Marine Mammal and Acoustical Monitoring of Missile Launches on San Nicolas Island, October 2003 – July 2004

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Naval Air Weapons Station
China Lake, California

to

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

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Marine Mammal and Acoustical Monitoring of Missile Launches on San Nicolas Island, October 2003 – July 2004

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ACRONYMS AND ABBREVIATIONS

The following list shows the meaning of acronyms and abbreviations used in this report.

ABM	Anti-Ballistic Missile
AGS	Advanced Gun System
ASCM	Anti-Ship Cruise Missile
ASEL	A-weighted Sound Exposure Level
ATAR	Autonomous Terrestrial Acoustic Recorder
ASL	Above Sea Level
cm	centimeter
C.F.R.	Code of Federal Regulations
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
DR	Ducted Rocket (pertains to GQM-163A “Coyote” SSST)
Hz	hertz
IHA	Incidental Harassment Authorization
kg	kilogram
LOA	Letter of Authorization
m	meter (1 m = 1.09 yards or 3.28 feet)
km	kilometer (1 km = 3281 ft, 0.62 st.mi., or 0.54 n.mi.)
mm	millimeter
MMPA	Marine Mammal Protection Act
NAWCWD	Naval Air Warfare Center Weapons Division
NAWS	Naval Air Weapons Station
NMFS	National Marine Fisheries Service, U.S. Dept of Commerce
n.mi.	nautical mile (1 n.mi. = 1.15 statute miles or 1.853 km)
PTS	Permanent Threshold Shift
RAM	Rolling Airframe Missile
rms	root mean square (a type of average)
SEL	Sound Exposure Level, a measure of the energy content of a transient sound
SNI	San Nicolas Island
SPL	Sound Pressure Level
SSST	GQM-163A “Coyote” Supersonic Sea-Skimming Target
TTS	Temporary Threshold Shift
V/µPa	volts per micropascal
µPa	micropascal
WOSA	Weighted Overlapped Segment Averaging

EXECUTIVE SUMMARY

Naval Air Weapons Station (NAWS) China Lake currently holds a Letter of Authorization (LOA) issued by the National Marine Fisheries Service (NMFS) allowing non-lethal takes of pinnipeds incidental to the Navy's missile launch operations on San Nicolas Island, California. The LOA is valid from 2 October 2003 through 1 October 2004. The LOA was issued pursuant to 50 Code of Federal Regulations (C.F.R.) 216.107, 50 C.F.R. 216.151–158, and §101(a)(5)(A) of the Marine Mammal Protection Act (MMPA), 16 United States Code (U.S.C.) § 1371(a)(5)(A). The LOA allows for the 'take by harassment' of small numbers of northern elephant seals (*Mirounga angustirostris*), harbor seals (*Phoca vitulina*), and California sea lions (*Zalophus californianus*) during routine launch operations on Navy-owned San Nicolas Island. Previously, two separate Incidental Harassment Authorizations (IHAs) were issued for this purpose 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 C.F.R. 216.151–158, a Marine Mammal Monitoring Plan was proposed. This plan included provisions to monitor any effects of launch activities on pinnipeds hauled out at San Nicolas Island. This report describes the results of the marine mammal and associated acoustic monitoring program during the October 2003 to July 2004 period. There were no launches at San Nicolas Island during October 2003 through April 2004. This report includes results from two launches at San Nicolas Island on 5 and 18 May 2004 and another three launches on 3 June 2004. Three additional launches on 26 and 29 July 2004 are described, but the acoustic data and pinniped observations from late July are not yet available. Four additional launches are anticipated to occur in August and September 2004, but that is subject to change. Results concerning 19 launches during August 2001 through July 2002 and 12 launches during August 2002 to August 2003 were reported by Lawson et al. (2002) and Holst and Greene (2003), respectively.

The following subsections briefly summarize the monitoring program during the October 2003 – July 2004 period. Details are provided in subsequent chapters of this report.

Missile Launches and Monitoring Program Described

During the October 2003 to June 2004 period, five launches occurred from San Nicolas Island on three different days. The launches included a “dual launch” of two Rolling Airframe Missiles (RAM) in quick succession, one GQM-163A Supersonic Sea-Skimming Target (SSST), one Advanced Gun System (AGS) missile, and two AGS slugs. The dual RAM launch on 5 May 2004 consisted of two missiles that were launched within ~12 seconds of each other; the dual launch is counted as a single launch. On 3 June 2004, two AGS slugs and one AGS missile were launched at intervals of 106–111 minutes; those launches were counted as separate launches. A single GQM-163A target was launched on 18 May 2004.

During July 2004, there were three launches, consisting of two AGS slugs launched on 26 July and one Arrow self-defense missile launched on 29 July.

Vehicles were launched from one of two launch complexes on San Nicolas Island. In May–June 2004, the dual RAM launch occurred from the Building 807 Launch Complex. This site is located close to shore on the western end of San Nicolas Island, ~35 ft (11 m) above sea level. The AGS slugs and missile and the GQM-163A target were launched from the Alpha Launch Complex. This launch site is 625 ft (190.5 m) above sea level on the west-central part of San Nicolas Island. In late July, the two AGS slugs were launched from the Building 807 complex, to which the AGS launcher had been relocated; the Arrow was launched from a pad near the Alpha Launch Complex.

The vehicles launched from the Alpha Launch Complex during May–June 2004 had launch elevation angles ranging from 18 to 50º above horizontal and were directed westward. They crossed the west end of San Nicolas Island at altitudes up to 4500 ft (1372 m). The Arrow launched nearby on 29 July was launched vertically. The RAM vehicles launched from the Building 807 Launch Complex had an elevation angle of 8º and crossed the west end of SNI at an altitude of 50 ft (15 m).

Acoustic Measurements During Missile Launches

Vehicle flight sounds were measured as received at various locations on western San Nicolas Island. The dual RAM launch resulted in a flat-weighted sound pressure level (SPL), measured over the 3 to 20,000 hertz (Hz) bandwidth, of 86–91 decibels (dB) re 20 micropascal (μPa) at nearshore sites located 1873 and 2273 ft (571 and 682 m) from the closest point of approach (CPA) of the missile. The GQM-163A target produced SPLs of 128–130 dB at nearshore sites up to 0.8 mi (1.3 km) from the CPA, and an SPL of 93 dB at a site located 1.5 mi. (2.3 km) from the CPA. The AGS vehicles (3 June) resulted in SPLs ranging from 100 to 111 dB at sites located up to 0.8 mi. (1.3 km) from the CPA. Acoustic data are not yet available for the launches in late July 2004.

Another measure of each launch sound, the SEL or Sound Exposure Level, represents the total received energy over the 3 to 20,000 Hz bandwidth at the same measurement locations as noted above. The dual RAM launch produced SELs ranging from 93 to 97 dB re $(20\ \mu Pa)^2 \cdot s$ (flat-weighted). SELs ranged from 105 to 119 dB for the GQM-163A target and from 94 to 103 dB for the AGS vehicles launched on 5 June. A-weighted SPL and SEL values were generally several decibels lower.

Behavior of Pinnipeds During Missile Launches

Behavior of pinnipeds around the periphery of western San Nicolas Island during missile launches was monitored by unattended video cameras 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. Monitoring was attempted at three sites during each launch, with launch-to-launch variation in the locations monitored. During the 29 July 2004 Arrow launch, a fourth video camera was also deployed. Videotaped behavioral data from the launches in late July 2004 have not yet been analyzed, and the following concerns the launches in May–June 2004.

California sea lions

California sea lions were observed during four launches on two launch dates in May–June 2004 (total of three site–date combinations). Responses of California sea lions to the launches varied by individual. Most sea lions hardly reacted during the launches and merely looked up. However, at several monitoring locations, up to 50% of sea lions reacted more vigorously by moving along the beach or entering the water. 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.

Northern elephant seals

Elephant seals were observed during all five of the launches on three launch dates in May–June 2004 (total of three site–date combinations). Most elephant seals exhibited little reaction to launch sounds; they merely raised their heads for a few seconds and then returned to their previous activity pattern (e.g., sleeping, resting). During two launches, up to 13% of northern elephant seals on the beach moved a small distance (<2 m) away from their resting site. On one occasion, during the RAM launch on 5 May 2004, one seal entered the water.

Harbor seals

Harbor seals were observed during four launches on two launch dates in May–June 2004 (three site-date combinations). During three of the launches, most seals (58–100%) left their haul-out sites and entered the water. During the launch of the first AGS slug on 3 June 2004, 27% of seals entered the water. Individuals that left the site typically did not return during the duration of the video-recording period, which lasted for an additional 1 to 2 hr.

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.

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. We considered pinnipeds that left the haul-out site, or exhibited prolonged movement or prolonged behavioral changes, as being affected.

Approximately 81 California sea lions, 13 northern elephant seals, and 46 harbor seals on the monitored beaches are estimated to have been affected by launch sounds during May and June 2004. These numbers are probably underestimates, because not all pinniped beaches around western San Nicolas Island could be monitored during any given launch, even though extrapolation of data for all potential haul-out sites was attempted. Given the lack of evidence of any serious effects on pinnipeds at the sites that were monitored, it is not likely that many (if any) of pinnipeds on San Nicolas Island were adversely impacted by the launches.

Behavior of some pinnipeds occurring near the launch azimuths during the launch operations was affected in subtle ways. However, the results suggest that any effects of these launch operations were minor, short-term, and localized, with no consequences for local pinniped populations. Any localized displacement of pinnipeds was of short duration (although some harbor seals may have left their haul-out site until the following low tide). Previous monitoring showed that numbers of pinnipeds occupying haul-out sites the day after a launch were similar to pre-launch levels (Holst and Lawson 2002).

1. MISSILE LAUNCHES AND MONITORING PROGRAM DESCRIBED[1]

Missiles are launched from one of two land-based launch complexes on the western part of San Nicolas Island (Fig. 1.1). Building 807 Launch Complex is located on the west coast of SNI, and the Alpha Launch Complex is located 625 ft (190.5 m) above sea level (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 most common pinniped species that occur on SNI include elephant seals (*Mirounga angustirostris*), harbor seals (*Phoca vitulina*), and California sea lions (*Zalophus californianus*).

Naval Air Weapons Station (NAWS) China Lake holds a Letter of Authorization (LOA) issued by the National Marine Fisheries Service (NMFS) allowing non-lethal takes of pinnipeds incidental to the Navy's missile launch operations on San Nicolas Island, California (see Appendix A). This LOA was issued under the regulations at 50 C.F.R. § 216.151–158, which were promulgated by NMFS in 2003 in response to a Petition for Regulations submitted by the Navy. The LOA allows the 'take by harassment' of small numbers of northern elephant seals, harbor seals, and California sea lions during routine launches from Navy-owned SNI. Previously, two separate Incidental Harassment Authorizations (IHAs) were issued for this purpose for the periods August 2001 to July 2002 and August 2002 to August 2003.

In the Navy's Petition for Regulations, a Marine Mammal Monitoring Plan was proposed to monitor any effects of launch activities on pinnipeds hauled out at San Nicolas Island. This report describes the results of the marine mammal and associated acoustic monitoring program during the period from October 2003 through June 2004. It also mentions three additional launches that occurred on 26 and 29 July 2004, for which monitoring results are not yet available. Results concerning 19 launches during August 2001 through July 2002 and 12 launches during August 2002 to August 2003 were reported by Lawson et al. (2002) and Holst and Greene (2004), respectively.

This report describes the vehicles and their launch processes, the associated monitoring program, and the monitoring results for the launches conducted by the Navy at San Nicolas Island, California. This report includes four chapters:

1. background, introduction, and description of the Navy's missile launches in the period October 2003 through June 2004, with brief mention of launches in July 2004 and launches planned for August–September 2004 [this chapter];
2. acoustical monitoring during the missile launches in October 2003 – June 2004 [Chapter 2];
3. visual monitoring of pinnipeds during those launches [Chapter 3];
4. estimated numbers of pinnipeds affected by the missile sounds during these launches [Chapter 4].

1.1 GQM-163A Supersonic Sea-Skimming Target

The Navy/Orbital Sciences Corp. GQM-163A "Coyote" Supersonic Sea-Skimming Target (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 n.mi. or 83 km (Fig. 1.3). It is designed to provide a ground-launched aerial target system to simulate a supersonic, sea-skimming Anti-Ship Cruise Missile (ASCM) . The GQM-163A is being developed as a replacement for the Vandal.

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[1] By **Meike Holst**, LGL Ltd., environmental research associates.

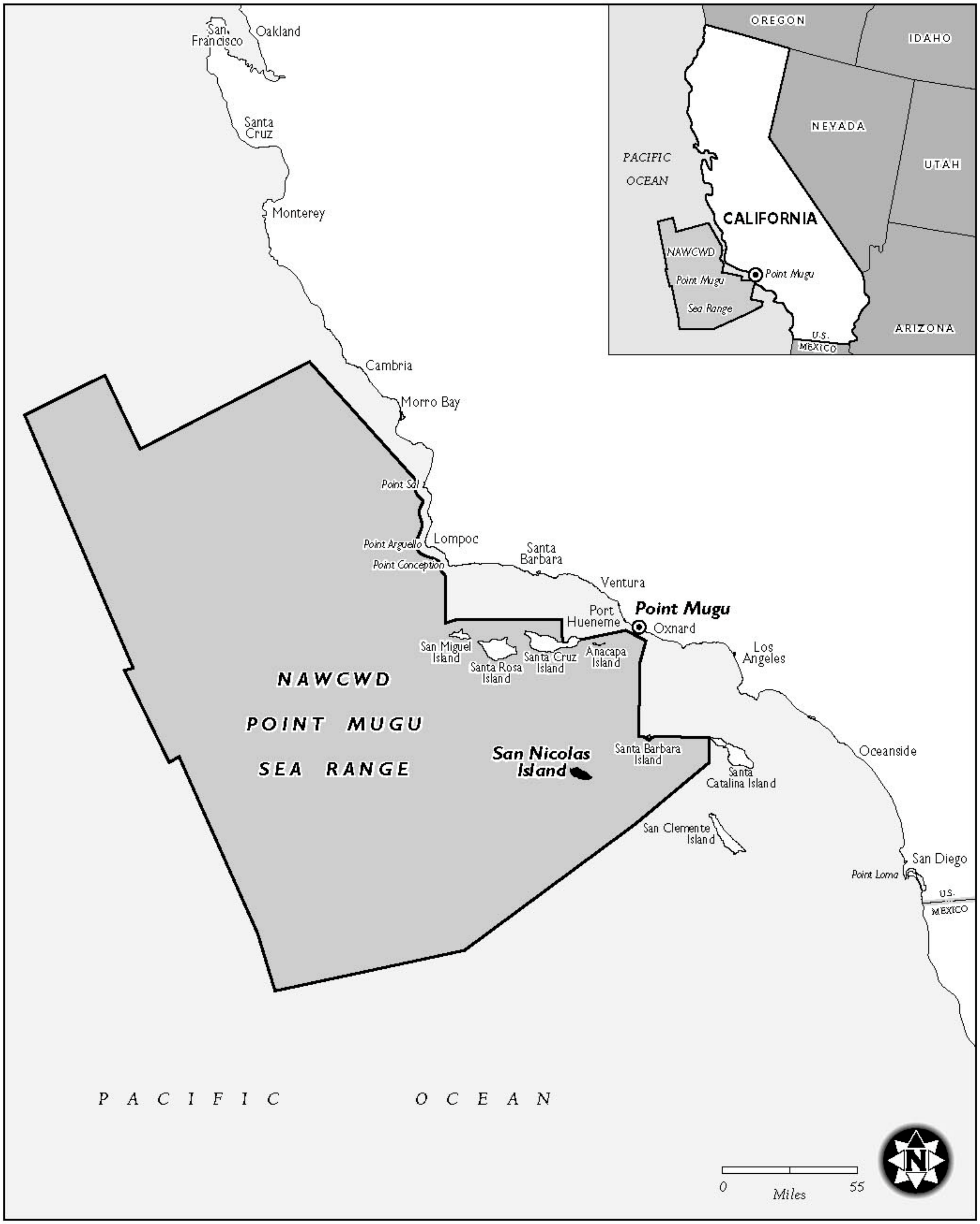

FIGURE 1.1. Regional site map of the Point Mugu Sea Range and San Nicolas Island (map by TEC).

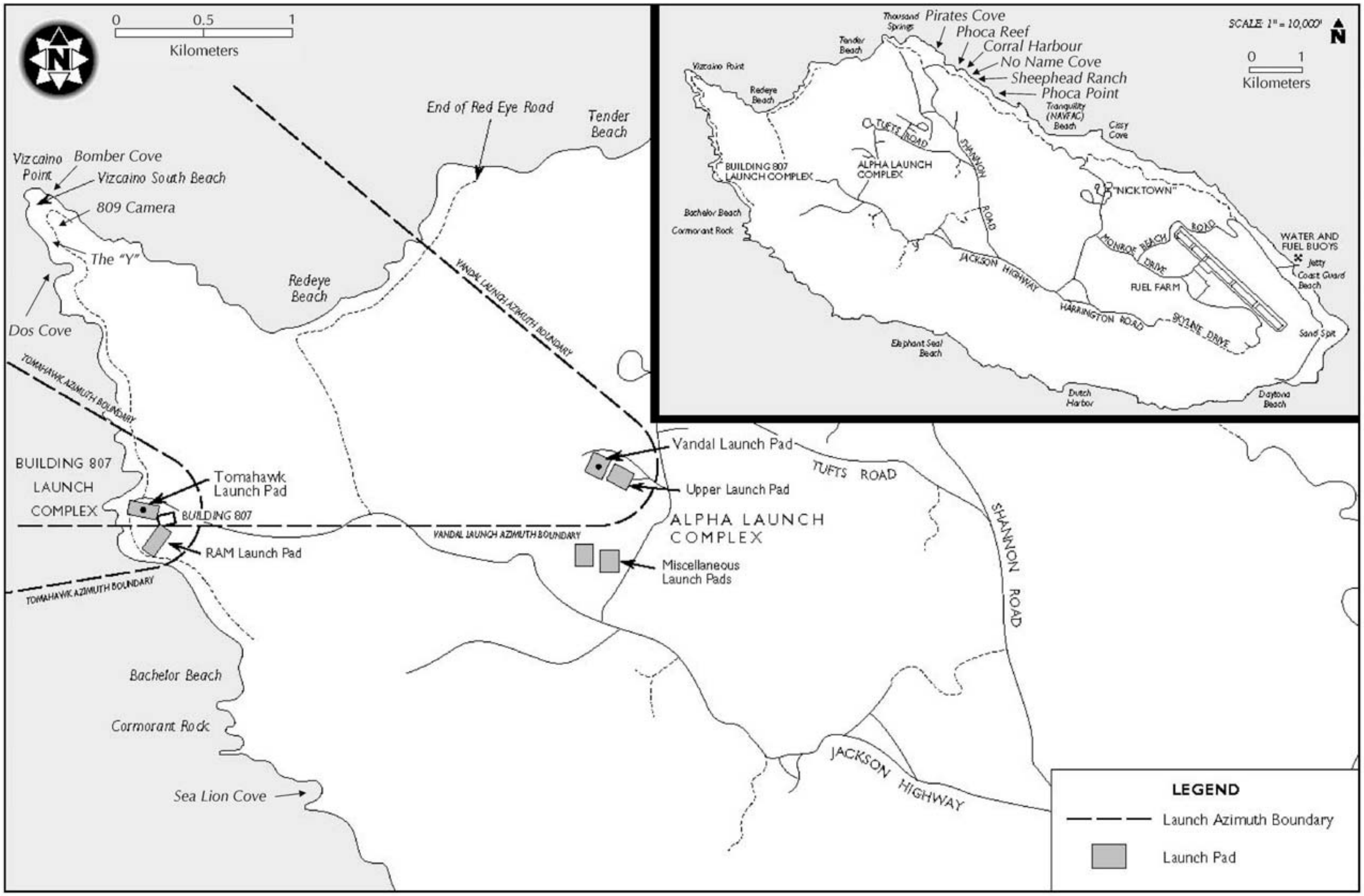

FIGURE 1.2. View of vehicle launch sites on San Nicolas Island. Shown are the Alpha Launch Complex and the Building 807 Launch Complex (at lower elevation near the shoreline). Also shown are the maximum predicted extent of the launch azimuths for vehicles leaving the two launch sites.

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

The SSST vehicle assembly consists of two primary subsystems: MK 12 or MK 70 solid propellant booster, and the GQM-163A target vehicle. The solid-rocket booster is about 18 inches (46 cm) in diameter, and is of the type used to launch the Navy's Standard surface-to-air missile. The GQM-163A target vehicle is 18 ft (5.5 m) long and 14 inches (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 GQM-163A target utilizes the unmodified Vandal launcher, currently installed at the Alpha Launch Complex on San Nicolas Island, with a Launcher Interface Kit (LIK; Fig. 1.3). A modified AQM-37C Aerial Target Test Set (ATTS) is utilized for target checkout, mission programming, verification of the vehicle's ability to perform the entire mission, and homing updates while the vehicle is in flight.

During a typical launch, booster separation would occur about 5.5 s after launch and about 1.4 n.mi. downrange, at which time the vehicle 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 vehicle 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 GQM-163A target settles down to an altitude of 13 ft (4 m) and Mach 2.3 until DR burnout.

1.2 Rolling Airframe Missile (RAM)

The Navy/Raytheon Rolling Airframe Missile (RAM) is a supersonic, lightweight, quick-reaction missile (Fig. 1.4). This relatively small missile, designated RIM-116, uses the infrared seeker of the *Stinger* missile and the warhead, rocket motor, and fuse from the *Sidewinder* missile. It has a high-tech radio-to-infrared frequency guidance system.

The RAM is a solid-propellant rocket with a 5-inch (12.7 cm) diameter and a length of 9.2 feet (2.8 m). Its launch weight is 162 pounds (73.5 kg), and operational versions have warheads that weigh 25 lbs (11.4 kg). At San Nicolas Island, RAMs are launched from the Building 807 Launch Complex.

1.3 Advanced Gun System (AGS)

The Advanced Gun System (AGS) is a gun designed for a new class of Destroyer; it will be used to launch both small missiles and ballistic shells. It is to be a fully integrated gun weapon system, including a 155-mm gun, integrated control, an automated magazine, and a family of advanced guided and ballistic projectiles, propelling charges, and auxiliary equipment. The operational AGS will have a magazine with a capacity for 600 to >750 projectiles and associated propelling charges. The regular charge for the gun will replace the booster that is usually associated with a missile. The gun gets the missile up to speed, at which point the missile's propulsion takes over. The missile itself is relatively quiet, as it does not have a booster, and it is fairly small. However, the gun blast is rather strong. The missiles are still under development, but are about 155 mm (6.1 inches) in diameter, up to 2.1 m (7 ft) long, and weigh up to about 118 kg (260 lb).

At San Nicolas Island, a howitzer (Fig. 1.5) has been used to launch test missiles and slugs, as the AGS gun is still being developed. Slugs are used to verify the performance of the howitzer before a missile launch. The launcher was located at the Alpha Launch Complex until after the 5 June launch, and the vehicles launched on 5 June were launched at an azimuth of 282°. Thereafter the launcher was moved to the Building 807 launch complex, and two slugs were fired there on 26 July. Future AGS launches are likely to be from the Building 807 location.

1.4 Arrow Self-Defense Missile

The Arrow is a theater missile defense weapon, or ABM (anti-ballistic missile). It was developed in Israel and is designed to intercept tactical ballistic missiles. It is about 22.3 ft (6.8 m) long and 2 ft (0.6 m) in diameter. The first test of an Arrow in the United States was conducted at San Nicolas Island on 29 July 2004. It was launched from the central part of western San Nicolas Island, near the Alpha Launch Complex, within the area labeled on Figure 1.2 as “Miscellaneous Launch Pads”.

1.5 Missile Launches during the Monitoring Period

During the period from October 2003 to June 2004, there were a total of five launches from San Nicolas Island on three separate days (Table 1.1). A dual RAM launch occurred on 5 May 2004, a GQM-163A target was launched on 18 May 2004, and three AGS vehicles were launched sequentially on 3 June 2004. Two AGS slugs were launched sequentially, 1 hr 51 min apart, followed by an AGS missile 1 hr 46 min later. Weather during the launches was usually cool and the winds were variable (Table 1.1). Conditions ranged from clear and sunny to partly cloudy.

FIGURE 1.4. View of the Rolling Airframe Missile (RAM) launcher at the Building 807 Launch Complex on San Nicolas Island (photograph by U.S. Navy).

FIGURE 1.5. View of the howitzer used for Advanced Gun Projectile System tests at the Alpha Complex on San Nicolas Island (photograph by U.S. Navy).

TABLE 1.1. Details of the five launches at San Nicolas Island during October 2003 – July 2004. The weather data were collected at the San Nicolas Island airport, which is located at an elevation of 500 ft (152 m) ASL toward the east end of San Nicolas Island; therefore weather conditions at haul-out sites may have differed somewhat. Times are local time.

Launch Date	Launch Time (local)	Vehicle Type	Launch Site	Launch Azimuth (true)	Elevation Angle/Altitude Over Beach	Weather at San Nicolas Island Airport	Tide State	Video Quality	Audio Quality
5 May 2004	11:46	Dual RAM	Building 807 Launch Complex	240°	8° / 50 ft	17°C; winds 315° at 6 kt; clear and sunny	Low at 16:02	Good - 2 cameras, Poor – 1 camera	3 ATARs ok
18 May 2004	12:40	GQM-163A	Alpha Launch Complex	300°	18° / 3300 ft	18°C; winds 315° at 15 kt; sunny and windy	Low at 15:11	Good - 2 cameras, Fair - 1 camera	1 of 3 ATARs ok; 2 overloaded
3 June 2004	11:31	AGS Slug	Alpha Launch Complex	282°	50° / 4500 ft	17°C; winds 270° at 6 kt; partly cloudy	Low at 15:40	Good - 2 cameras, Poor - 1 camera	3 ATARs ok
“	13:22	AGS Slug	“	“	“	“	“	“	“
“	15:08	AGS Missile	“	“	“	“	“	“	“

The dual RAM launch occurred from the Building 807 Launch Complex (Fig. 1.2, 1.4); it had a launch azimuth of 240º and an elevation angle of 8º. The GQM-163A target was launched from the Alpha Launch Complex at an azimuth of 300° and elevation angle of 18° (Fig. 1.2, 1.3). The three AGS vehicles were launched from the Alpha Launch Complex (Fig. 1.2, 1.5) and had azimuths of 282° and elevation angles of 50°.

These launch azimuths caused the vehicles to pass over or near various acoustic measurement sites and pinniped monitoring sites where Autonomous Terrestrial Acoustic Recorders (ATARs) and video systems had been deployed. The latter consisted of several wagon- or tripod-mounted cameras, as well as a remotely-controlled fixed video camera ("809 Camera") near Building 809 (Fig. 1.2). Appendix B maps the locations of the monitoring sites in relation to the launcher and launch trajectory for each launch in May–June 2004.

Three additional launches occurred on two dates in late July. On 26 July, two AGS slugs were launched from the Building 807 launch complex, to which the AGS launcher (howitzer) had been relocated subsequent to the 3 June launch. On 29 July, an Arrow ABM was launched vertically near the Alpha Launch Complex. During the July launches, paired video cameras and ATARs were deployed at three sites, and for the Arrow launch on 29 July, another video camera was also deployed at a fourth monitoring site. For the launches in late July 2004, analyses of the acoustic and pinniped data have not yet been completed. Those data will be included in a later report.

Approximately four more launches are anticipated to occur during August and September 2004, prior to the end of the period covered by the present Letter of Authorization (Appendix A). The Navy anticipates a GQM SSST launch in mid-August, an Arrow launch in late August, an AGS launch in late August, and a RAM launch in mid-September. However, this schedule is subject to change. Acoustic and video monitoring of launches occurring during those months is planned.

1.6 Acoustical Monitoring of the Missile Launches

Audio recordings were obtained to document launch sounds at several distances from the launch trajectories of the vehicles. In addition, these recordings provided measures of 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 detect (or not) 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.

Based on a review of the literature (Lawson et al. 1998), it is evident that the sound levels that might cause notable disturbance for each of the pinniped species are variable and context-dependent. Lawson et al. (1998) estimated the minimum received level (on an A-weighted "Sound Exposure Level" or ASEL basis) that might elicit substantial disturbance as 100 dBA re 20 μPa. That 100-dBA figure pertained to exposure to prolonged sounds, which were taken to last at least several seconds. It is arguable whether the launch sounds should be considered to be "prolonged" from the perspective of a pinniped at a fixed location on a beach.

Measured durations typically range much less than 1 to ~5 seconds (Greene and Malme 2002; Greene 2004; see also Chapter 2). In any event, the assumption that reactions might occur at distances up to those where received levels diminished to 100 dBA re 20 µPa on an SEL basis was one factor in selecting acoustic (and video) monitoring sites during the 2001–2004 monitoring periods.

After reviewing video recordings of launches at San Nicolas Island during 2001–2002 (see Holst and Lawson 2002), the 100-dBA level seemed reasonable as a minimum received level (SEL) that might elicit disturbance for California sea lions. However, 90 dBA SEL seemed more appropriate for harbor seals, as they showed a strong response to most launches, including a number of launches where received levels were <100 dBA SEL. The majority of elephant seals usually exhibited little or no reaction to launch sounds. The received levels of sounds from the larger missiles, indicated that levels at or above 90 dBA SEL could be expected out to distances of about 4 km from the launch trajectory (see Fig. 2.39 *in* Greene and Malme 2002). This determined where acoustic (and video) monitoring was done during 2002–2003 and during the current 2003–2004 monitoring period.

1.7 Visual Monitoring of Pinnipeds During Missile Launches

The Navy conducted continued video and visual monitoring of pinnipeds during the missile launches from San Nicolas Island in the October 2003 to July 2004 period, supplemented by simultaneous autonomous audio recording of launch sounds (see Chapter 2). The video and visual monitoring provided data on samples of the pinnipeds hauled out on western San Nicolas Island during launches. The accumulation of such data across numerous launches will provide the data required to characterize the extent and nature of disturbance effects. In particular, it will provide 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.

The video records are to be used to document pinniped responses to the launches. The objectives include the following:

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

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

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

In the October 2003 – June 2004 period for which analyses are completed, the number of launches was limited. Also, a different type of vehicle was launched on each of the three launch dates (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) will require consideration of additional data, including data from the previous years of monitoring (Lawson et al. 2002; Holst and Greene 2004) and data from planned future monitoring. Therefore, objectives (3) and (4) are not addressed in the present report. A detailed description of the methods for the visual monitoring can be found in Section 3.2 of Chapter 3.

1.8 Letter of Authorization

The monitoring program for the Navy's missile launches in 2001–2004 was designed, in part, to provide the data needed to estimate the numbers of pinnipeds affected by the launches and the manner in which they were affected. Pinnipeds are assumed to be 'taken by harassment' if there is a reason to believe that Temporary Threshold Shift (TTS) might have occurred as a result of a launch, or if biologically significant behavioral patterns of pinnipeds are disrupted. NMFS (2000) defines 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." Consistent with NMFS (2002), "…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".

An LOA to authorize possible harassment takes of pinnipeds hauled out at San Nicolas Island during missile launches was issued to the Navy on 2 October 2003. IHAs were previously issued for launches conducted from 2001 to 2003 (NMFS 2001, 2002). Acoustic and visual monitoring has been conducted during launches from San Nicolas Island from August 2001 to the present. Lawson et al. (2002) and Holst and Greene (2004) described the results from the previous monitoring years. The present report describes the results from the 2003–2004 monitoring period.

1.9 Summary

From October 2003 through June 2004, Naval Air Warfare Center Weapons Division (NAWCWD) conducted a total of five launches from San Nicolas Island, on three different days. Three additional launches occurred in late July 2004. Launches occurred from two parts of the island: the Building 807 Launch Complex near the beach on the west-central part of San Nicolas (one dual RAM launch in May, plus two AGS slugs in late July), and from the Alpha Launch Complex farther inland on San Nicolas Island (four launches on two days in May–June; one launch in late July). An acoustic and visual monitoring program was conducted during these launches to assess the effects of these operations on the pinniped species on the island. Monitoring procedures were consistent with those during previous launches in 2001–2003 period (see Lawson et al. 2002; Holst and Greene 2004). Monitoring procedures and results of the acoustic and visual monitoring during October 2003 to June 2004 are described in Chapters 2 and 3. Results from the launches during July 2004 will be reported later.

2. ACOUSTICAL MEASUREMENTS OF MISSILE LAUNCHES, OCTOBER 2003 – JUNE 2004[1]

2.1 Introduction

A total of six vehicles were launched from San Nicolas Island (SNI) during the period from 5 May 2004 through 3 June 2004. The first of the launches was a dual RAM launch, with the two missiles being launched in quick succession (12 seconds apart) on 5 May. On 18 May 2004, a single GQM-163A was launched. On 3 June 2004, three vehicles were launched sequentially; two AGS slugs were launched 1 hr 51 min apart, followed by an AGS missile 1 hr 46 min later. Table 2.1 lists the launch dates, times, and types of vehicles; and Table 2.2 lists the acoustic monitoring locations. Maps of the launch azimuths and monitoring locations for each launch date can be found in Appendix B. Three launches in late July 2004 were also monitored, but those results have not yet been analyzed and are not considered in this chapter.

The acoustic measurement program during the October 2003 – June 2004 period was consistent in approach and methodology with that used during the preceding years (Greene and Malme 2002; Greene 2004). The sounds of each vehicle, as well as background sounds, were recorded at up to three sites on the island during each vehicle flight. Autonomous Terrestrial Acoustic Recorders (ATARs), described below, were developed for this purpose by the Navy's acoustical contractor, Greeneridge Sciences Inc. of Santa Barbara, CA. The ATARs were used to record the launch sounds at places and times where launch safety considerations required that no operator could be present. Of the 15 possible recordings during the present monitoring period (five launches × three recording sites per launch), 15 recordings were obtained and analyzed (Table 2.1) but two recordings from the GQM-163A launch overloaded and the signals were clipped.

When acoustic data from sufficient flights are available, measured sound levels at various microphone locations can be used to characterize sound exposure vs. distance downrange and laterally from the launch azimuth. Initial analyses of this type, for data collected from August 2001 through August 2003, were reported by Greene (2004). Weather is expected to have important effects on the received sounds and needs to be considered in later analyses, along with results from additional flights. Other factors to be considered include vehicle type, launch azimuth, and launch characteristics (e.g., low- vs. high-angle launch). Given the small number of launches during the present monitoring period, distributed across a variety of target and missile types, the data reported here provide only a small increment of information over and above the data reported by Greene (2004). No overall across-year analysis of acoustic data has been done in this report. An updated across-year analysis is anticipated at a future date, after a larger increment of "new" data has accumulated.

2.2 Field Methods

2.2.1 Deployment of ATARs

During each flight within the present monitoring period, the three ATARs were all positioned near pinniped haul out sites at varying distances from the planned launch azimuth. During each of these launches, at least one ATAR was within 600 m (horizontal distance) of the planned azimuth or, on 5 May, the launcher itself (Appendix B). The other ATARs were positioned to the sides of that azimuth at other locations where pinniped responses were to be monitored by video methods (see Chapter 3). The

[1] By **Charles R. Greene**, **Jr**., Greeneridge Sciences Inc.

TABLE 2.1. Vehicle launches recorded at San Nicolas Island from October 2003 to June 2004.

Date	Local Time	Vehicle	Elevation Angle	Acoustic Recording Sites	Acoustic Data
5 May 04	11:46	Dual RAM	8°	3	3 ATARs OK [a]
18 May 04	12:40	GQM-163A	18°	3	1 ATAR OK [b]
3 June 04	11:31	AGS Slug	50°	3	3 ATARs OK
3 June 04	13:22	AGS Slug	50°	3	3 ATARs OK
3 June 04	15:08	AGS Missile	50°	3	3 ATARs OK

[a] Data from one ATAR not interpretable due to uncertain gain setting. [b] Other ATARs overloaded (signal was clipped).

TABLE 2.2. Deployment locations of ATAR recording devices from October 2003 to June 2004 (also see Appendix B).

Launch Date	Vehicle	ATAR Locations
5 May 04	Dual RAM	Dos Coves, Bachelor Beach North, Bachelor Beach South [a]
18 May 04	GQM-163A	Pirates Cove, Harbor Seal Overlook [b], Redeye I [b]
3 June 04	AGS slugs and missile	Dos Coves, Harbor Seal Overlook, 809 Camera

[a] Data from this ATAR not interpretable due to uncertain gain setting. [b] ATAR overloaded (signal was clipped).

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 will be combined with the pinniped behavioral data to determine if there is a "dose-response" relationship between received sound levels and pinniped behavioral reactions. However, additional data acquired during previous monitoring (Lawson et al. 2002; Holst and Greene 2004) and ongoing monitoring will need to be used to fully meet that objective.

ATARs were set up at the recording locations on the launch day well before the launch time and were retrieved later the same day. The three ATAR units were deployed by Navy personnel at sites as close as practical to three pinniped haul-out sites at various distances from the launch site and launch trajectory. These three ATAR sites included the following locations: (1) as close as possible to the vehicle's planned flight path, (2) where the received sound levels were estimated to reach a sound exposure level (SEL) ~90 to 100 dBA re 20 $\mu Pa^2 \cdot s$, as shown in Greene and Malme (2002), and (3) midway between sites 1 and 2. Over the period since monitoring started (August 2001), the Navy has distributed the ATARs such that, for types of target or missile that are launched commonly at SNI, recordings have been made at a variety of different distances and locations relative to the flight trajectories.

2.2.2 ATAR Design

The ATARs were designed to record continuously and unattended for up to 48 hours. It was necessary to use autonomous extended-duration recorders because safety considerations required all personnel to leave the monitoring sites one hour prior to the planned launch. With the 48 hour recording capability, an ATAR can still make recordings of flight sounds even if prolonged launch delays occur. The extended recording capabilities of the ATAR units, as compared with DAT audio recording units used previously (e.g., Greene 1999), were important in accommodating any launch delays and periods between launches on the same day.

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 Hz. The principal components of an ATAR are two calibrated dissimilar microphones, two adjustable gain amplifiers (signal conditioners), a two-channel audio interface and analog-to-digital converter, and a laptop computer on whose hard disk the digitized sound samples are recorded. 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 in each ATAR is a PCB 106B50 quartz microphone (PCB Piezotronics Inc., Depew, NY). These relatively insensitive microphones, with sensitivity –202 dB re 1 volt per micropascal (V/µPa), were designed for transduction of strong signals with received sound levels up to 185 dB re 20 µPa. To record ambient sounds concurrently, each ATAR includes a more sensitive microphone, the TMS 130P10 (–157 dB re 1 V/µPa). This, in conjunction with the PCB 106B50, provides additional dynamic range. Each microphone signal is sampled at 44.1 kHz and digitized to a 16-bit two-byte integer.

At each of the monitoring sites, the microphones were placed in hemispherical windscreens and positioned so they were 2–3 mm from the flat side of the hemisphere. The windscreens were then each affixed to the center of an aluminum base plate 0.25 inches thick and 22 inches in diameter. The two base plates were set on the ground or sand in an area generally free of vegetation (Fig. 2.2). 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, just as an animal would near the ground (Greene 1999).

Each microphone required a PCB model 480E09 signal conditioner. These low-noise, unity-gain amplifiers apply the microphone polarizing voltage. The signal conditioners had gain selections of 1, 10 and 100 (corresponding, respectively, to 0, 20 and 40 dB). These signal conditioners were mounted in waterproof Pelican cases with the remaining equipment, excluding the microphones and battery (Fig. 2.1, 2.2).

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.

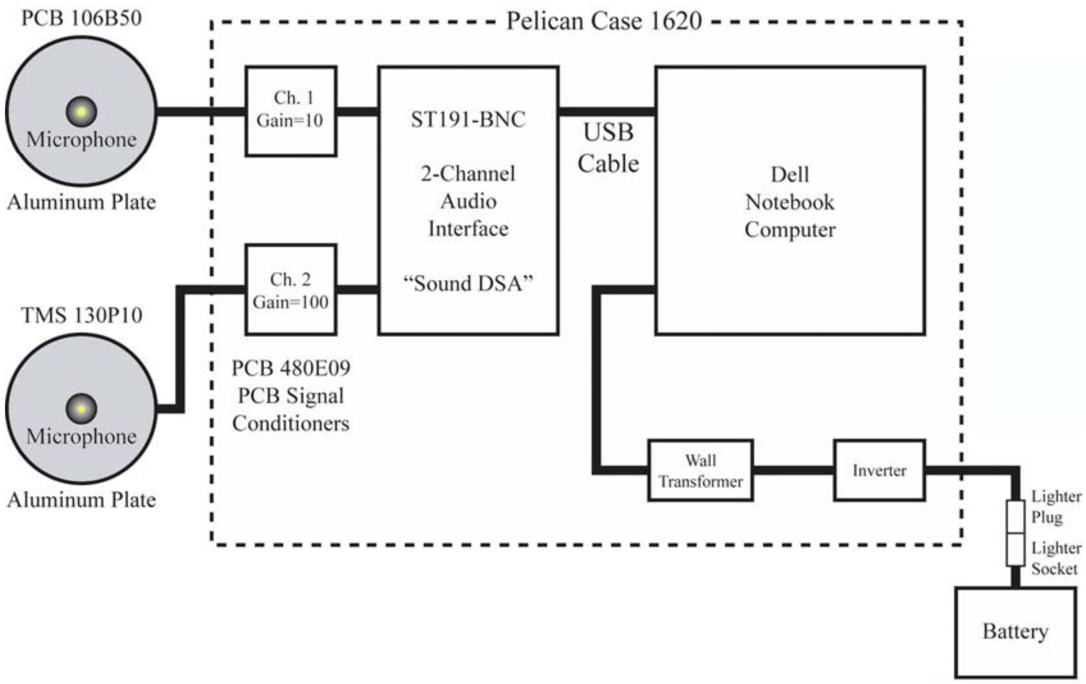

FIGURE 2.1. Block diagram of an Autonomous Terrestrial Acoustic Recorder (ATAR).

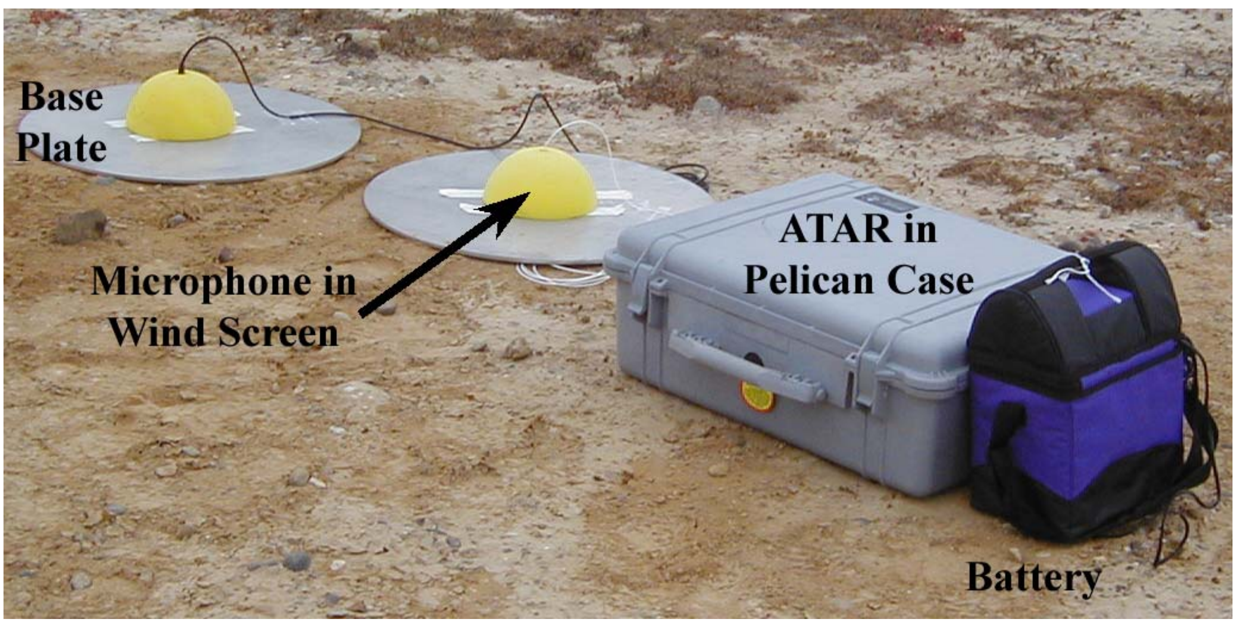

FIGURE 2.2. Typical field installation of an Autonomous Terrestrial Acoustic Recorder (ATAR) at the west end of San Nicolas island, California (photograph by J. Lawson, LGL).

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 mile away, they operated successfully on the first try. The ATARs did not fail when tested either in the lab 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. During the present monitoring period, shielding and new grounding were tested on one unit successfully. The other two ATARs have been modified (July 2004) with shielding.

2.3 Audio and Data Analysis Methods

The ATARs recorded digital data directly onto a hard drive within the ATAR. The digital data on the hard drives were copied to a recordable CD-ROM after the recording period and returned to the acoustical contractor, Greeneridge Sciences Inc., 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 sound pressure level (SPL), root mean square (RMS) SPL, and sound exposure level (SEL). Frequency-domain results included estimation of sound pressure levels in one-third octave bands for center frequencies from 4 to 16,000 kHz. This section describes how these values are defined and calculated.

2.3.1 Time-Series Analysis

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

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

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

Based on this consistent definition of net energy E, the beginning and end of a flight sound 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 $Pa^2 \cdot s$. **SEL** (sound exposure level) was determined from 10·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 (root-mean-square) value of the signal, less background noise, over the duration. **SPL** (sound pressure level) 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. The acoustical contractor used Welch's (1967) "Weighted Overlapped Segment Averaging" (WOSA) method 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 broad-band time series analysis) as follows:

- for duration > 1 second, use 32,768-sample blocks of total length 0.74 seconds with Blackman-Harris 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 < duration < 1 second, use 4096-sample blocks of total length 0.0929 seconds 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 seconds, 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 seconds 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 3-term window, resulting 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 sound pressure levels 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). Note that 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 A-Weighting

Time-series results for the full 3 to 20,000 Hz bandwidth were calculated both for A- and flat-weighted data. With A-weighting, the signal's spectrum is multiplied by the standard A-weighting spectrum (Kinsler et al. 1982, p. 280; Richardson et al. 1995, p. 99). This multiplication 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 weighting applied by the human ear and is a standard method of presenting data on airborne sounds. Flat weighting, on the other hand, leaves the signal spectrum unchanged. The relative sensitivity of pinnipeds listening in air to different frequencies is generally similar to that of humans (Richardson et al. 1995), so A-weighting may be relevant to pinnipeds. However, measurement data from each launch are presented by one-third octave band in Appendix C, so other weighting methods, e.g., C-weighting or species-specific weighting functions, could be applied to these data.

Only flat weighting was used for frequency-domain analyses. The concept of A-weighting is not useful when reporting results for specific frequencies or narrow frequency bands.

2.3.4 Closest Point of Approach Distance by the Missile

To relate missile sounds to the proximity of the missile trajectory, the 3-D distance from the recording site to the closest point of approach (CPA) of the missile was calculated for each launch date and sound monitoring site.

2.4 Results

2.4.1 Missile Flight Sounds

Four parameters are reported for the missile flight sounds: peak pressure level, sound pressure level (SPL), sound exposure level (SEL), and duration. These parameters are explained in Section 2.3. Table 2.3 presents the results for acoustic monitoring during October 2003 to June 2004 based on flat- and A-weighting. It was to be expected that A-weighted levels would almost always be less than flat-weighted levels because sonic boom noise is strong at frequencies below 1000 Hz, which are de-emphasized with A-weighting. The flight sound durations are sometimes long because of rocket noise and reverberation.

The dual RAM launch produced flat-weighted SPLs of 86 and 87 decibels (dB) re 20 micropascal (µPa) at Dos Coves, located 1904 ft (571 m) from the CPA, and 90–91 dB at Bachelor Beach North, 2273 ft (682 m) from the CPA (Fig. B-1 A). At each site, the two values pertain to the sounds from the two missiles launched 12 s apart. SELs ranged from 93 to 97 dB. Corresponding A-weighted values were lower by 5–8 dB for both SPL and SEL (Table 2.3).

The GQM-163A SSST target produced SPLs >128–130 dB at nearshore sites up to 0.65–0.79 mi (1.0–1.3 km) from the CPA, and an SPL of 93 dB at Pirates Cove, located 1.5 mi (2.3 km) from the CPA (Fig. B-1 B). SELs ranged from 105 to >119 dB. At the two closer sites, the values quoted here are minimum figures (the signals were clipped), and there were no indications of a sonic boom. A-weighted values were much lower than flat-weighted values (Table 2.3). One-third octave spectra for the SSST launch show that the received sound was strongest at low frequencies (e.g., ≤125 Hz), in contrast to sounds from the dual RAM launch (Appendix C). This accounts for the greater difference between flat- and A-weighted levels for the SSST; low-frequency energy is strongly discounted when calculating A-weighted levels.

The AGS vehicles resulted in SPLs ranging from 100 to 111 dB at three sites (Dos Coves, Harbor Seal Overlook, and Near 809 Camera) located 0.7–0.8 mi. (1.1–1.3 km) from the CPA (Fig. B-2 C,D,E). SELs ranged from 94 to 103 dB. Again, A-weighted values were notably lower than flat-weighted values (Table 2.3). Sounds from the powered AGS missile were not notably stronger than those from the unpowered slugs as received at the three monitoring sites.

Two graphs are presented in Appendix C for each flight recording during the October 2003 through June 2004 period. For each launch, both graphs are based on flat-weighted data; no graphs are presented for A-weighted waveforms. One graph presents the pressure signature (pressure vs. time waveform). The second presents the sound exposure levels 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 sound pressure levels. Because the ambient sounds are continuous, expressing them as sound exposure levels is unconventional. However, for purposes of comparison with the transient missile sounds, one can consider the sound pressure levels for ambient noise to be the sound exposure levels in a one-second period.

TABLE 2.3. Pulse parameters for flat- and A-weighted sound from vehicle flights at San Nicolas Island during October 2003 to June 2004. The peak levels and sound pressure levels are in dB relative to 20 µPa, the sound exposure levels (energy levels) are in dB relative to (20 µPa)^2·s, and the durations (Dur.) are in seconds. The 3-D closest point of approach (CPA) distance of the vehicle from the monitoring site is given in m. Broadband (10-20,000 Hz) flat- and A-weighted sound levels for each site as recorded before the launch by the high-sensitivity sensor designed to measure ambient sounds are also given (dB re 20 µPa). See Appendix B for maps of monitoring locations.

Date				CPA	Flat-weighted sound				A-weighted sound				Ambient sound	
2004	Time	Vehicle	Site	(m)	Pk	SPL	SEL	Dur	Pk	SPL	SEL	Dur.	Flat-	A-wt
5 May	11:46:00	RAM[a]	Dos Coves	571	111	86	93	4.5	86	80	86	3.9	64.2	47.3
"	11:46:12	"	Dos Coves	571	114	87	93	4.0	93	79	85	3.7	64.2	47.3
"	11:46:00	"	Bachelor Beach North	682	116	90	97	4.2	97	85	91	3.7	67.2	57.0
"	11:46:12	"	Bachelor Beach North	682	116	91	96	3.0	95	84	90	3.6	66.9	57.1
18 May	12:40	GQM-163A[b]	Pirates Cove	2359	106	93	105	15.8	75	71	79	6.7	N/A	N/A
"	12:40	"	Harbor Seal Overlook*	1271	>136	>128	>117	0.1	>133	>106	>103	0.5	79.3	36.9
"	12:40	"	Redeye I *	1045	>136	>130	>119	0.1	>135	>111	>103	0.1	77.9	44.6
3 June	11:31	AGS Slug[c]	Dos Coves	1325	117	105	98	0.2	110	88	78	0.1	71.1	52.6
"	13:22	AGS Slug[c]	Dos Coves	1325	113	100	94	0.2	97	82	73	0.1	75.6	54.0
"	15:08	AGS Missile[c]	Dos Coves	1325	114	105	98	0.2	98	81	73	0.1	71.5	55.9
"	11:31	AGS Slug[c]	Harbor Seal Overlook	1145	124	110	103	0.2	107	88	80	0.2	N/A	N/A
"	13:22	AGS Slug[c]	Harbor Seal Overlook	1145	115	101	95	0.3	107	85	76	0.1	N/A	N/A
"	15:08	AGS Missile[c]	Harbor Seal Overlook	1145	125	111	103	0.2	105	87	79	0.2	N/A	N/A
"	11:31	AGS Slug[c]	809 Camera	1248	127	110	103	0.2	118	107	89	0.0	65.6	40.4
"	13:22	AGS Slug[c]	809 Camera	1248	128	109	103	0.3	119	94	88	0.3	64.0	41.0
"	15:08	AGS Missile[c]	809 Camera	1248	120	108	102	0.2	96	82	75	0.2	73.4	41.8

N/A: the high-sensitivity channel did not record properly.
[a]Vehicle launched at an 8° angle. [b]Vehicle launched at an angle of 18°. [c]Vehicles launched at an angle of 50°.
*Signal was clipped (ATAR overloaded).

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 are tabulated in Table 2.3 for the current monitoring period. The averaging time was 4.0 seconds.

The effect of A-weighting compared to flat weighting is manifest. The measured values are indicative of very quiet background sounds, comparable to sound levels expected in quiet residential areas. Furthermore, 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 were excluded, broadband levels were typically 10 dB lower than those quoted in Table 2.3 for the 10–20,000 Hz band.

Ambient sound levels could not be determined at one location (Pirates Cove) due to malfunction of the high-sensitivity channel during the GQM-163A launch on 18 May and at one location (Harbor Seal Overlook) during the AGS launches on 3 June. These malfunctions have been corrected.

2.5 Discussion and Summary

Six vehicles of a variety of types were launched from San Nicolas Island from 5 May to 3 June 2004. The sound levels received from RAM, AGS, and GQM-163A vehicles were comparable to those recorded previously for these three types of vehicles (Greene and Malme 2002; Greene 2004). Also, sound levels during the launch of the new type of supersonic target missile, the GQM-163A SSST, were similar to or less than those recorded previously at similar distances from flight paths of Vandal targets (*cf.* Greene 2004).

Two of the ATARs overloaded during the GQM-163A launch due to incorrect gain settings. However, there is no reason to believe that the average received level at overloaded ATARs was greater than that for non-overloaded ATARs, as the problem was an incorrect gain setting rather than an unexpectedly high level of the received signals.

3. BEHAVIOR OF PINNIPEDS DURING MISSILE LAUNCHES[1]

3.1 Introduction

A total of five launches occurred from the west end of San Nicolas Island, California, during October 2003 through June 2004, on three separate dates. One launch was a dual launch of two vehicles within ~12 seconds of one another, so a total of six vehicles were launched. Specific information about each of the launches is given in Chapter 1. (Data from three additional launches in late July 2004 have not yet been analyzed and are excluded from this chapter.) Chapter 2 documents the sounds measured at various sites on western San Nicolas Island during each launch. Corresponding information concerning previous launches during 2001–2003 are reported by Lawson et al. (2002) and Holst and Greene (2004). This chapter documents the behavioral reactions of pinnipeds exposed to the launch sounds during the October 2003 to June 2004 monitoring period.

Three species of pinnipeds are common on the beaches of San Nicolas Island: the California sea lion *Zalophus californianus*, the harbor seal *Phoca vitulina*, and the northern elephant seal *Mirounga angustirostris*. No other species were recorded during the monitoring work, either during the present monitoring period or during previous monitoring efforts since August 2001.

During launches in May to June, missiles flew high over haul-out sites occupied by molting harbor and elephant seals, as well as breeding/pupping California sea lions. No evidence of injury or mortality was observed on the day of any launch, and behavioral reactions of the three species were consistent with those observed during the August 2001 – August 2003 period (*cf.* Holst 2004a).

In most cases, elephant seal and sea lion behavior returned to pre-launch states within seconds or minutes following the launches. In fact, most northern elephant seals demonstrated little or no reaction to the missile launches. Behavior as well as numbers of sea lions and elephant seals hauled-out several hours after the launches appeared similar to the behavior and numbers observed before launches. In contrast, harbor seals commonly left their haul-out sites to enter the water and did not return during the duration of the video-recording period. Data from previous monitoring showed that the behavior and numbers of harbor seals hauled-out on the day following a launch were similar to those on the day of the launch (Holst and Lawson 2002).

3.2 Field Methods

The launch monitoring program was based primarily on remote video recordings. Observations were obtained before, during, and after each vehicle launch. Remote cameras were essential because, during missile launches, safety rules prevent personnel from being present in many of the areas of interest. 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 studied per launch depended on how many species were hauled out within the presumed area of influence, and on the deployment of the three video systems used during each launch.

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 flight path of the missile during each launch from San Nicolas Island. Video data are generally obtained via two or three portable cameras that can be set up temporarily at any site, plus a permanent ("fixed") camera that has been installed near

[1] By **Meike Holst,** LGL Ltd., environmental research associates. Thanks also to John W. Lawson who planned the work and established the format for earlier related reports.

Building 809. However, the latter fixed camera was not operational during the present monitoring period. During each launch in May–June 2004, the closest monitoring location was within a horizontal distance of 571 m from the planned launch azimuth or the launcher itself; the other monitoring sites were at varying distances from the launch azimuth or launcher. Appendix B shows the monitoring locations relative to the launch azimuths. The monitoring locations varied from launch to launch.

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 will require data from a relatively large number of launches. The few launches (of diverse types) during the current monitoring period could not, in themselves, provide sufficient data for such an analysis. To investigate the dose-response relationships, acoustic and pinniped response data from the present monitoring period will be used, along with corresponding data from previous monitoring during 2001–2003 (Lawson et al. 2002; Holst and Greene 2004) and from future monitoring. An initial analysis of the first two years' data was conducted by Holst (2004a).

3.2.1 Fixed Camera

A permanent, fixed camera is installed in an elevated position at Building 809 at the west end of San Nicolas Island (see Appendix B). This camera, designated "809 Camera", is situated on a metal tower overlooking Vizcaino Point (Fig. 3.1). The camera can be remotely zoomed, tilted, and panned by an observer stationed in a remote blockhouse (Building 127). Digital video data from this camera can be sent back to the blockhouse where they can be viewed on a large video monitor and recorded on large-format digital videotape. Data from this camera can be recorded for any desired duration. This camera does not include a built-in microphone. The "809 Camera" was not operational during the October 2003–June 2004 monitoring period, but was used in July 2004.

3.2.2 Mobile Cameras

During the day of each launch, Navy personnel placed up to two portable Sony Hi-8 digital video cameras on tripods that overlooked haul-out sites. Placement of the cameras was such that disturbance to the pinnipeds was minimal, and the cameras were set to record a focal subgroup within the haul-out aggregation for the maximum 4 hr permitted by the videotape capacity of the mobile cameras. The entire haul-out aggregation at a given site was not recorded, as the wide-angle view that would have been necessary to encompass an entire beach would not have allowed detailed behavioral analyses. It was more effective to obtain a higher-magnification view of a sample of the animals at the site. 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.

3.2.3 Wagoncam

A "wagoncam" (or Camera Cart) was also used on several occasions (Fig. 3.2). A wagoncam, unlike the "mobile cameras", transmits its signal back to a centralized location where it is recorded. The signal from the wagoncam was recorded at Building 127. The wagoncam did not include a built-in microphone. During the day of each launch, Navy personnel placed wagoncams at locations overlooking haul-out sites. Placement was such that disturbance to pinnipeds was minimal. 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 analyses.

FIGURE 3.1. View of the permanent fixed video camera at Building 809. This camera can be remotely zoomed, tilted, and panned, but was non-operational during the present monitoring period. (Photograph by U.S. Navy)

FIGURE 3.2. View of a wagoncam, which unlike other portable video cameras, can transmit its signal back to a centralized location where it is recorded. (Photograph by U.S. Navy)

TABLE 3.1. Video data collected for California sea lions, northern elephant seals, and harbor seals during vehicle launches at San Nicolas Island, October 2003 – June 2004.

	Launch Date 2004		
Video Recording Location	**5 May Dual RAM**	**18 May GQM-163A**	**3 June AGS (x3)**
California Sea Lion			
Dos Coves South	x		x x x
Near 809 Camera			x[a] x x
Northern Elephant Seal			
Bachelor Beach North	x		
Bachelor Beach South	x[a]		
Redeye I		x	
Dos Coves South			x x x
Harbor Seal			
Harbor Seal Overlook		x	x x x
Pirates Cove		x	

[a] No observations or behavioral data were obtained from the recording of northern elephant seals at Bachelor Beach South on 5 May nor from the recording of sea lions near 809 Camera at 11:31 on 3 June.

3.2.4 Visual Observations

Navy personnel from the Environmental Project Office, China Lake, made direct visual observations of the pinniped groups prior to deployment of the cameras and ATARs. 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) was shown superimposed on the video. For sites where harbor seals were monitored, the observers returned to the monitoring sites for follow-up monitoring either ~2 hours after the launch or the following day to note the status of pinnipeds at the haul-out site (e.g., had the numbers of pinnipeds changed? Was there obvious evidence of recent injury or mortality?). Most video recordings of harbor seals showed that haul-out sites were usually occupied by only a few seals or void of seals for minutes or even hours following launches.

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, for analysis.

Subsequent to the launch, experienced biologists reviewed and coded the video data on the DVD-ROMs as they were played back to a high-resolution color monitor. The DVD player was connected to the monitor using a high-quality S-video output lead. The player had a high-resolution freeze-frame capability. A jog shuttle was used to facilitate distance estimation, launch timing, and characterization of behavior.

The videotaped data for several hours before, during, and up to 1 hour after each launch were reviewed in order to document the types and numbers of pinnipeds present, and the nature of any overt responses to the launch. 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.

In addition, quantitative observations of pinnipeds were made based on two 1-min samples of each video recording from the day of each launch. The objective was to determine whether behavioral changes attributable to the launches persisted for more than a few minutes. (Following NMFS [2002], subtle behavioral reactions that persisted for only a few minutes were considered unlikely to have biologically significant consequences for the pinnipeds.) Data were recorded for the 1-min interval immediately preceding the launch and for a 1-min duration starting 10 min after the launch (i.e., from 10–11 min after the launch). A focal subgroup was chosen from the group of clearly visible animals, and individuals were observed. Only individuals that were easily seen throughout the entire sample period were chosen as focal animals.

More specifically, the variables transcribed from the videotapes included

1. composition of the focal subgroup of pinnipeds (numbers by sex and age class),
2. description and timing of disruptive event (missile launch); this included documenting the occurrence of the launch and whether launch noise was evident on the video record's audio channel (if present),
3. movements of pinnipeds, including number and proportion moving, direction and distance moved, pace of movement (slow or vigorous),
4. interaction type: agonistic, mother/pup, play, or copulatory sequence types, and
5. interaction distance: an estimate of the minimum distance [cm] between interacting pinnipeds' bodies, based on the known size of morphological features [body or head length] or comparison with adjacent substratum features of known size.

In addition, the following variables concerning the circumstances of the observations were also 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,
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 meters] around the focal subgroup of pinnipeds, as determined by meteorological conditions and/or physical obstructions; this was estimated by determining what the farthest visible object was 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 closest point of approach (CPA) of the missile was calculated. For some launches and recording sites, the CPA distance is the distance from the launcher to the recording site. As evident from Appendix B, this was the case for all three recording sites on 5 May (RAM launch) and for one recording site on 18 May (Pirates Cove recording site).

3.4 Descriptions of Pinniped Behavior During Specific Launches

The following subsections provide overall descriptions of pinniped responses during each launch in the current monitoring period, descriptions of any notable reactions, and quantitative descriptions of pinniped behavior and distribution prior to and following the launches. Corresponding descriptions concerning pinniped responses to launches in 2001–2003 are reported by Holst and Lawson (2002) and Holst (2004a).

Video recordings of pinniped behavior during launches in the October 2003 – June 2004 period were collected on two dates for California sea lions and harbor seals and on three dates for elephant seals (Table 3.1). During that period, sea lions were monitored at two different sites (total of three site-date combinations), elephant seals were observed at three different sites (three site-date combinations), and harbor seals were monitored at two different sites (three site-date 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 Dual RAM Launch, 5 May 2004

A dual RAM launch occurred from the Building 807 Launch Complex, with a launch azimuth of 240º and an initial elevation angle of 8º. The two vehicles were launched sequentially, ~12 seconds apart. California sea lions were videotaped at Dos Coves South, ~1904 ft (571 m) from the CPA, and elephant seals were observed at Bachelor Beach North, ~2273 ft (682 m) from the CPA (Table 3.1; Fig. B-1A). Another recording of elephant seals was attempted slightly farther away (~3200 ft or 976 m), at Bachelor Beach South, but the video quality during the launch was too poor for observations. In all three cases, the CPA distance was the distance from the launcher (Appendix B). Launch sound was audible on the audio track of the video recordings at Dos Coves South and at Bachelor Beach North. There was no sound track on the video recording at Bachelor Beach South, where a wagoncam was used. Launch sounds were recorded quantitatively (via ATARs) at Dos Coves and Bachelor Beach North (Table 2.2; Fig. B-1A).

California Sea Lions.—About 100 individuals were monitored at Dos Coves South, although more animals were likely present outside the field of view of the camera. Prior to the launch, there was movement on the beach, mainly by juvenile sea lions. During the first launch, most animals looked up but only a few (3–4) animals moved, by less than 1 m. Sea lions reacted more vigorously to the second launch. Although most animals still merely looked up, 12 animals moved 1–2 m, and one sea lion entered the water. Within 1 min after the launch, the sea lions had settled again, although several juveniles were moving around on the beach (Table 3.2). However, this behavior was also observed prior to the launch.

Northern Elephant Seals.—Groups of juvenile northern elephant seals were videotaped at Bachelor Beach North. Around 76 seals were observed; 60 were lying on the sand and cobble, and 16 animals were in the water. A thousand or more elephant seals were present on the beach but outside the field of view of the camera. Prior to the launch, there was movement by seals on the beach. During the first launch, all focal animals looked up, but none moved. During the second launch, all focal seals looked up, 5 seals moved 1–2 m, and 1 seal that was already situated close to the water entered the water (Table 3.3). Those remaining on the beach settled within 10 seconds.

TABLE 3.2. Details of vehicle launches, sound exposure levels (SEL), and ***California sea lion*** reactions at San Nicolas Island during October 2003 – June 2004. A dual RAM launch occurred on 5 May 2004. The RAM vehicles were launched from the Building 807 Launch Complex, whereas the AGS vehicles were launched from the Alpha Launch Complex. Times are local time.

Launch Date	Launch Time	Vehicle Type	Launch Azimuth	Elevation Angle / Altitude Over Beach	Pinniped Monitoring Site	3-D CPA distance (m)	Sound Exposure Levels [dB re $(20\ \mu Pa)^2 \cdot s$] flat-weighted/A-weighted	Behavioral Reaction of Animals to Launch
5 May 04	11:46	RAM	240°	8° / 50 ft	Dos Coves South[n]	571	93/85-86	~100 individuals monitored; during first launch, most animals (80–90%) looked up but only ~4% moved (<1 m); during second launch ~12% moved (1-2 m) and 1 entered water; settled within minutes
3 June 04	11:31	AGS Slug	282°	50° / 4500 ft	Dos Coves South[s]	1325	98/78	35 individuals monitored; no overt reaction to launch
					Near 809 Camera[n]	1248	103/89	60 animals monitored; all startled and scattered. 50% of animals moved at least 20–30 m, whereas others moved short distances of only several meters. Settled within several minutes
3 June 04	13:22	AGS Slug	282°	50° / 4500 ft	Dos Coves South[s]	1325	94/73	50 individuals monitored; most (80–90%) looked up during launch but none moved
					Near 809 Camera[n]	1248	103/88	30 sea lions monitored; all were startled but none moved
3 June 04	15:08	AGS Missile	282°	50° / 4500 ft	Dos Coves South[s]	1325	98/73	40 sea lions were monitored; did not show any reaction
					Near 809 Camera[n]	1248	102/75	31 monitored; most (80–90%) were startled and 50% moved in response to the launch

[n] monitoring site located north of the launch azimuth.
[s] monitoring site located south of the launch azimuth.

TABLE 3.3. Details of vehicle launches, sound exposure levels (SEL), and ***northern elephant seal*** reactions at San Nicolas Island during October 2003 – June 2004. A dual RAM launch occurred on 5 May 2004. The RAM vehicles were launched from Building 807 Launch Complex, whereas the GQM-163A target was launched from the Alpha Launch Complex. Times are local time.

Launch Date	Launch Time	Vehicle Type	Launch Azimuth	Elevation Angle / Altitude Over Beach	Pinniped Monitoring Site	3-D CPA Distance (m)	Sound Exposure Levels [dB re (20 μPa)^2·s] flat-weighted/A-weighted	Behavioral Reaction of Animals to Launch
5 May 04	11:46	RAM	240°	8° / 50 ft	Bachelor Beach North[s]	682	96-97/90-91	~76 seals were observed; during the first launch, all animals looked up, but none moved; during the second launch, all seals looked up, 7% moved (1-2 m), and 1 seal entered the water; settled within 10 s
18 May 04	12:40	GQM-163A	300°	18° / 3300 ft	Redeye I[s]	1045	>119/>103	8 were observed; all seals looked up during launch and 1 seal moved 0.5 m; seals settled within 10 s after launch
3 June 04	11:31	AGS Slug	282°	50° / 4500 ft	Dos Coves South[s]	1325	98/78	4 seals monitored; no overt reaction to launch
3 June 04	13:22	AGS Slug	282°	50° / 4500 ft	Dos Coves South[s]	1325	94/73	40 seals monitored; only a few (5–10) looked up during launch, and settled within 10 s after launch; others showed no reaction
3 June 04	15:08	AGS Missile	282°	50° / 4500 ft	Dos Coves South[s]	1325	98/73	40 seals monitored; no overt reaction

[s] monitoring site was located south of the launch azimuth

3.4.2 GQM-163A Launch, 18 May 2004

A GQM-163A target was launched from the Alpha Launch Complex, with an azimuth of 300º and an elevation angle of 18º. A video recording of northern elephant seals was made at Redeye I, 0.6 mi (1 km) from the CPA along the trajectory, and recordings of harbor seals were obtained at Harbor Seal Overlook, 0.8 mi or 1.3 km from CPA, and at Pirates Cove, 1.4 mi or 2.4 km from the launcher (Table 3.1; Fig. B-1B). Launch sound was audible on the audio track of the video recordings at Pirates Cove and Harbor Seal Overlook. A wagoncam, which did not have a microphone, was used at Redeye I. Launch sounds were also recorded via ATARs at Redeye I, Pirates Cove, and Harbor Seal Overlook (Tables 2.2 and 2.3 in Chapter 2; Fig. B-1B). The signals received at Harbor Seal Overlook and at Redeye I were clipped but strong. Launch sounds received at Pirates Cove were weaker.

Northern Elephant Seals.—Eight seals were observed at Redeye I, although more seals were likely present outside of the field of view of the camera. During the launch, all seals looked up and one seal moved 0.5 m (Table 3.3). The seals settled within 10 seconds after the launch.

Harbor Seals.—At Pirates Cove, five seals were observed during the launch. During the launch, all seals moved into the water, which was 1–3 m from the seals' original locations (Table 3.4). There were no seals on the beach for the remainder of the video recording period (1 hr after the launch). Simultaneously, observations of 21 harbor seals were made at Harbor Seal Overlook. All seals entered the water during the launch. Harbor seals started hauling out again at the same site ~25 min after launch. The following day, harbor seals were also hauled out at Harbor Seal Overlook.

3.4.3 Triple AGS Launch, 3 June 2004

Two AGS slugs and one AGS missile were launched from the Alpha Launch Complex, with an azimuth of 282º and a 50º elevation angle. The two slugs were launched sequentially, 1 hr 51 min apart, followed by the AGS missile 1 hr 46 min later. During all three launches, a video recording of harbor seals was obtained at Harbor Seal Overlook (0.7 mi or 1.1 km from CPA), and California sea lions were monitored at Dos Coves South and near 809 Camera, both located ~0.8 mi (1.3 km) from the CPA. Elephant seals were monitored during all three launches at Dos Coves South. At Dos Coves South, the video quality was poor (lens foggy) for the recording of sea lions and elephant seals during the first AGS launch at 11:31; video quality for the subsequent launches at 13:22 and 15:08 was fair. Near 809 Camera, some observations of sea lions could be made during the launch of the first AGS slug at 11:31, but no detailed behavioral data could be obtained, due to poor video quality. The video quality for the subsequent launches at 13:22 and 15:08 was good.

For all three AGS launches on this date, launch sounds were recorded quantitatively via ATARs at Harbor Seal Overlook, Dos Coves, and near 809 Camera (Table 2.2 in Chapter 2; Fig. B-1C,D,E). Launch sounds from all three launches were also audible on the audio channel of the video recordings at Harbor Seal Overlook. Launch sounds were not audible on the audio channel of the video recording at Dos Coves South. A wagoncom was used at 809 Camera, so no sounds were on the video recorded there.

California Sea Lions.—During all three AGS launches, California sea lions at Dos Coves showed very little reaction. From 35 to 50 sea lions were monitored at that site during each AGS launch. Before the first AGS slug was launched at 11:31, there was movement by pups and juveniles along the beach. There was no overt reaction by the sea lions to the first launch. During the second AGS slug launch at 13:23, most sea lions looked around, but none moved. During the launch of the AGS missile at 15:08, there was no overt reaction.

TABLE 3.4. Details of vehicle launches, sound exposure levels (SEL), and ***harbor seal*** reactions at San Nicolas Island during October 2003 – June 2004. All launches were from the Alpha Launch Complex. Times are local time.

Launch Date	Launch Time	Vehicle Type	Launch Azimuth	Elevation Angle / Altitude Over Beach	Pinniped Monitoring Site	3-D CPA distance (m)	Sound Exposure Levels [dB re (20 μPa)^2·s] flat-weighted/A-weighted	Behavioral Reaction of Animals to Launch
18 May 04	12:40	GQM-163A	300°	18° / 3300 ft	Pirates Cove[ne]	2358	>117/103	5 seals observed; during launch, all seals rushed into the water (1–3 m away)
					Harbor Seal Overlook[s]	1271	105/79	21 seals observed; all entered water immediately; seals hauled out again ~25 min after launch
3 June 04	11:31	AGS Slug	282°	50° / 4500 ft	Harbor Seal Overlook[n]	1145	103/80	15 seals observed; all startled and moved quickly (1–4 m); 4 entered the water
3 June 04	13:22	AGS Slug	282°	50° / 4500 ft	Harbor Seal Overlook[n]	1145	95/76	19 seals observed; all startled and moved quickly (1–5 m); 1 seal seen entering water and 10 others likely also entered water
3 June 04	15:08	AGS Missile	282°	50° / 4500 ft	Harbor Seal Overlook[n]	1145	103/79	11 seals observed; all startled and all moved at least 1–5 m. 9 left the area and probably entered water

[n] monitoring site located north of the launch azimuth
[ne] monitoring site located northeast of (in opposite direction to) the launch azimuth
[s] monitoring site located south of the launch azimuth

Near 809 Camera, there was some video interference during the first AGS launch, and detailed behavioral data could not be collected before the launch. During the launch, all 60 animals startled and scattered, and most (80–90%) moved vigorously along the beach. About 50% of the animals moved out of the field of view of the camera (at least 20–30 m) during the launch. Sea lions reacted less to the second AGS launch at 13:22. Most (80–90%) of the 30 animals were startled by the launch, but none moved in immediate response to the launch. Most animals settled with 1 or 2 min. During the launch of the AGS missile at 15:08, most (80–90%) of the 31 sea lions were startled, and about 50% moved along the beach. Received sound levels during the three launches were higher near 809 Camera than at Dos Coves (Table 2.3).

Northern Elephant Seals.—Four seals were monitored during the first AGS slug launch at 11:31, but no overt reactions were observed. During the second launch at 13:23, elephant seals still showed very little reaction to the launch; 10 of 40 seals looked up, but they returned to resting positions within 10 seconds. During the last launch at 15:08, the seals showed no overt reaction.

Harbor Seals.—Eight seals were monitored at Harbor Seal Overlook during the launch of the first AGS slug at 11:31. In response to the launch, all 15 seals startled and moved quickly several meters (1-4 m) likely towards the water (not in field of view of camera), and another seven seals entered the field of view of the camera (probably moving towards the water). In total, two animals entered the water within 30 seconds after the launch, and two more seals entered the water >30 seconds after the launch. During the second launch at 13:22, 19 seals were observed and all startled and moved quickly at least 1–5 m in response to the launch, likely towards the water. Ten of those seals moved out of the field of view of the camera and likely entered the water. One seal was actually seen to enter the water 30 seconds after the launch. During the AGS missile launch at 15:08, 11 seals were monitored. All seals startled in response to the launch and moved quickly at least several meters (1–5 m) probably towards the water. Nine of the seals left the area immediately and likely entered the water. The other two seals remained in the area for another minute and then left the field of view of the camera. No seals were hauled out at Harbor Seal Overlook during the remainder of the video recording (1.5 hr), but 1 was hauled out during follow-up monitoring 2 hr after the launch.

3.5 Pinniped Behavior and Distribution Prior to and Following Launches

The "units of observation" for the quantitative studies were individual pinnipeds within the focal subgroups. Individuals were chosen that were clearly visible on the video recordings for the entire 1-min sampling period of interest (either pre- or post-launch). The individuals chosen for the focal subgroups before and after the launch were not necessarily the same animals, especially in the situation where pinnipeds moved or left the haul-out site in response to the launch (e.g., harbor seals). In the case of northern elephant seals, the focal animals were often the same individuals that were observed prior to the launch.

Means and standard deviations are presented for inter-individual spacing, total distance moved, and number of position changes before and after launches, separately by species (Table 3.5). Given the low number of launches in the present monitoring period, sample sizes are small, and no statistical comparisons are justified on these data alone. Additional related data (for the launches in August 2001 – August 2003) are given in Holst (2004a).

TABLE 3.5. Description of pinniped behavior and distribution prior to and after launches, October 2003 – June 2004. *n* = number of animals; SD = standard deviation.

	Before Launch			After Launch		
Behavior Analyzed	*n*	Mean	SD	*n*	Mean	SD
Number of Position Changes						
California Sea Lions	58	0.14	0.51	48	0.10	0.31
Northern Elephant Seals	43	0	0	41	0.07	0.26
Harbor Seals	44	0.09	0.29	18	0.28	0.70
Total Distance Moved (m)						
California Sea Lions	58	0.32	1.62	48	0.35	2.02
Northern Elephant Seals	43	0	0	41	0.03	0.16
Harbor Seals	44	0.22	0.88	18	0.22	0.55
Distance to Neighbor (m)						
California Sea Lions	58	0.20	0.63	48	0.13	0.26
Northern Elephant Seals	43	0.23	0.60	41	0.20	0.55
Harbor Seals	44	0.73	0.50	17	0.94	0.93

3.6 Summary

Pinniped behavioral responses to launch sounds during the October 2003 – June 2004 period were, with the exception of some responses by harbor seal seals, usually brief and not severe. These responses were similar to those for the 2001–2003 monitoring periods (Holst and Lawson 2002; Holst 2004a). In general, northern elephant seals usually exhibited little reaction to the launches, California sea lions showed variable responses, and harbor seals were the most responsive. No evidence of injury or mortality was observed during or immediately succeeding the launches.

Responses of California sea lions to the missile launches varied by individual. Some sea lions exhibited brief startle responses and increased vigilance for a short period after each launch. Other sea lions, appeared to react more vigorously by moving around on the beach. Movement into the water was rare.

Northern elephant seals exhibited little reaction to launch sounds. Most individuals merely raised their heads briefly upon hearing the launch sounds and then, within a few seconds, returned to their previous activity pattern (usually sleeping). During some launches, a small proportion of northern elephant seals on the beach moved a short distance away from their resting site, but settled within seconds. Movement into the water in response to launches was rare.

During the majority of those launches, most harbor seals rushed from their haul-out sites on rocky ledges to enter the water within seconds of the launch (few seals took >30 s) and did not return during the duration of the video-recording period (which extended up to 1.5 hr after the launch time). Follow-up monitoring on one occasion showed that harbor seals were again hauling out at that site ~2 hr after the launch. Follow-up monitoring the day after a launch was conducted once; it showed that harbor seals were again hauled out at that site. All launches during the current monitoring period occurred outside of the harbor seal pupping season.

4. ESTIMATED NUMBERS OF PINNIPEDS AFFECTED BY MISSILE LAUNCHES, OCTOBER 2003 – JUNE 2004[1]

4.1 Pinniped Behavioral Reactions to Noise and Disturbance

Some of the pinnipeds on the beaches at San Nicolas Island 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, or the combined sight plus sound, of a vehicle launch. Furthermore, pinnipeds may, at times, react to the sight and sound of seabirds reacting to a launch.

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, but pinnipeds often show considerable tolerance of noise and other forms of human-induced disturbance (Richardson et al. 1995; Reeves et al. 1996; Lawson et al. 1998; Holst 2004a).

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 the launches indicates that this assumption was generally correct. However, monitoring conducted during 2002–2003 showed that, in some cases, several 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. During the present monitoring period, harbor seals were seen rushing towards and into the water during launches. However, no small harbor seal pups were present during the May–June 2004 (or July 2004) launches, and no pups (or others) were observed being knocked over or injured during these launches.

Since no injuries or deaths were observed during the monitored launches in either the present monitoring period or the August 2001 – August 2003 period, 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 launch sounds 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 (e.g., Holst 2004b), we have assumed that only those animals that met the following criteria would be counted as affected by launch sounds:

1. pinnipeds that were injured or killed during launches (e.g., by stampedes),
2. pinnipeds exposed to launch sounds equal to or greater than 145 dBA re 20 μPa SEL for harbor seals and California sea lions, or 165 dBA re 20 μPa SEL for northern elephant seals (see next subsection for rationale), 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.

[1] By **Meike Holst**, LGL Ltd., environmental research associates.

The numbers of such affected pinnipeds were calculated for the periods during and immediately following the five launches (including one dual RAM launch) on three days from May through June 2004. (Results from three launches in late July 2004 are not yet available.) Disturbance reactions (if any) were short-lived for northern elephant seals and California sea lions and did not appear to extend into subsequent hours or days. Harbor seals typically left their haul-out site during a launch, but seals often started to haul out again at the same site within an hour of 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 permanent hearing impairment (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, the difference may be smaller (Kryter 1985).

Although few data on the effects of missile-like sounds on in-air hearing sensitivity of pinnipeds are available, it is unlikely that launch sounds as received on any pinniped beach on San Nicolas Island were sufficient to cause more than minor TTS, if that:

- Results from acoustic monitoring of Vandal launches in 1997 (Burgess and Greene 1998) and 1999 (Greene 1999) showed that pinnipeds on the beaches near the launch sites were exposed to maximum received levels of about 131 dB SEL re 20 $\mu Pa^2 \cdot s$, flat-weighted (Table 1 in Greene 1999). A-weighted values were lower.
- During the 2001–2003 monitoring period, the maximum SEL values measured for Vandal launches near haul-out locations were 129 dB flat-weighted and 118 dBA re 20 $\mu Pa^2 \cdot s$ (Greene and Malme 2002; Greene 2004).
- In 2001–2003, SEL values from 130 to 143 dB (flat) and up to 131 dBA were occasionally measured, but these values were recorded close to the launcher and not near pinnipeds on the beaches (Greene and Malme 2002; Greene 2004).
- Results from the present monitoring period show that SEL values at the monitoring sites up to at least 119 dB re 20 µPa SEL on a flat-weighted basis, or at least 103 dBA.
- The sounds received from missile and target launches were sometimes impulse sounds (when there was a sonic boom), but at other times and locations were non-impulsive.

The received SEL values on the beaches with pinnipeds were below (usually by a wide margin) the acoustic criteria proposed by Lawson et al. (1998). Those were 145 dBA SEL for harbor seals and California sea lions, and 165 dBA SEL for northern elephant seals (re 20 $\mu Pa^2 \cdot s$). Some pinnipeds were no doubt exposed to higher levels than those documented by recorders placed at nearshore locations (Chapter 2), as pinnipeds sometimes occurred closer to the launcher or launch azimuth than the location of the closest functional sound recording system. However, based on the data collected in the October 2003 – June 2004 period, it is unlikely that pinnipeds were exposed to sounds exceeding the criteria listed above.

The rationale for the speculative criteria proposed by Lawson et al. was given in § 4.7.1.4 of Lawson et al. (1998), and was based on then-assumed TTS thresholds. More recently, J. Francine quoted in NMFS (2001, p. 41837) has mentioned evidence of mild TTS in captive California sea lions exposed to a 0.3-sec transient with level 135 dB SEL re 20 $\mu Pa^2 \cdot s$ (see also Bowles et al. 1999). The measured SEL values near the pinniped beaches during missile launches during October 2003 – June 2004 were below this 135-dB level. However, mild TTS may occur in harbor seals exposed to received levels lower than 135 dB SEL (A. Bowles, pers. comm. to W.J. Richardson, LGL, 2003).

PTS would not be expected unless the received levels were considerably higher than the TTS threshold, as noted above. This issue was discussed at the NMFS-organized "Acoustic Criteria" workshop (see also Gisiner [ed.] 1999). The consensus then was that received levels would have to be at least 10 dB above the TTS threshold, and probably considerably higher than that, before there would be concern about the possibility of permanent hearing impairment as a result of relatively short-term exposure. At the time of writing (July 2004), an expert panel is evaluating (for NMFS) the likely relationship between sound levels associated with onset of PTS vs. TTS in marine mammals. Their final conclusions are not yet available. However, for harbor seals and other pinnipeds in air exposed to non-impulse sound, the PTS threshold probably is above an SEL value of 135 dB re 20 $\mu Pa^2 \cdot s$. For impulse sounds, e.g., sonic booms, the PTS threshold may be lower, and closer to 135 dB re 20 $\mu Pa^2 \cdot s$ in the case of harbor seals.

Overall, the results to date indicate that there is little potential for appreciable TTS or especially PTS in pinnipeds hauled out near the vehicle azimuths during the launch operations. This conclusion is necessarily speculative given the lack of directly relevant TTS data for pinnipeds in air exposed to strong sounds for brief periods. In the event that levels are 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 San Nicolas Island, 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 launches when strong sonic booms occur at beach locations. These cases should be re-considered when specific noise exposure criteria become available for possible PTS in pinnipeds in air that are exposed to impulse sounds. Recommended criteria are expected to become available within the next year.

4.3 Conclusions Regarding Effects on Pinnipeds

Disturbance is the main concern during the Navy's missile launch program. Responses of pinnipeds to acoustic disturbance are highly variable, with the most conspicuous changes in behavior occurring when pinnipeds are hauled out on land when exposed to strong sounds. Vehicle launch activities conducted during October 2003 – June 2004 appeared to cause no more than limited, short-term, and localized disturbance of California sea lions and especially elephant seals. In the case of harbor seals, a substantial fraction moved into the water in response to launches. With the exception of most harbor seals, the majority of pinnipeds remained in the haul-out areas (see Chapter 3). There was no evidence that pinniped reactions to launches resulted in any pup mortality or injuries.

Levels of missile sounds recorded near pinniped haul-out locations around western San Nicolas Island during launch operations in the present monitoring period were up to at least 119 dB re 20 $\mu Pa^2 \cdot s$ on a flat-weighted SEL basis, and up to at least 103 dBA on an A-weighted SEL basis. These values represent substantial levels of transient noise, and probably underestimated the maximum values occurring at certain unmonitored nearshore locations. However, they are below the levels expected to be necessary to cause permanent hearing impairment, and for pinnipeds at most locations, it is unlikely that temporary threshold shift would occur either.

4.4 Estimated Numbers of Pinnipeds Affected by Launches

The approach to estimating the numbers of pinnipeds affected by launch sounds during October 2003 through June 2004 period was based on video observations of pinnipeds, combined with estimates of the numbers of hauled out pinnipeds not videotaped but exposed to the same launch sounds. 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 only for the periods during and immediately following the five launches on three days. Disturbance reactions (if any) for northern elephant seals and California sea lions were short-lived and did not appear to extend into subsequent hours or days. Harbor seals typically left their haul-out sites during a launch; some harbor seals were observed to haul out at the same site again during follow-up monitoring (i.e., within 2 hr after the launch) but others did not return during post-monitoring periods.

For pinniped groups that extended farther along the beach than encompassed by the field of view 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 section 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 launch sounds are likely underestimates.

For pinniped species that were not monitored on certain launch dates, the number of animals affected by launch sounds was estimated based on data from the 2001–2003 monitoring periods (Lawson 2002; Holst 2004b). That is, the number of affected animals for the corresponding season and vehicle type was used, if possible, from previous monitoring periods.

Navy personnel did not sight any northern fur seals or Guadalupe fur seals on San Nicolas Island from October 2003 through June 2004, and none were evident in the video segments that were analyzed.

There appeared to be no increase in aggressive interactions as a result of the reactions to the launches. There was no evidence of injury or mortality during any of the launches.

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).

4.5 Summary

This chapter provides estimates of the numbers of pinnipeds affected by the Navy’s missile launches on San Nicolas Island, California, October 2003 – June 2004, based mainly on information provided in previous chapters of this report.

TABLE 4.1. Minimum estimated numbers of California sea lions, northern elephant seals, and harbor seals potentially affected by launch sounds from the Navy's missile launch program on San Nicolas Island, October 2003 – June 2004. Some individual pinnipeds were probably affected on more than one launch day, so total numbers of different individuals affected could have been less than the totals shown here. Does not allow for pinnipeds on beaches where there was no monitoring on the day in question.

Date in 2004	Vehicle Type	Monitoring Site	Total # in Area	# of Focal Animals Potentially Affected	Total # Potentially Affected in Area
California Sea Lions					
5 May	RAM	Dos Coves South	>100	1 of 100	1
18 May	GQM-163A	Sea lion haul-out sites*	*>100*		*50*
3 June	AGS	Dos Coves South	>100	0	0
3 June	AGS	809 Camera	>60	30 of 60	30
Total number of sea lions potentially affected					**81**
Northern Elephant Seals					
5 May	RAM	Bachelor Beach	>1000	1 of 76	13
18 May	GQM-163A	Redeye I	>8	0	0
3 June	AGS	Dos Coves South	50	0	0
Total number of elephant seals potentially affected					**13**
Harbor Seals					
5 May	RAM	Harbor seal haul-out sites*			*0*
18 May	GQM-163A	Pirates Cove	5	5 of 5	5
18 May	GQM-163A	Harbor Seal Overlook	>21	21 of 21	21
3 June	AGS	Harbor Seal Overlook	>20	20 of 20	20
Total number of harbor seals potentially affected					**46**

Note: Numbers in italics are estimates derived from data previously collected during the 2001–2003 monitoring programs (Lawson 2002; Holst 2004b), as well as the current monitoring period, for launch dates when monitoring of certain pinniped species did not occur.

* No sites were monitored during launch dates.

No evidence of pinniped injuries or fatalities related to launch noises was evident, nor was it expected. The levels above which Lawson et al. (1998) assumed that a pinniped might experience TTS upon exposure to a single launch were 145 dBA SEL for harbor seals and California sea lions, and 165 dBA SEL for northern elephant seals (re 20 $\mu Pa^2 \cdot s$). However, the specific received levels of transient airborne sound that cause the onset of TTS in pinnipeds are uncertain. None of the recorded sound pressures appears to have been sufficiently strong to have induced TTS if the TTS onset occurs at about the level assumed by Lawson et al. (1998). If TTS onset occurs at slightly lower levels than previously assumed, any TTS would presumably be mild and quickly recoverable. PTS is unlikely to have occurred.

At least 81 California sea lions, 13 northern elephant seals, and 46 harbor seals are estimated to have been affected by launch sounds during the October 2003 – June 2004 period. These figures are very approximate, because they (a) include extrapolations for pinnipeds on beaches that were not monitored on any given launch day, and (b) very likely count some of the same individuals more than once, but also (c) 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. Of the California sea lions, most were young animals such as pups or juveniles. It is not likely that any of these pinnipeds on San Nicolas Island were adversely impacted by such behavioral reactions.

The results suggest that any effects of these launch operations were minor, short-term, and localized, at least for California sea lions and especially elephant seals. In the case of harbor seals, a substantial fraction moved into the water in response to launches. Some harbor seals may have left their haul-out site until the following low tide; however, numbers occupying haul-out sites shortly after a launch, or the next day, were similar to pre-launch levels.

5. ACKNOWLEDGEMENTS

The 2003–2004 acoustical and marine mammal monitoring work was funded and in part conducted by Naval Air Warfare Center Weapons Division, Point Mugu, California. It was done under the provisions of a Letter of Authorization (LOA) issued by the National Marine Fisheries Service (NMFS) during September 2003. We thank Alex Stone, Steve Schwartz, Grace Smith, Gina Smith, Sandra Harvill, Tony Parisi, and many others at Point Mugu and on San Nicolas Island for their support, assistance, and very positive approach to the monitoring and mitigation effort. In particular, Grace Smith, Sandra Harvill, and Steve Schwartz of NAWCWD have been instrumental in acquiring and providing the sound and video recordings from San Nicolas Island, and ancillary visual observations, weather data, and other information. Dr. Schwartz also provided comments on the draft report.

Bob Norman and Clay Rushing, consultants to Greeneridge, were largely responsible for the design of the ATARs, and continue to improve their operation. Bob Norman of Greeneridge analyzed the recordings and prepared the figures of launch-by-launch acoustic results. Sandra Harvill, Steve Schwartz, Grace Smith, and Lisa Thomas at San Nicolas Island 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. He has continued to provide various types of input since leaving LGL in 2002. Dr. W. John Richardson of LGL helped with project design and administration, and reviewed the draft report. Anne Wright helped with report production.

Peer Amble at TEC, prime contractor for this work, assisted with management and logistical matters.

We are grateful to all concerned.

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APPENDIX A: LETTER OF AUTHORIZATION

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Silver Spring, MD 20910

SEP 4 2003

Ms. Carolyn A. Shepherd
Head, Environmental Project Office
Naval Air Weapons Station
Department of the Navy
1 Administration Circle
China Lake, California 93555-6100

Received
16 SEP 2003

Dear Ms. Shepherd:

Enclosed is a Letter of Authorization (LOA), issued to the Naval Air Warfare Center Weapons Division, Point Mugu (NAWCWD) under the authority of Section 101(a)(5)(D) of the Marine Mammal Protection Act (16 U.S.C. 1361 et seq.), to take by harassment small numbers of seals and sea lions incidental to target missile launch operations from the western end of San Nicolas Island, California.

The NAWCWD is required to comply with the conditions contained in the LOA and the regulations (enclosed). In addition, the NAWCWD must cooperate with any federal, state or local agency monitoring the impacts of your activities, and submit a draft report to the National Marine Fisheries Service's (NOAA Fisheries) Office of Protected Resources and Southwest Regional Office no later than 120 days prior to the expiration of this Authorization. The LOA requires monitoring the presence of seals and sea lions, reporting any behavioral modifications resulting from this activity as observed by a qualified individual, and collection of acoustic measurements from missile launch activities.

If you have any questions concerning the LOA or its requirements, contact Kenneth Hollingshead, Office of Protected Resources, NOAA Fisheries, at (301) 713-2322, ext. 128.

Sincerely,

Laurie K. Allen

Laurie K. Allen
Acting Director
Office of Protected Resources

Enclosure

DEPARTMENT OF COMMERCE

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

NATIONAL MARINE FISHERIES SERVICE

Letter of Authorization

The Department of the Navy, Naval Air Warfare Center Weapons Division, Point Mugu, 1 Administration Circle, China Lake, California 93555 is hereby authorized under section 101(a)(5)(A) of the Marine Mammal Protection Act (16 U.S.C. 1371(a)(5)(A)), 50 CFR 216.107, and 50 CFR 216.151 to harass small numbers of marine mammals incidental to vehicle launch operations from the western end of San Nicolas Island, California, contingent upon the following conditions:

1. This Authorization is valid from October 2, 2003, through October 1, 2004.

2. This Authorization is valid only for activities associated with a maximum of 40 Vandal (or similar sized) vehicles from Alpha Launch Complex and smaller missiles and targets from Building 807 from the western end of San Nicolas Island, California.

3. General Conditions:

(a). The taking, by incidental harassment only, is limited to the species listed under condition 3(b) below. The taking by serious injury or death of these species, 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 species authorized for incidental harassment takings are: northern elephant seals (*Mirounga angustirostris*), harbor seals (*Phoca vitulina*), and California sea lions (*Zalophus californianus*).

(c). The taking of any marine mammal in a manner prohibited under this Authorization must be reported within 48 hours of the taking to the Southwest Regional Office, National Marine Fisheries Service (NOAA Fisheries) at (562) 980-4023.(h). If injurious or lethal take is discovered during monitoring, in coordination with NOAA Fisheries, launch procedure, mitigation measures, and monitoring methods must be reviewed and appropriate changes made prior to the next launch.

4. Cooperation:

The holder of this Authorization is required to cooperate with NOAA Fisheries and any other Federal, state or local agency monitoring the impacts of the activity on marine mammals. The holder must notify the Southwest Regional Office, NOAA Fisheries, at least 48 hours prior to launches (unless constrained by the date of issuance of this Authorization).

5. Mitigation Requirements:

To the extent practicable, the holder of this Authorization must:

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

(b). Avoid launch activities during harbor seal pupping season (February to April), when operationally practicable.

(c). Limit launch activities during other pinniped pupping seasons, when operationally practicable.

(d). Not launch Vandal target missiles from the Alpha Complex at low elevation (less than 1,000 feet) on launch azimuths that pass close to pinniped haul-out site(s).

(e). Avoid launching multiple target missiles in quick succession over haul-out sites, especially when young pups are present.

(f). Limit launch activities during nighttime hours.

(g). Ensure that aircraft and helicopter flight paths maintain a minimum altitude of 1,000 feet from pinniped haul-outs.

6. Monitoring Requirements:

(a). General.

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

(2). The NOAA Fisheries must be informed immediately of any changes or deletions to any portions of the proposed monitoring plan submitted, in accordance with condition 7(a) of this Authorization.

(b). Visual Land-Based Monitoring.

(1). Prior to each missile launch, an observer(s) will place 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 4 hours or as permitted by the videotape capacity.

(2). Systematic visual observations, by those individuals described in condition 6(a)(1) above, on pinniped presence and activity will be conducted and recorded in a field logbook a minimum of 2 hours prior to the estimated launch time and for no less than 1 hour immediately following the launch of Vandal and similar types of target missiles.

(3). Systematic visual observations, by those individuals described in condition 6(a)(1) above, on pinniped presence and activity will be conducted and recorded in a field logbook a minimum of 2 hours prior to launch, during launch, and for no less than 1 hour after the launch of the BQM-34, BQM-74, Exocet, Tomahawk, RAM target and similar types of missiles.

(4). Documentation, both via autonomous video camera and human observer, will consist of: (a) numbers and sexes of each age class in focal subgroups; (b) description and timing of launch activities or other disruptive event(s); (c) movements of pinnipeds, including number and proportion moving, direction and distance moved, and pace of movement; (d) description of reactions; (e) minimum distances between interacting and reacting pinnipeds; (f) study location; (g) local time; (h) substratum type; (i) substratum slope; (j) weather condition; (k) horizontal visibility; and (l) tide state.

(c). Acoustic Monitoring.

(1). During all launches, calibrated recordings of the levels and characteristics of the received launch sounds will be obtained from 3 different locations of varying distances from the target missile's flight path. Insofar as possible, these acoustic recording locations will correspond with the haul-out sites where video and human observer 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 dimensions.

(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 target missile.

7. Reporting:

(a). For each target 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, NOAA Fisheries (562-980-4023), providing reporting items found under condition 7(b), unless other arrangements for monitoring are agreed in writing.

(b). An initial report must be submitted to the Office of Protected Resources, and the Southwest Regional Office after the first 90 days of the authorization period. 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 in other ways.

(c). A draft final technical report will be submitted to the Office of Protected Resources and Southwest Regional Office, NOAA Fisheries, 120 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 launches planned during the next 1-2 months.

(d). A revised final technical report, including all monitoring results during the entire period of the Authorization will be due 90 days after the end of the Authorization's expiration.

(e). Both the 90-day and final reports will be subject to review and comment by NOAA Fisheries. Any recommendations made by NOAA Fisheries must be addressed in the final comprehensive report prior to acceptance by NOAA Fisheries.

8. 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.

9. 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 216.151-216.158) may result in the modification, suspension or revocation of this Authorization

10. A copy of this Authorization and the attached Subpart N of the regulations must be in the possession of each observer or group operating under the authority of this Letter of Authorization.

Laurie K. Allen 09/04/03

Laurie K. Allen Date
Acting Director
Office of Protected Resources
National Marine Fisheries Service

APPENDIX B: MAPS OF LAUNCH AZIMUTHS AND MONITORING SITES FOR OCTOBER 2003–JUNE 2004

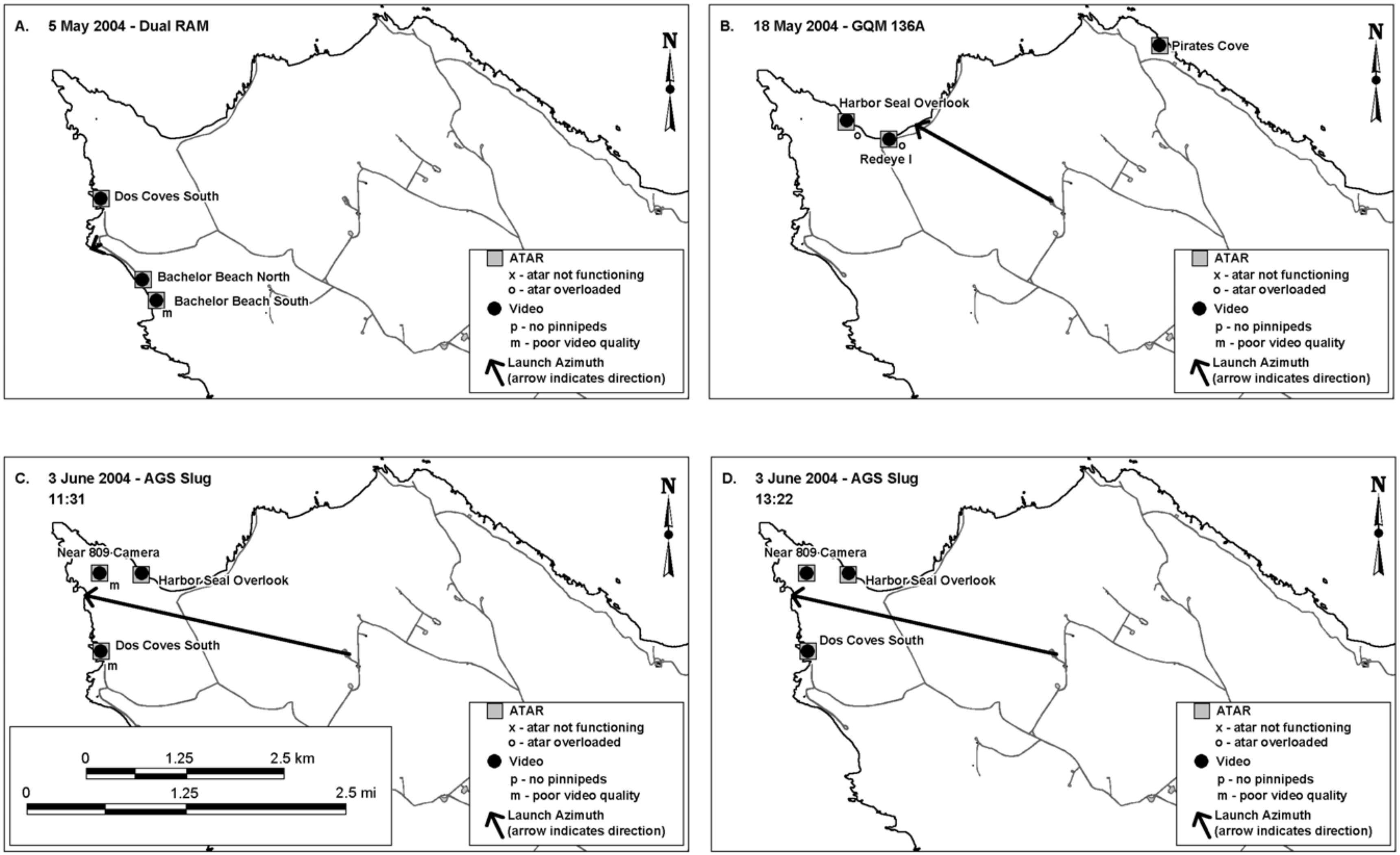


FIGURE B-1. Launch azimuths, acoustic recording sites (ATARs), and video recording sites for launches at San Nicolas Island from 5 May to 3 June 2004. For 5 May 2004, data from the ATAR at Bachelor Beach South were not used because the gain setting was uncertain.

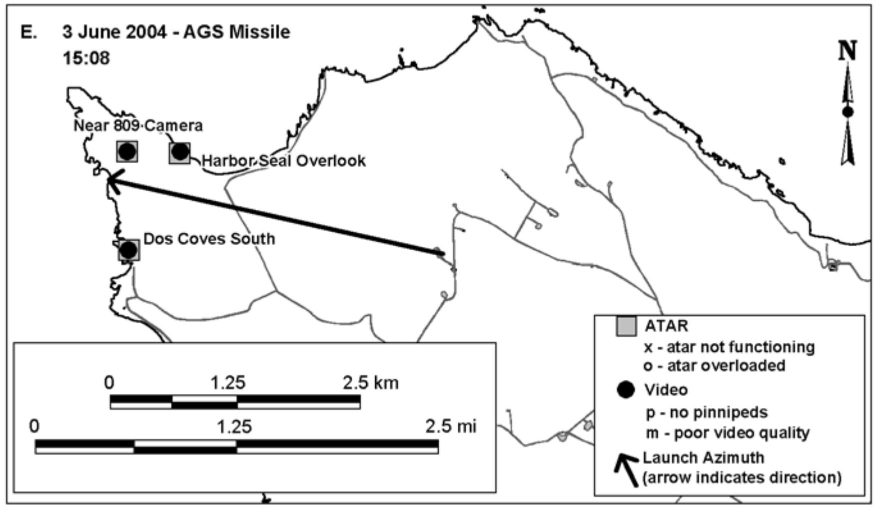


FIGURE B-1. (cont'd). Launch azimuths, acoustic recording sites (ATARs), and video recording sites for launches at San Nicolas Island from 5 May to 3 June 2004.

APPENDIX C: ACOUSTIC DATA FROM INDIVIDUAL LAUNCHES FOR OCTOBER 2003–JUNE 2004

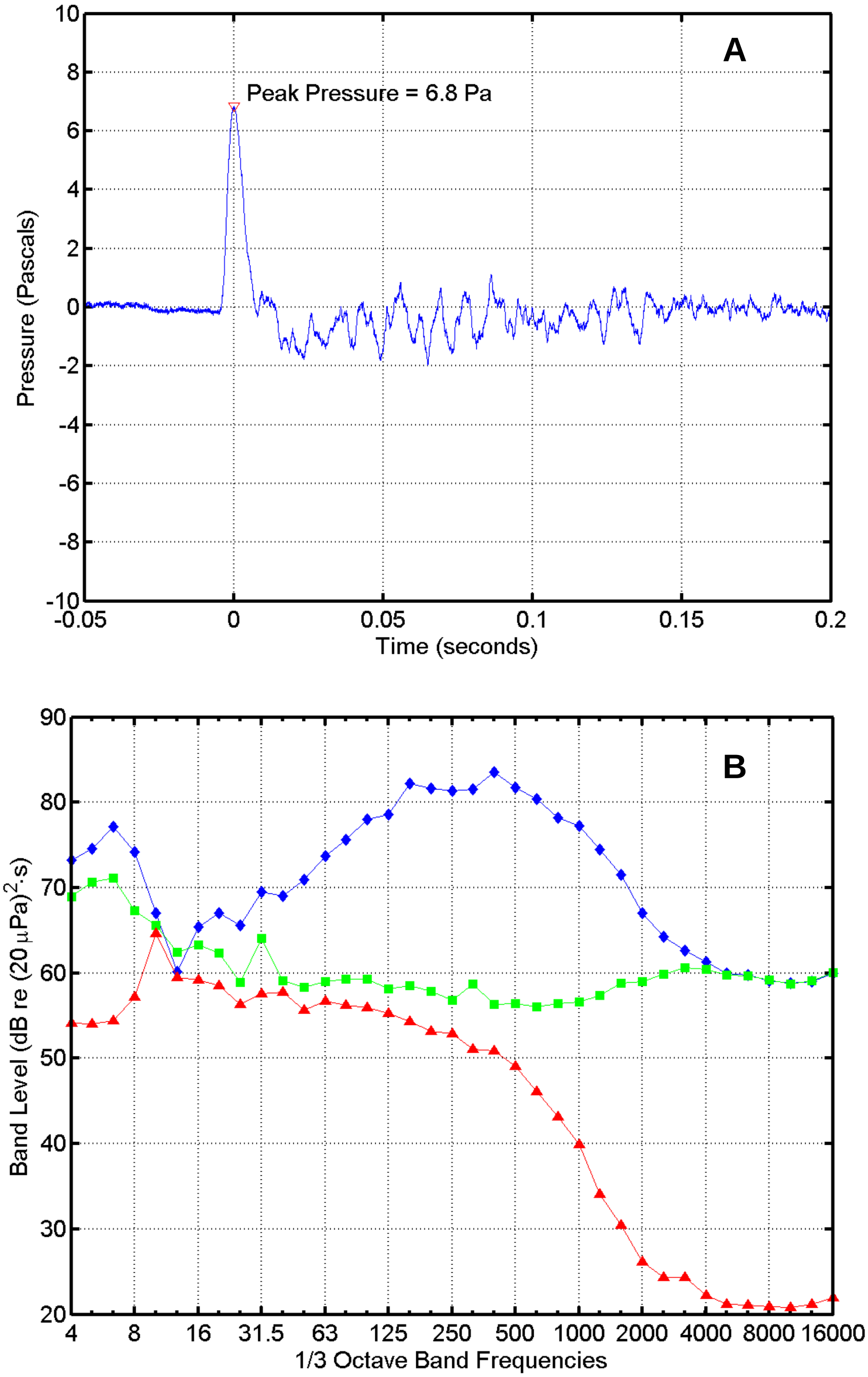


FIGURE C-1. (A) Pressure waveform and (B) one-third octave band levels for the first missile of the dual RAM launch at 11:46:00 on 5 May 2004 at "Dos Coves". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in hertz (Hz).

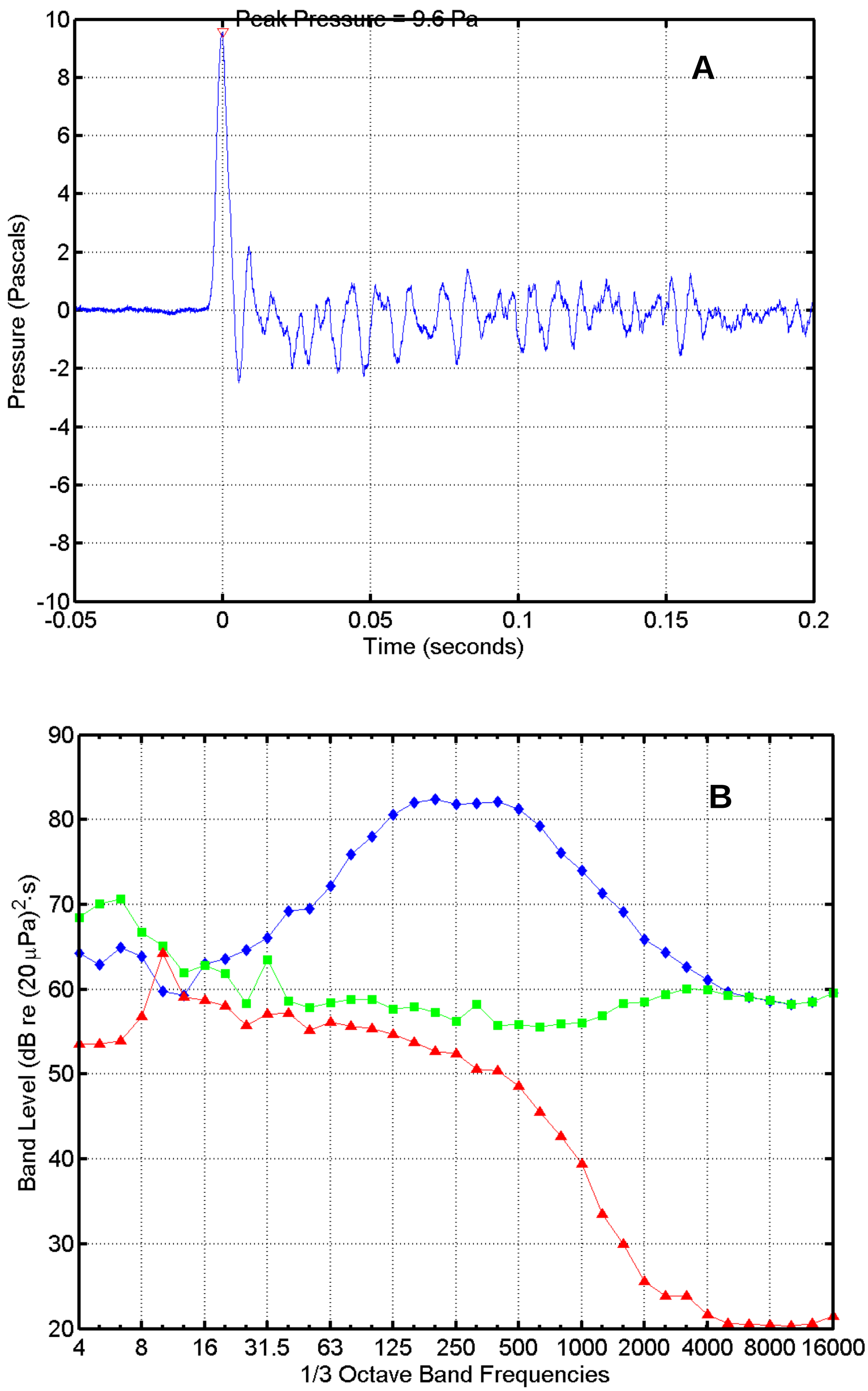


FIGURE C-2. (A) Pressure waveform and (B) one-third octave band levels for the second missile of the dual RAM launch at 11:46:12 on 5 May 2004 at "Dos Coves". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in hertz (Hz).

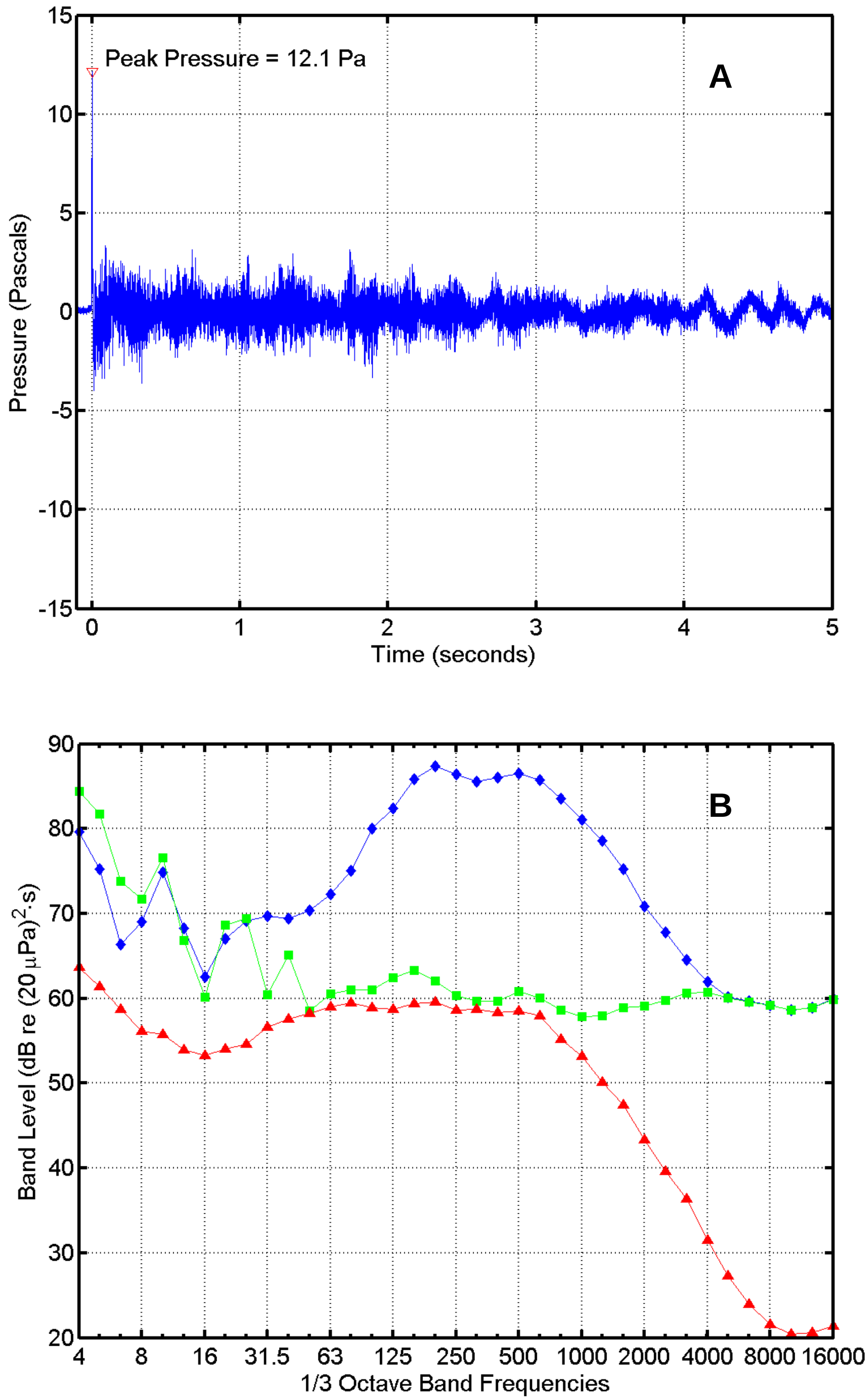


FIGURE C-3. (A) Pressure waveform and (B) one-third octave band levels for the first missile of the dual RAM launch at 11:46:00 on 5 May 2004 at "Bachelor Beach North". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in hertz (Hz).

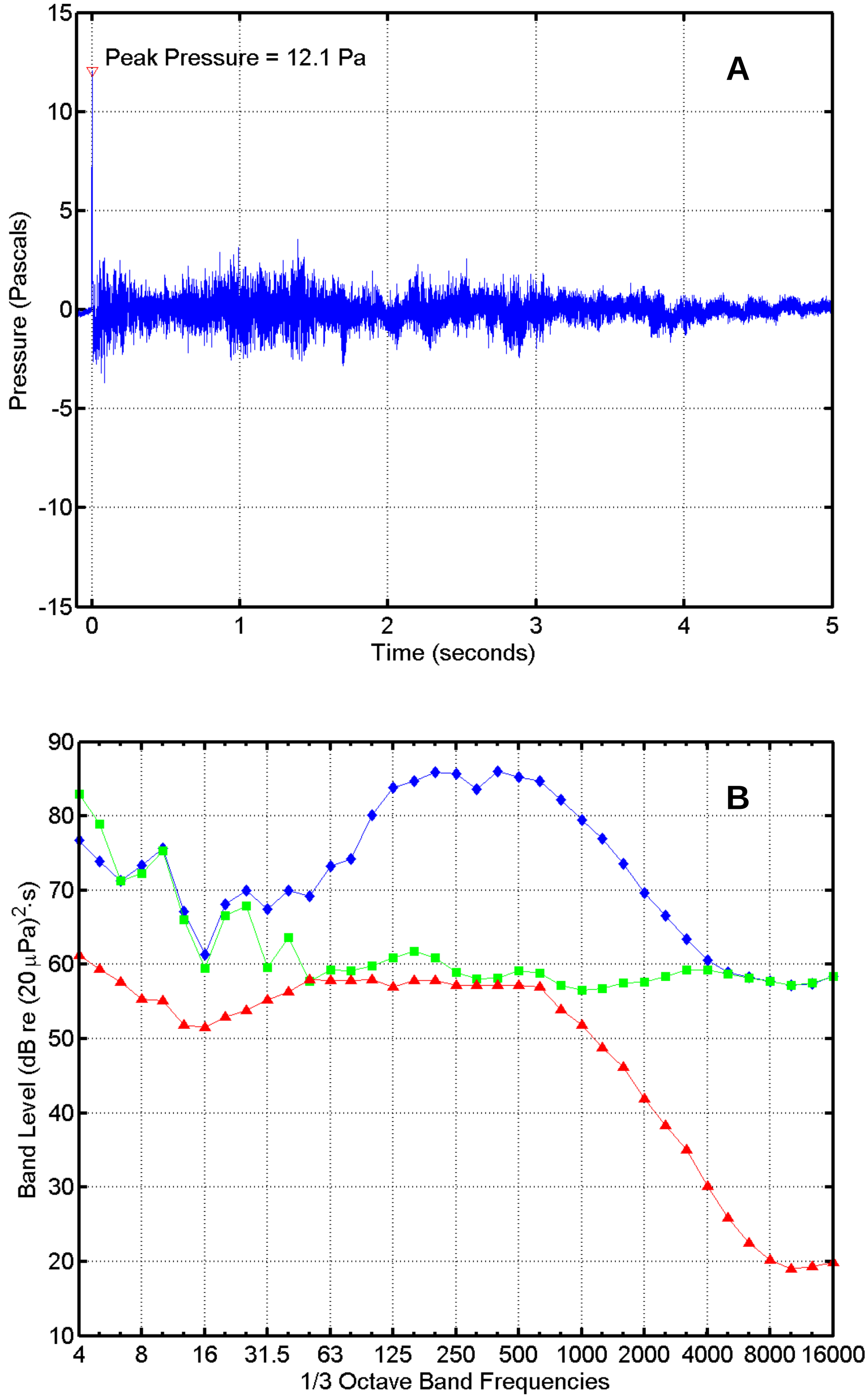


FIGURE C-4. (A) Pressure waveform and (B) one-third octave band levels for the second missile of the dual RAM launch at 11:46:12 on 5 May 2004 at "Bachelor Beach North". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in hertz (Hz).

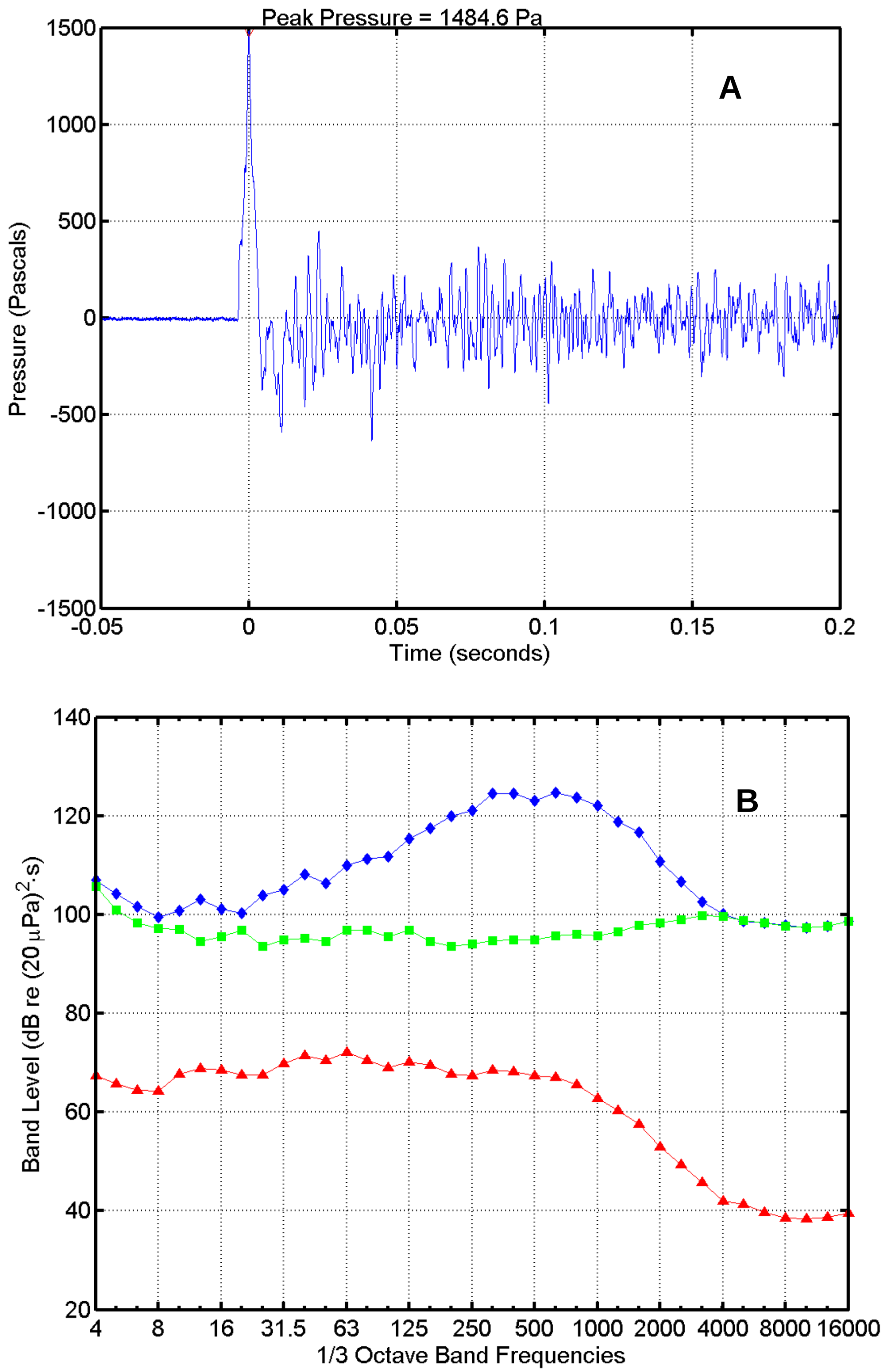


FIGURE C-5. (A) Pressure waveform and (B) one-third octave band levels for the first missile of the dual RAM launch at 11:46:00 on 5 May 2004 at "Bachelor Beach South". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in hertz (Hz). **Note:** Vertical scales in (A) and for the top two curves in (B) should be considered to be relative, not absolute; the gain setting was uncertain.

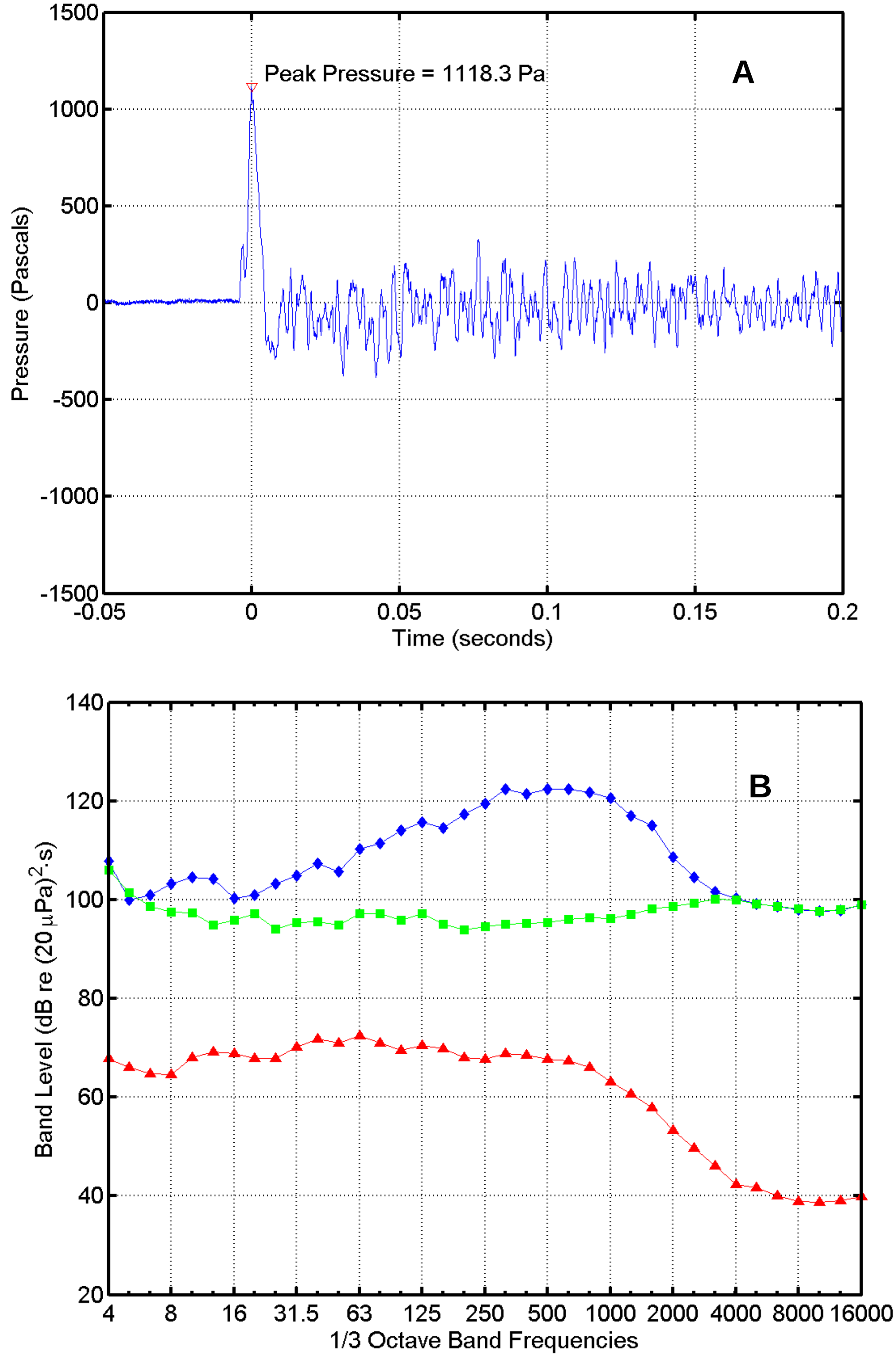


FIGURE C-6. (A) Pressure waveform and (B) one-third octave band levels for the second missile of the dual RAM launch at 11:46:12 on 5 May 2004 at "Bachelor Beach South". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in hertz (Hz). **Note:** Vertical scales in (A) and for the top two curves in (B) should be considered to be relative, not absolute; the gain setting was uncertain.

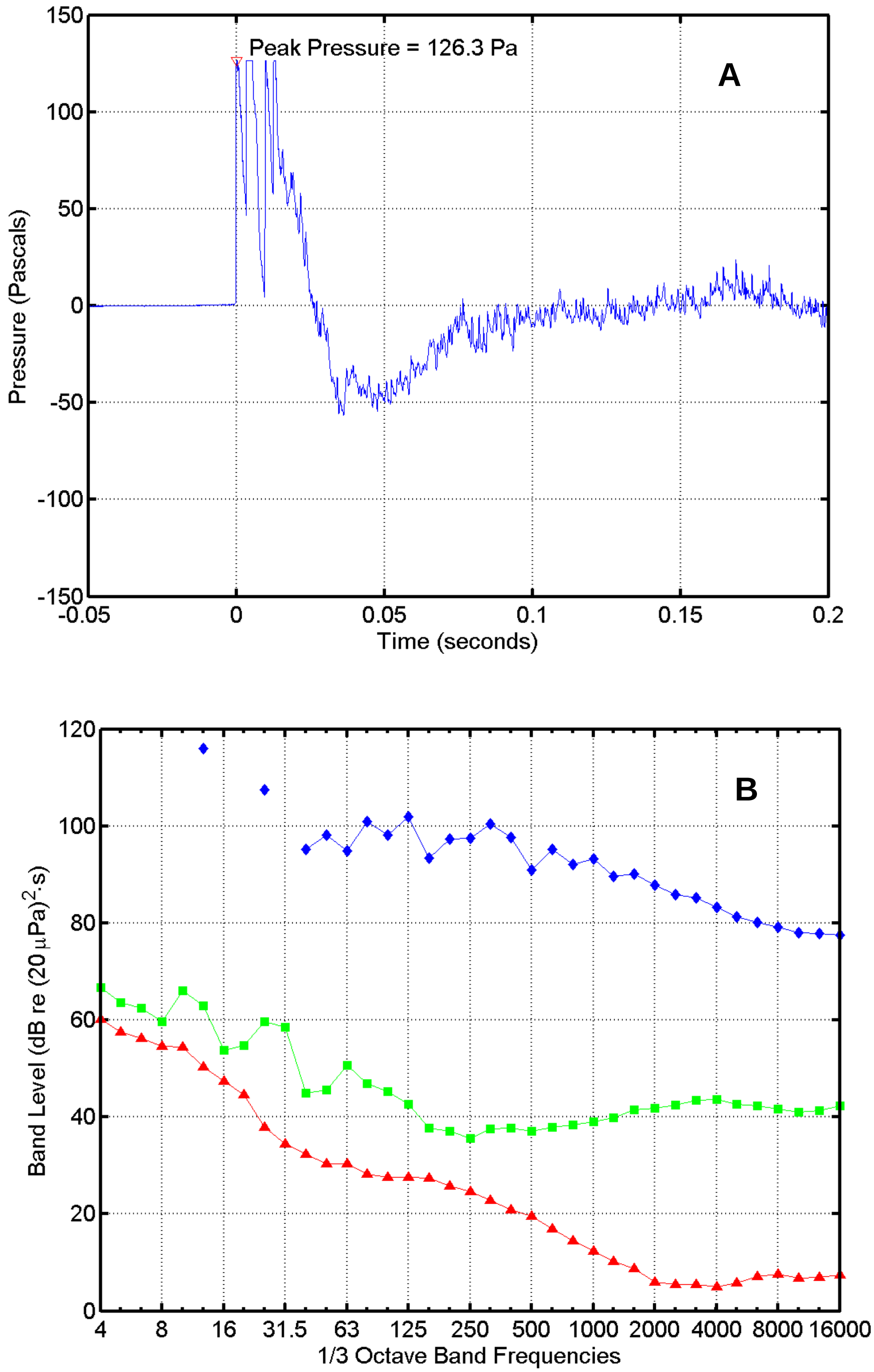
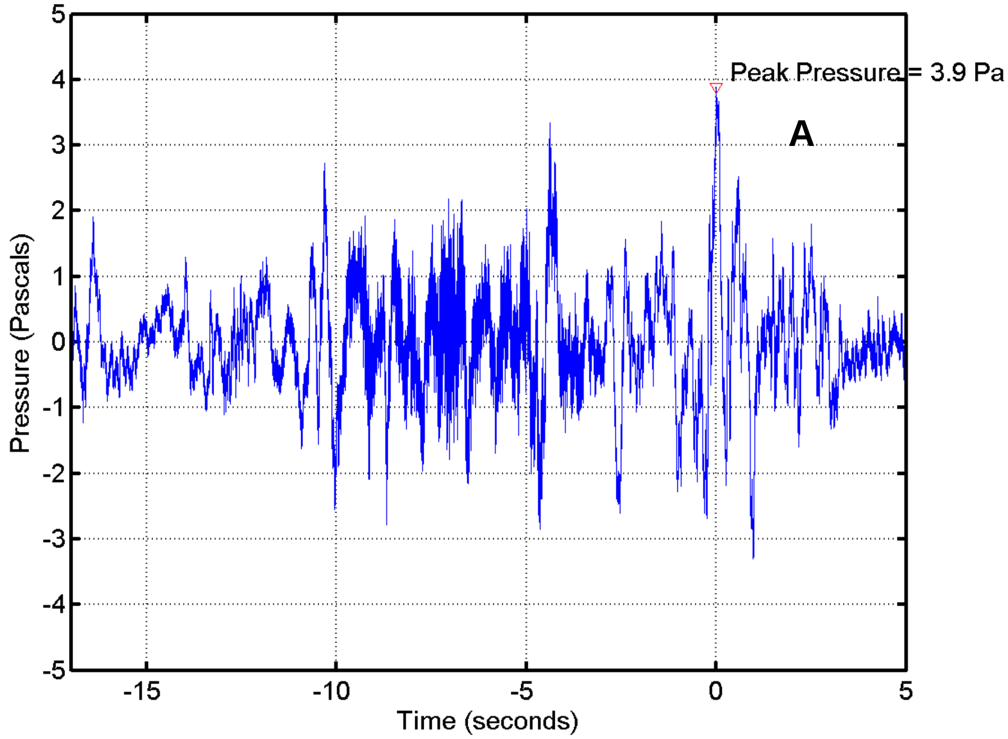


FIGURE C-7. (A) Pressure waveform and (B) one-third octave band levels for the GQM-163A launch at 12:40 on 18 May 2004 at "Harbor Seal Overlook". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in hertz (Hz).



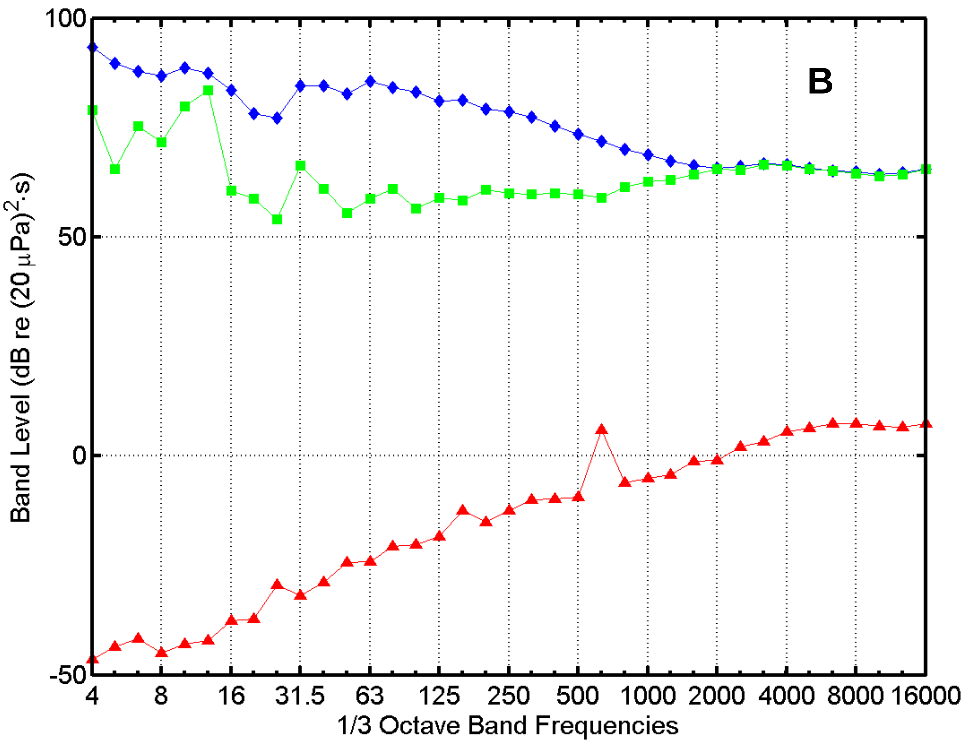


FIGURE C-8. (A) Pressure waveform and (B) one-third octave band levels for the GQM-163A launch at 12:40 on 18 May 2004 at "Pirates Cove". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in hertz (Hz).

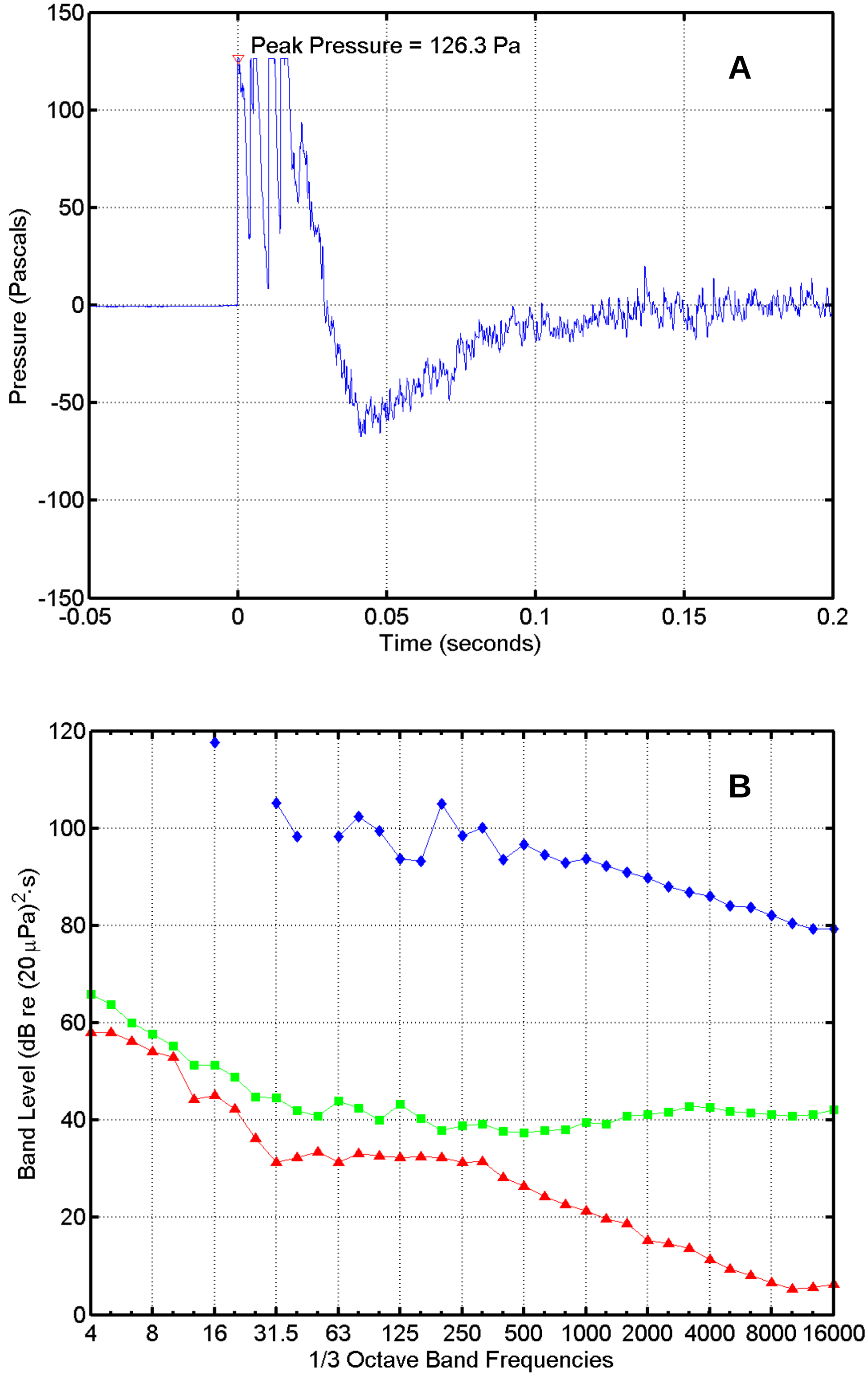


FIGURE C-9. (A) Pressure waveform and (B) one-third octave band levels for the GQM-163A launch at 12:40 on 18 May 2004 at "Redeye I". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in hertz (Hz).

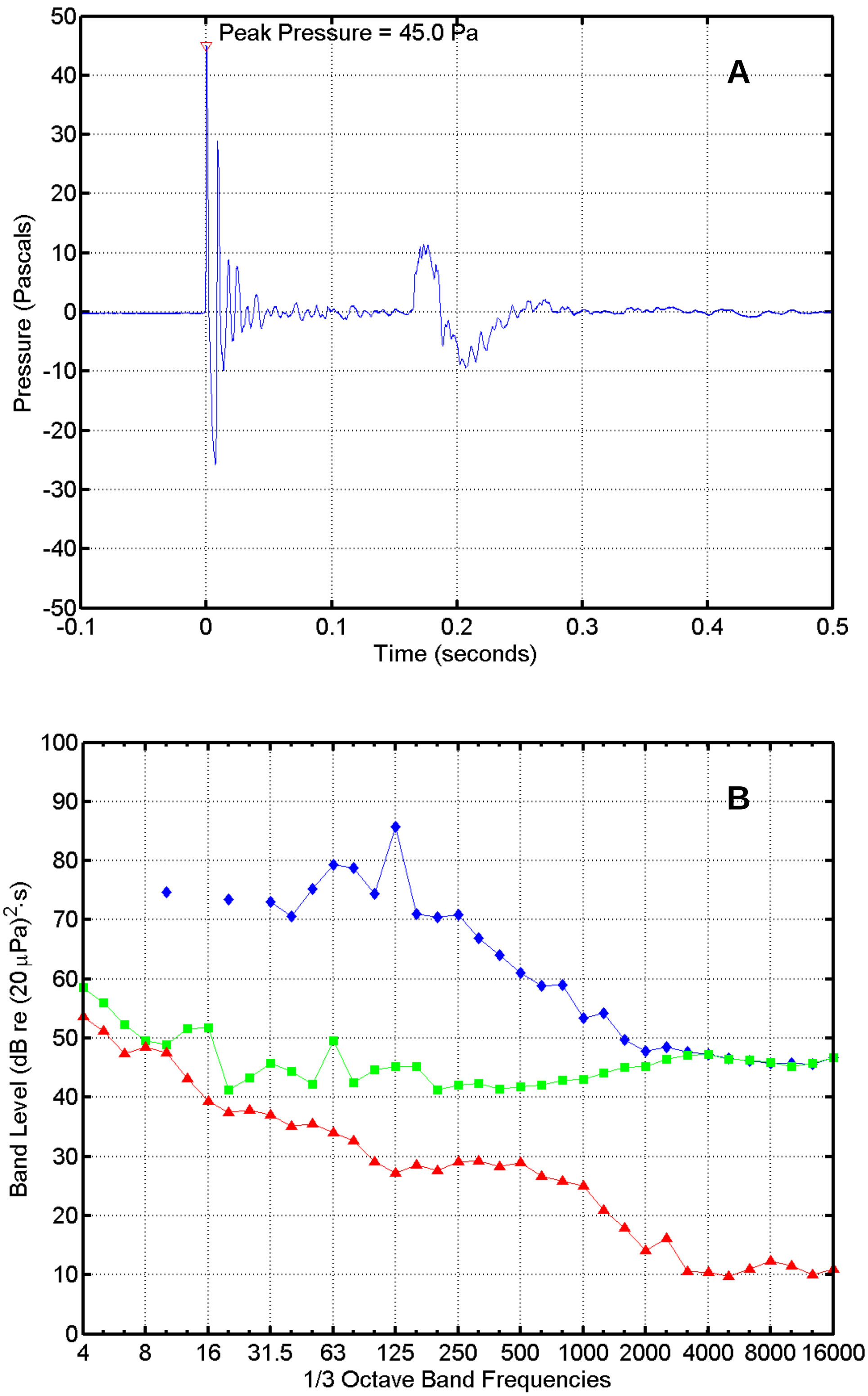


FIGURE C-10. (A) Pressure waveform and (B) one-third octave band levels for the AGS Slug launch at 11:31 on 3 June 2004 "Near 809 Camera". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in hertz (Hz).

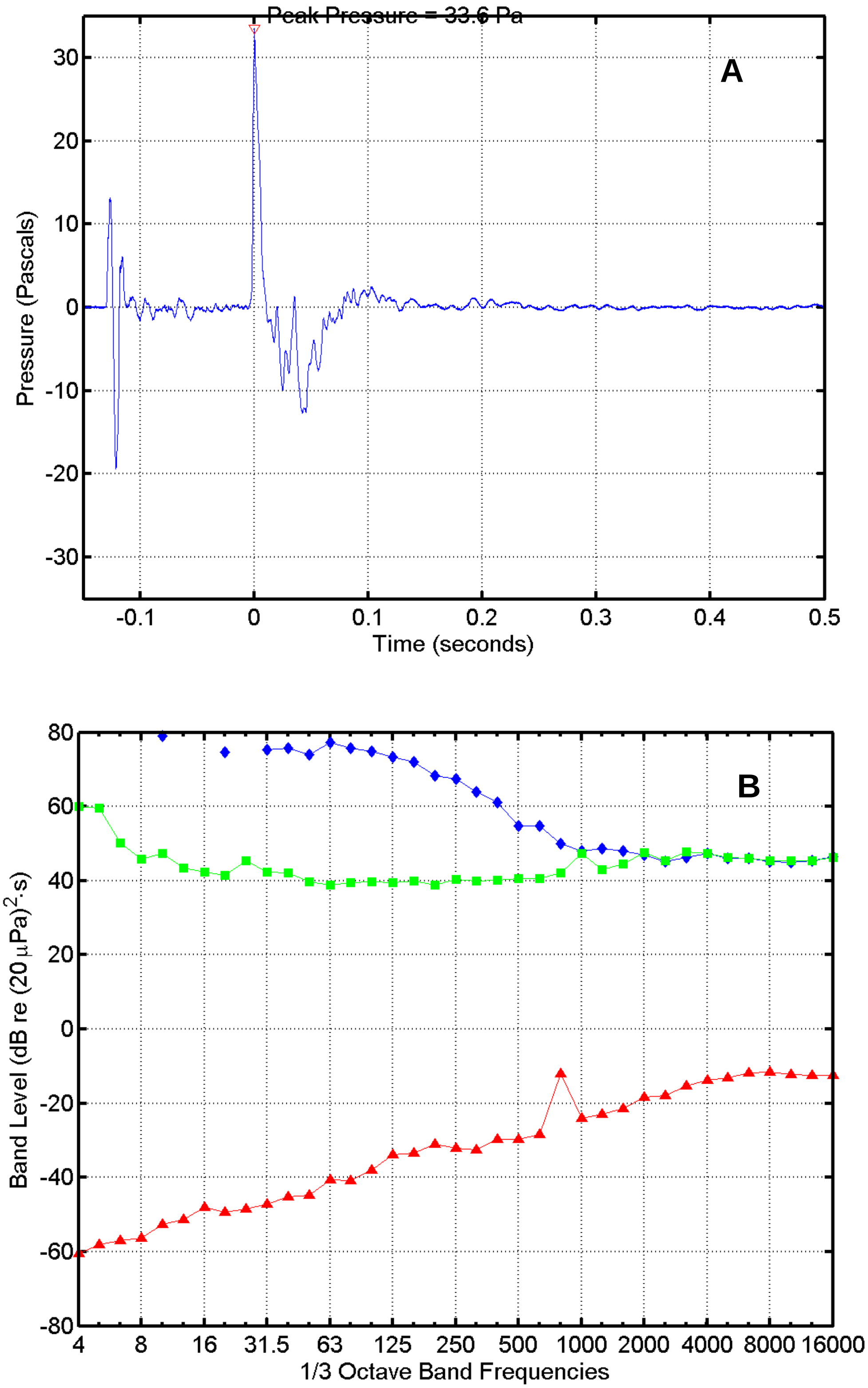
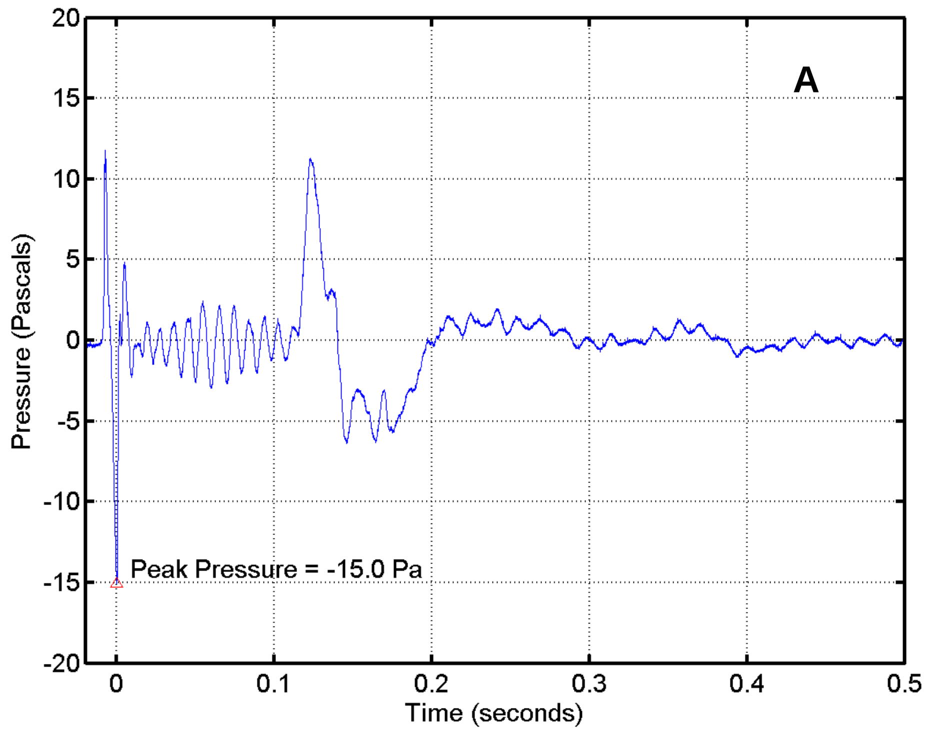


FIGURE C-11. (A) Pressure waveform and (B) one-third octave band levels for the AGS Slug launch at 11:31 on 3 June 2004 at "Harbor Seal Overlook". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in hertz (Hz).



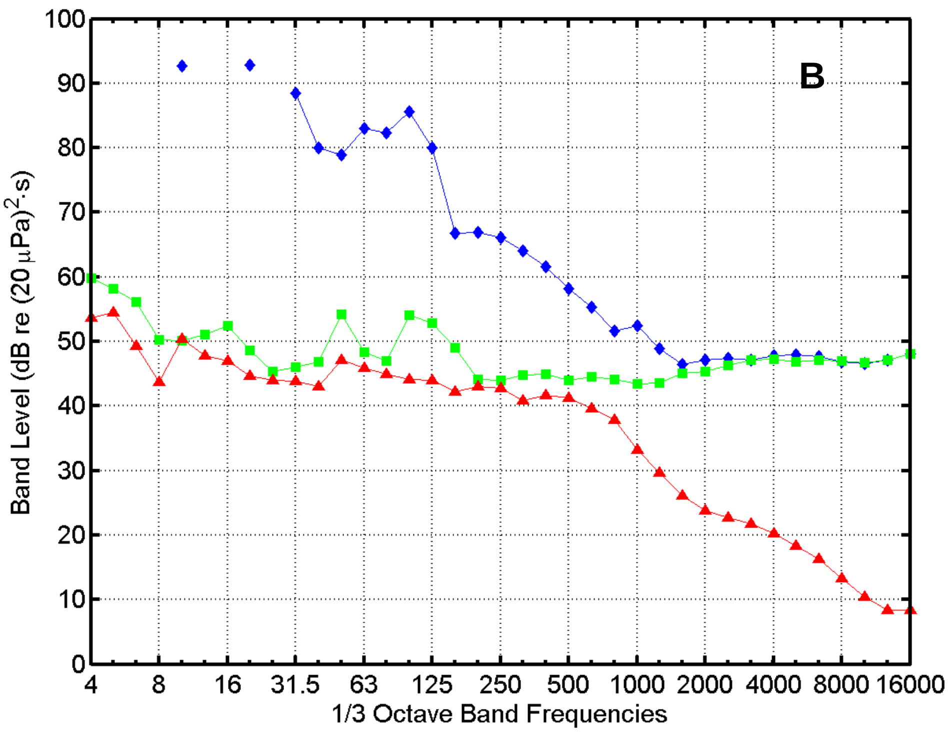
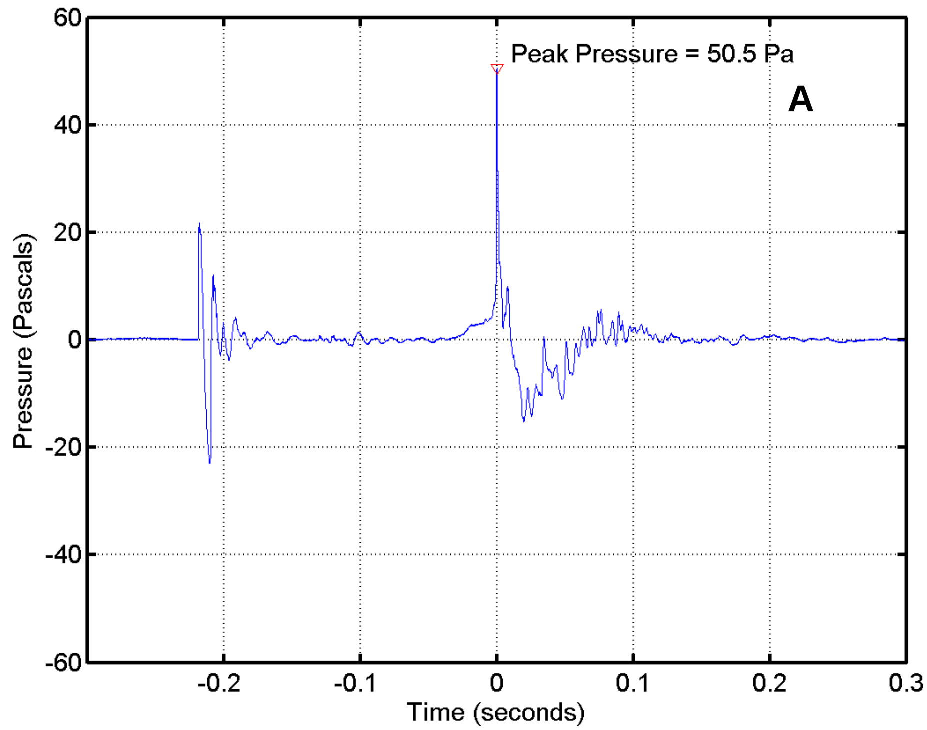


FIGURE C-12. (A) Pressure waveform and (B) one-third octave band levels for the AGS Slug launch at 11:31 on 3 June 2004 at "Dos Coves". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in hertz (Hz).



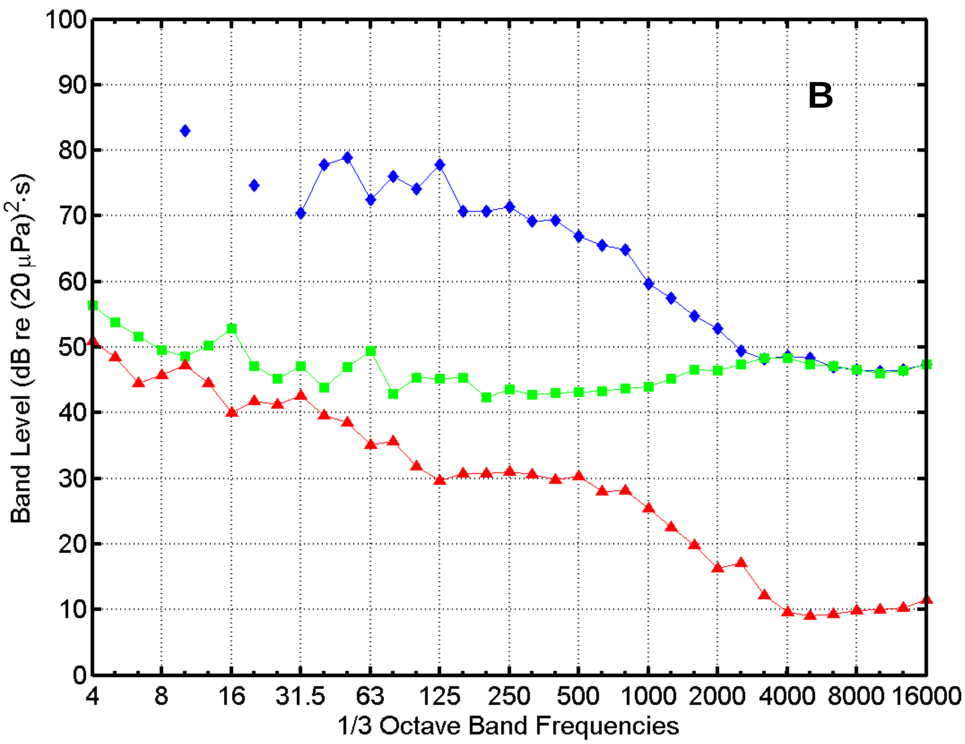


FIGURE C-13. (A) Pressure waveform and (B) one-third octave band levels for the AGS Slug launch at 13:22 on 3 June 2004 "Near 809 Camera". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in hertz (Hz).

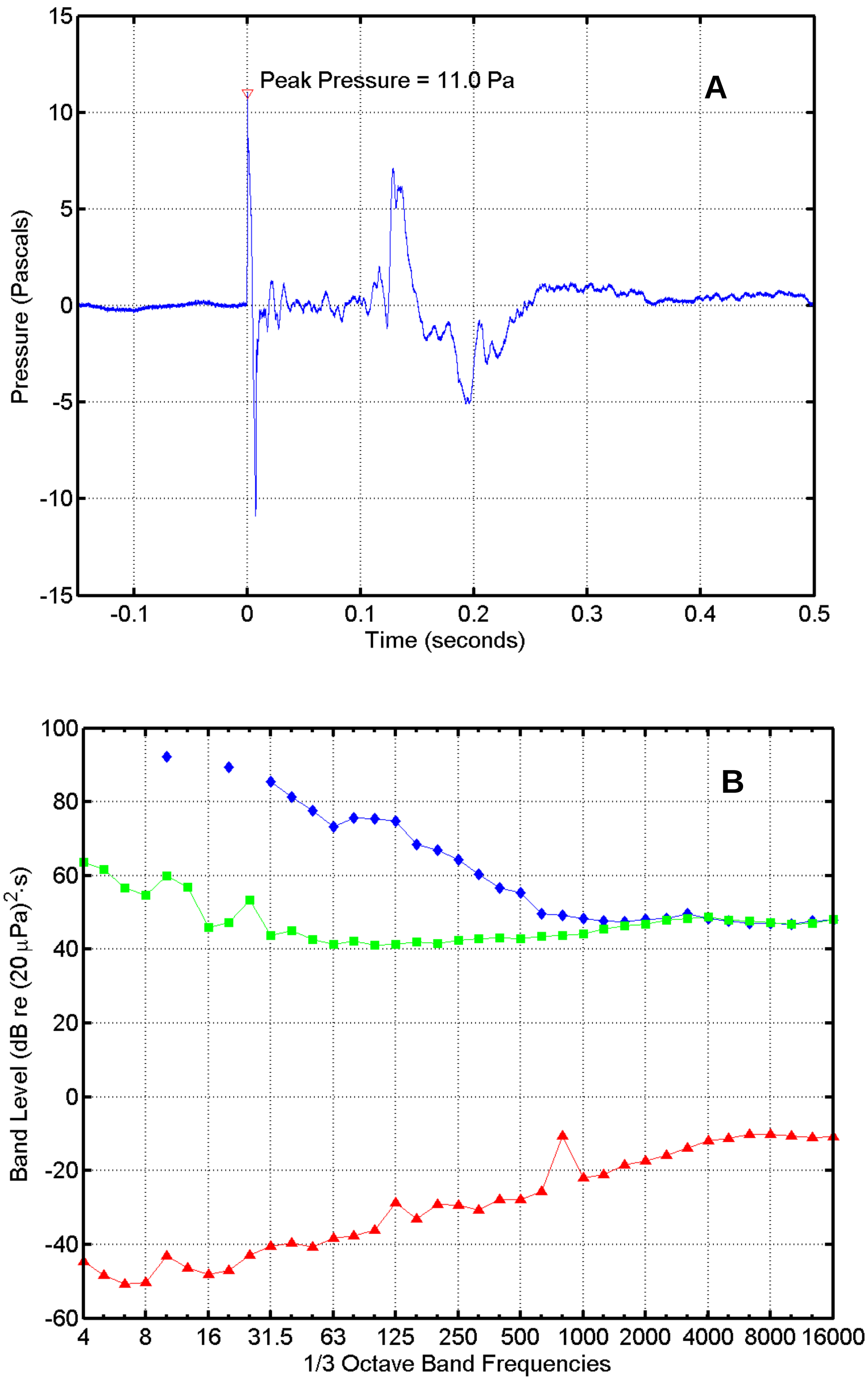


FIGURE C-14. (A) Pressure waveform and (B) one-third octave band levels for the AGS Slug launch at 13:22 on 3 June 2004 at “Harbor Seal Overlook”. In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in hertz (Hz).

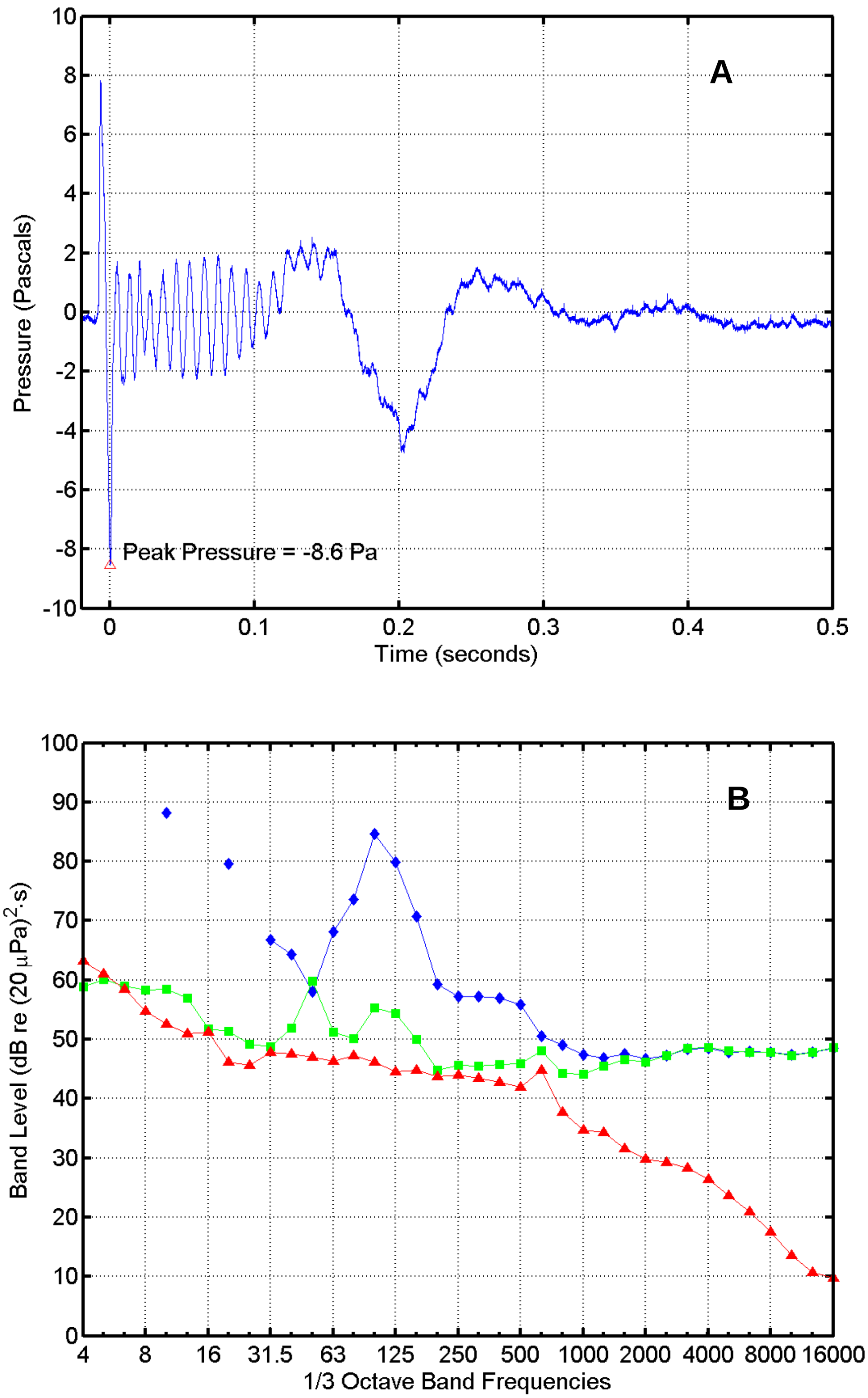


FIGURE C-15. (A) Pressure waveform and (B) one-third octave band levels for the AGS Slug launch at 13:22 on 3 June 2004 at "Dos Coves". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in hertz (Hz).

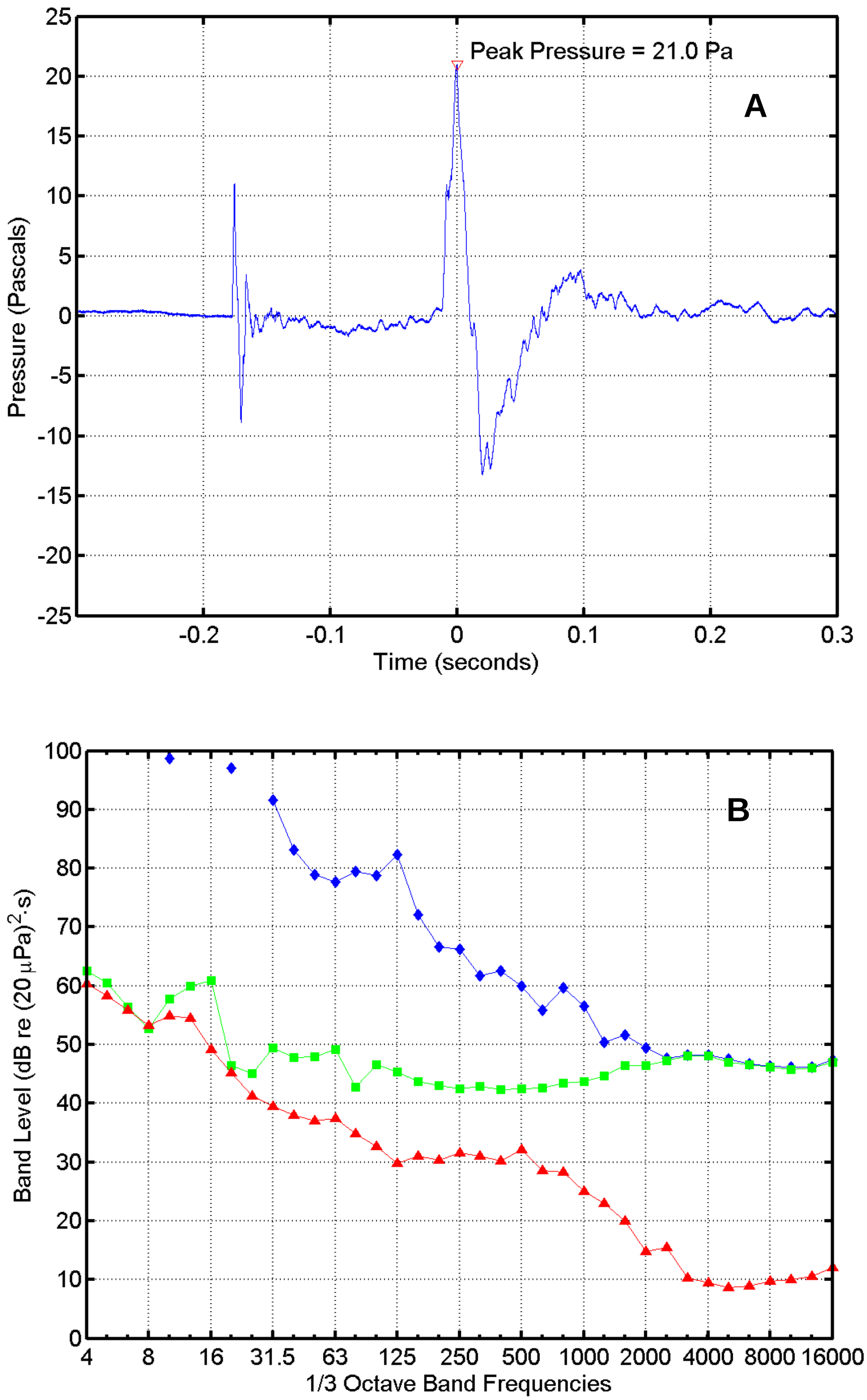


FIGURE C-16. (A) Pressure waveform and (B) one-third octave band levels for the AGS Missile launch at 15:08 on 3 June 2004 "Near 809 Camera". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in hertz (Hz).

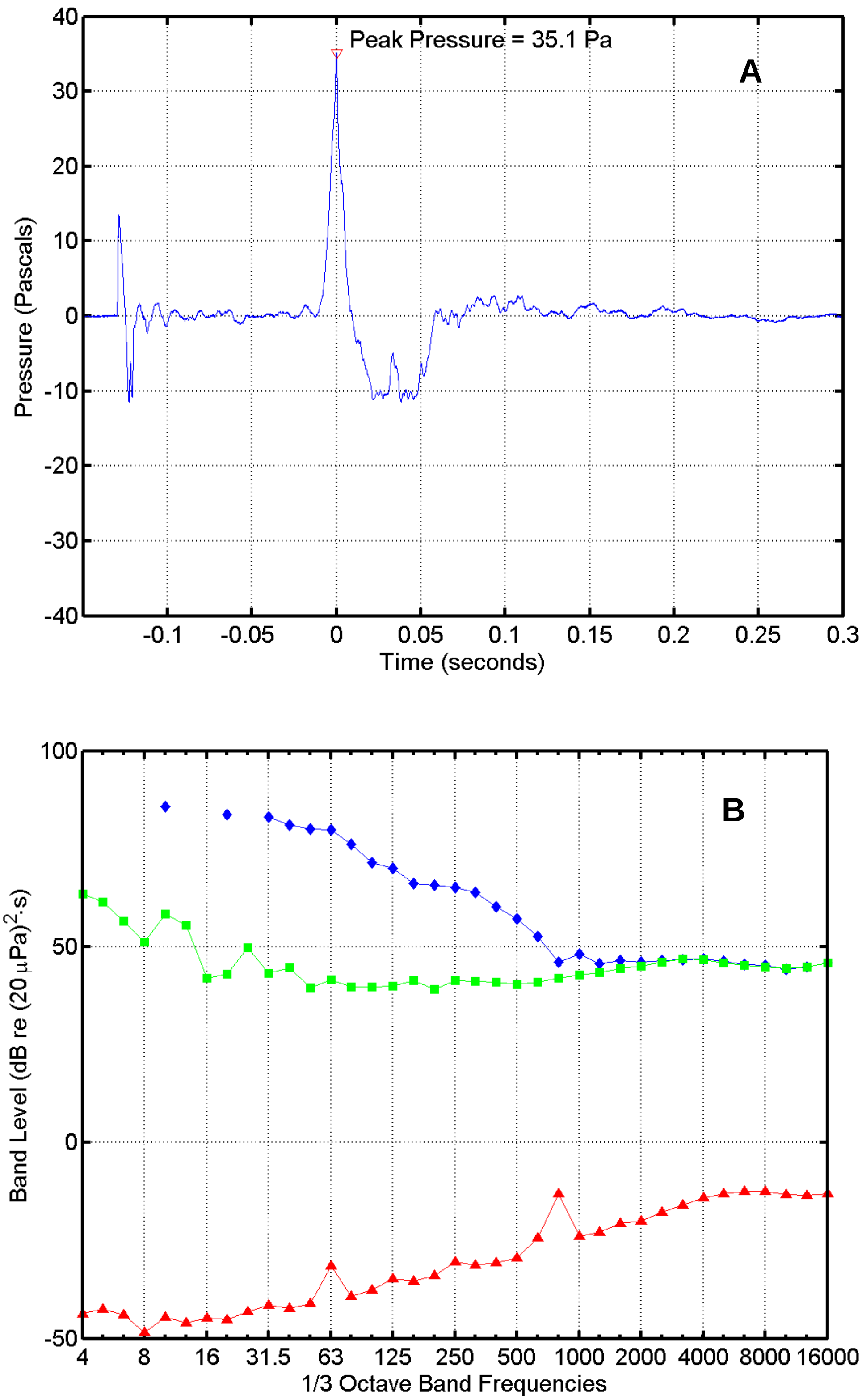


FIGURE C-17. (A) Pressure waveform and (B) one-third octave band levels for the AGS Missile launch at 15:08 on 3 June 2004 at "Harbor Seal Overlook". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in hertz (Hz).

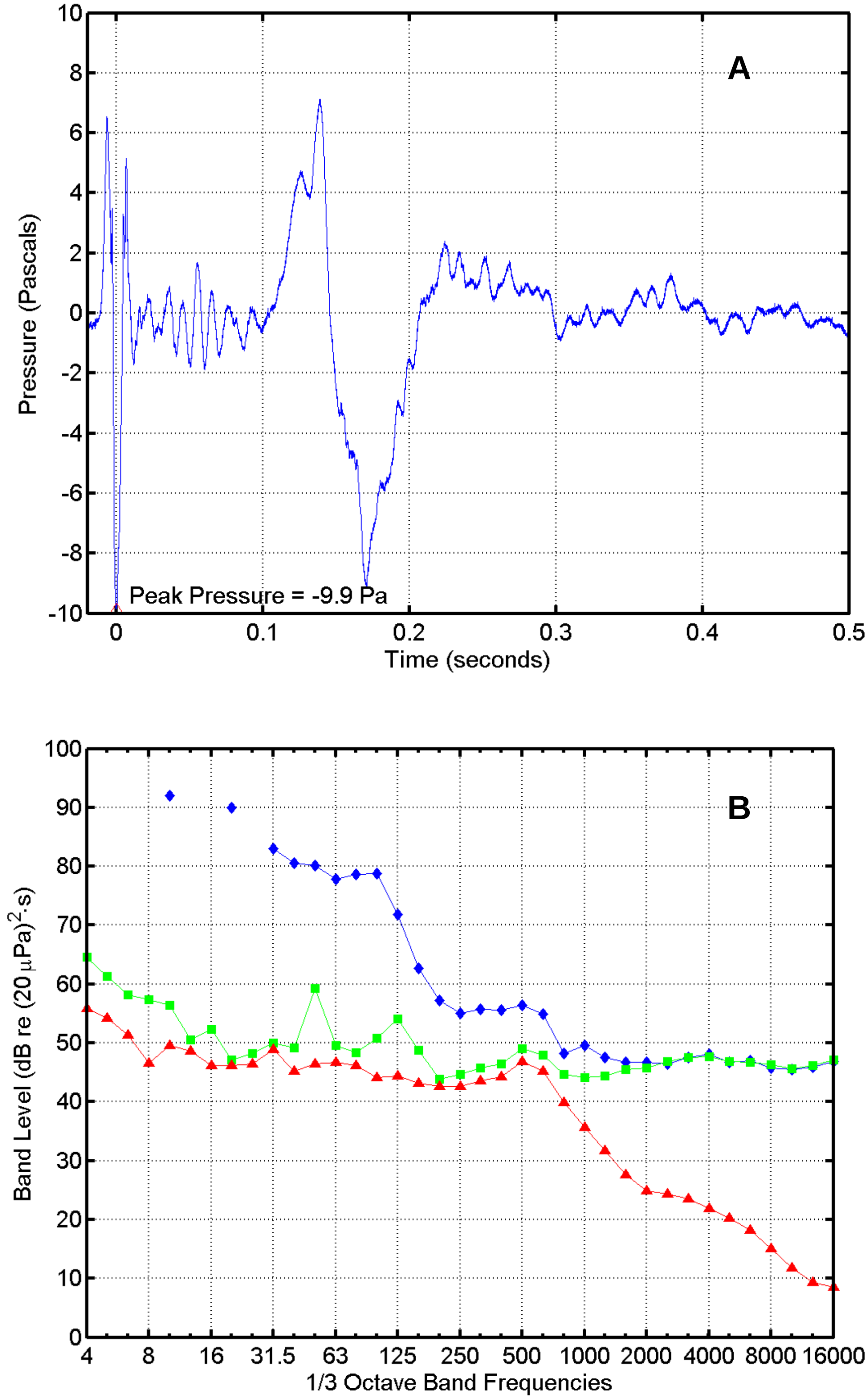


FIGURE C-18. (A) Pressure waveform and (B) one-third octave band levels for the AGS Missile launch at 15:08 on 3 June 2004 at "Dos Coves". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in hertz (Hz).