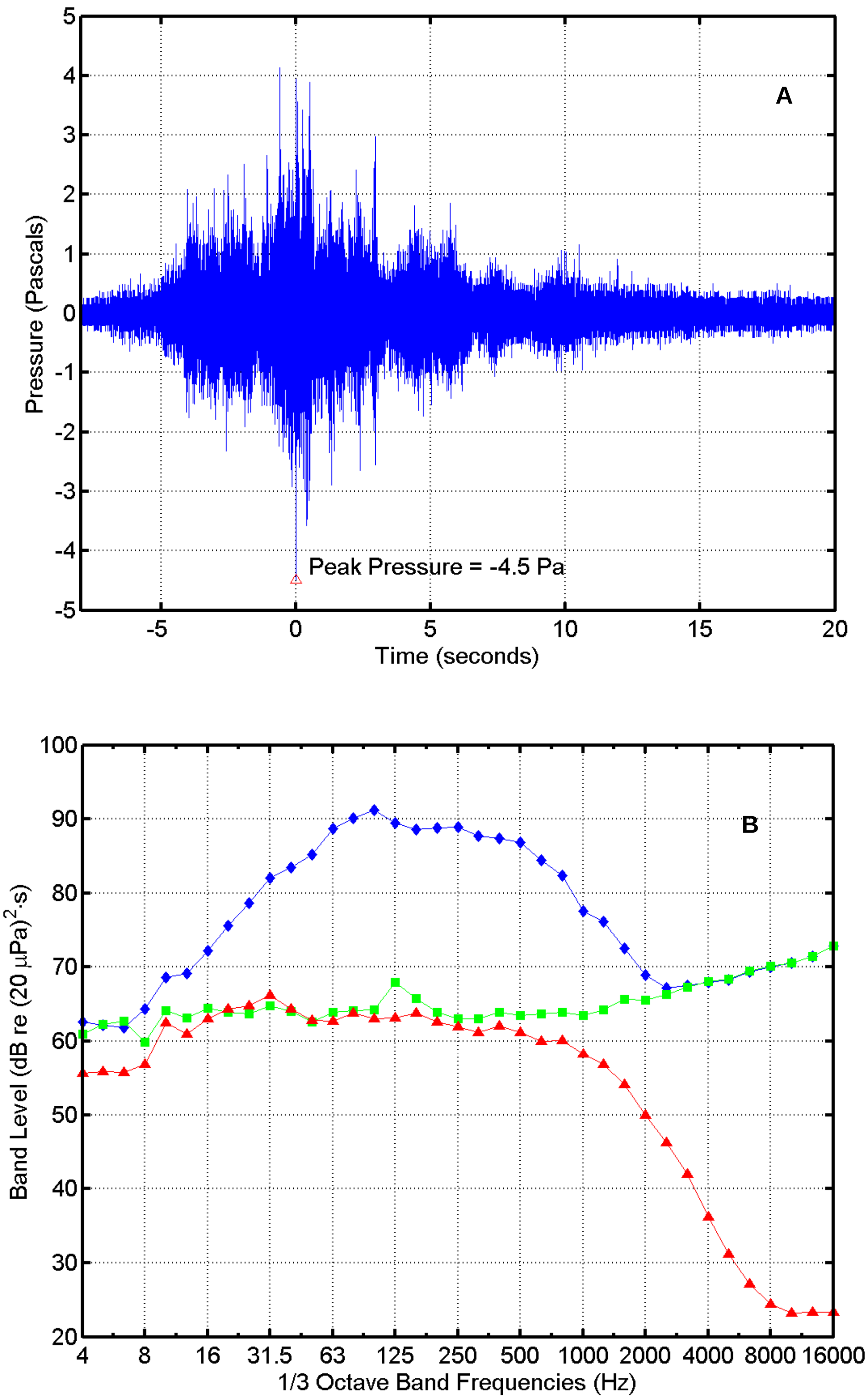
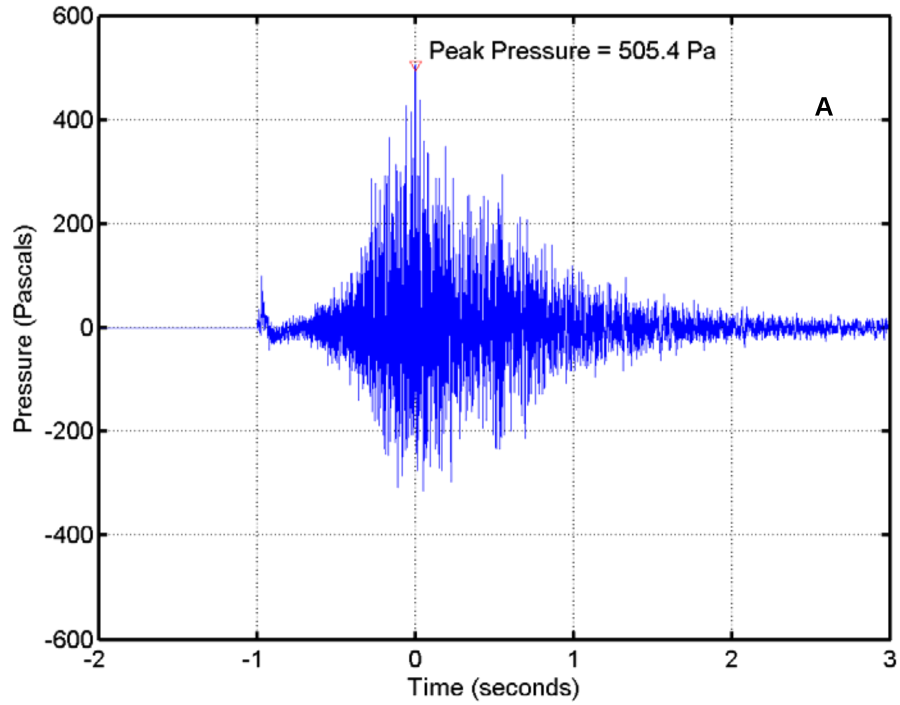


FIGURE B-11. (A) Pressure waveform and (B) one-third octave band levels for an Arrow flight at 22:35 on 21 February 2011 recorded at Dos Coves. In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).



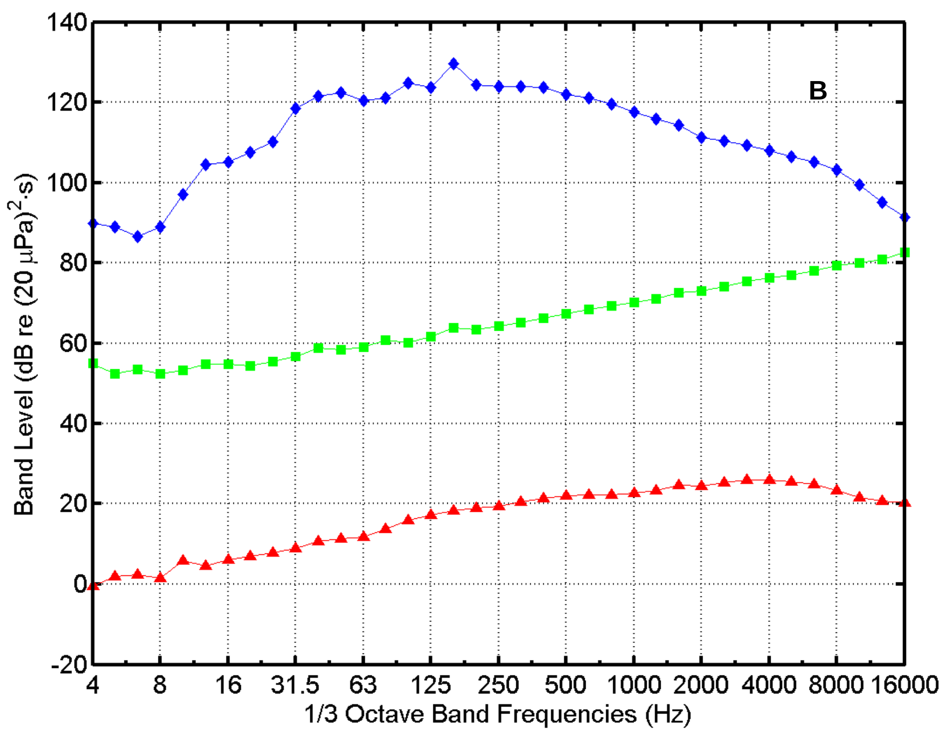


FIGURE B-12. (A) Pressure waveform and (B) one-third octave band levels for an Arrow flight at 22:35 on 21 February 2011 recorded at the Coast Guard Above Barrow Pit. In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

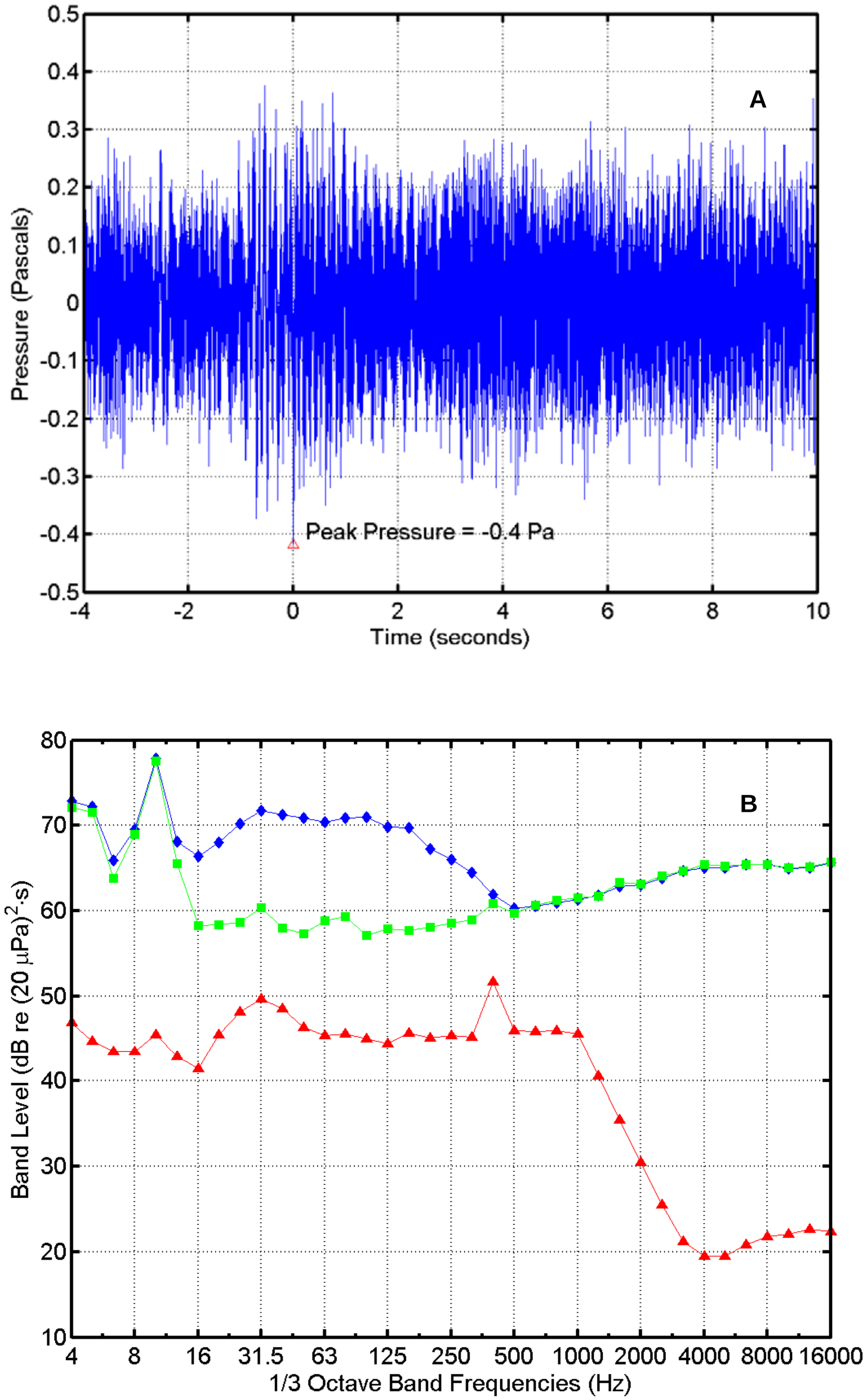


FIGURE B-13. (A) Pressure waveform and (B) one-third octave band levels for an Arrow flight at 22:35 on 21 February 2011 recorded at the Coast Guard Above Barrow Pit. In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

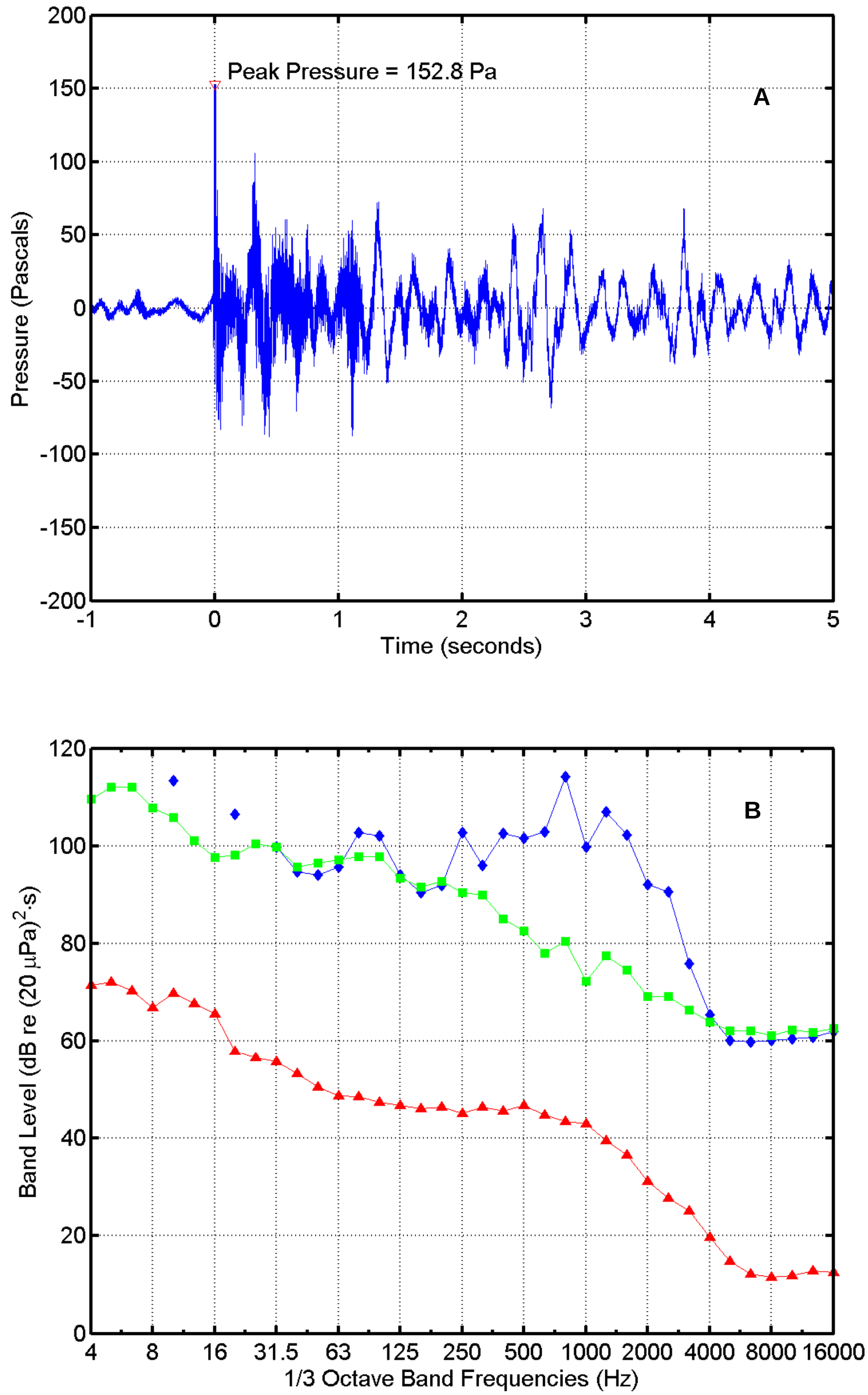


FIGURE B-14. (A) Pressure waveform and (B) one-third octave band levels for a Coyote flight at 14:36 on 24 February 2011 recorded at Dos Coves. In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).