Marine Mammal and Acoustical Monitoring during Vehicle Launches on San Nicolas Island, California October 2004 – October 2005

submitted by

Naval Air Warfare Center Weapons Division
Point Mugu, California

to

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

10 April 2006

Marine Mammal and Acoustical Monitoring during Vehicle Launches on San Nicolas Island, California October 2004 – October 2005

by

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

LGL Report TA2665-6

10 April 2006

Suggested format for citation:

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

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ACRONYMS AND ABBREVIATIONS

3-D	3-dimensional
AGS	Advanced Gun System
ASCM	Anti-Ship Cruise Missile
ASL	above sea level
ATAR	Autonomous Terrestrial Acoustic Recorder
ATTS	Aerial Target Test Set
CFR	Code of Federal Regulations
cm	centimeter
Corp.	Corporation
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)
FES	Front End Subsystem
ft	feet
hr	hour
Hz	hertz
IHA	Incidental Harassment Authorization
in.	inch
kg	kilogram
kHz	kilohertz
km	kilometer (1 km = 3281 ft, 0.62 mi, or 0.54 n.mi)
LIK	Launcher Interface Kit
LOA	Letter of Authorization
m	meter (1 m = 1.09 yards or 3.28 feet)
min	minute
mm	millimeter
MMPA	Marine Mammal Protection Act
M_{pa}	Frequency weighting appropriate for pinnipeds in air (see Gentry et al. 2004; Miller et al. 2005)
NAWCWD	Naval Air Warfare Center Weapons Division
NMFS	National Marine Fisheries Service
PTS	Permanent Threshold Shift
rms	root mean square (a type of average)
s	second
SEL	Sound Exposure Level, a measure of the energy content of a transient sound
SEL-A	A-weighted sound exposure level
SEL-f	flat-weighted sound exposure level
SNI	San Nicolas Island
SPL	sound pressure level
SPL-f	flat-weighted sound pressure level
SSST	GQM-163A "Coyote" Supersonic Sea-Skimming Target
TTS	Temporary Threshold Shift
µPa	micropascal
V/µPa	volts per micropascal

EXECUTIVE SUMMARY

Naval Air Warfare Center Weapons Division (NAWCWD) was the holder of a Letter of Authorization (LOA) issued by the National Marine Fisheries Service (NMFS) on 8 October 2004 allowing non-lethal takes of pinnipeds incidental to the Navy's vehicle launch operations on San Nicolas Island (SNI), California. The LOA was valid from the date of issuance through 7 October 2005. The LOA was issued pursuant to 50 Code of Federal Regulations (CFR) 216.107, 50 CFR 216.151–158, and §101(a)(5)(A) of the Marine Mammal Protection Act (MMPA), 16 United States Code (USC) §1371(a)(5)(A). The LOA allowed 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 SNI. Previously, an LOA was issued for this purpose for the period October 2003 to October 2004, and two separate Incidental Harassment Authorizations (IHAs) were issued for the periods August 2001 to July 2002 and August 2002 to August 2003.

In the Navy's Petition for Regulations that led to promulgation of 50 CFR 216.151–158, a Marine Mammal Monitoring Plan was proposed. This plan included provisions to monitor any effects of vehicle launch activities on pinnipeds hauled out at SNI. This report describes the results of the marine mammal and associated acoustic monitoring program for vehicle launches from SNI during the October 2004 to October 2005 period; no launches occurred from October through December 2004. This report includes results from 25 launches from SNI in 2005: three launches on each of 27 January, 29 June, 28 July, and 25 August; two launches on 24 February, 2 and 16 June, and 26 July; and single launches on 11 and 24 March, 22 April, 27 July, and 6 October. Holst et al. (2005) summarized the monitoring results concerning the 44 previous launches at SNI for the period 2001 to 2004. The following subsections briefly summarize the monitoring program during the October 2004–October 2005 period. Details are provided in subsequent chapters of this report.

Description of Vehicle Launches and Monitoring Program

During the October 2004 to October 2005 period, 25 launches occurred from SNI on 13 different days. The launches included one "dual launch" of Vandals in quick succession, as well as up to three launches of single vehicles on the same day. The dual Vandal launch on 11 March consisted of two vehicles that were launched within seconds of each other; this is counted as a single launch. In addition, two Vandals were launched on 2 June, one Vandal launch occurred on 27 July, and three Vandals were launched on 28 July. Three Advanced Gun System (AGS) guided rounds were launched on each of 27 January, 29 June, and 25 August; and two AGS launches occurred on 24 February, 16 June, and 26 July. Aside from the dual Vandal launch on 11 March, all multiple launches were counted as separate launches. Single GQM-163A Supersonic Sea-Skimming Targets (SSST) were launched on 24 March, 22 April, and 6 October.

Vehicles were launched from one of two launch complexes on SNI. The AGS slugs and missiles were launched from the Building 807 Launch Complex located close to shore on the western end of SNI, 11 meters (m) above sea level (ASL). The Vandals and GQM-163A targets were launched from the Alpha Launch Complex located 190.5 m ASL on the west-central part of SNI.

The vehicles launched from the Alpha Launch Complex had launch elevation angles ranging from 8 to 35º above horizontal and were directed westward. They crossed the west end of SNI at altitudes up

to an estimated 2591 m. The AGS slugs and missiles launched from the Building 807 Launch Complex had elevation angles of 50 to 65º and crossed the west end of SNI at altitudes up to 1676 m.

The launch azimuths caused the vehicles to pass over or near various pinniped monitoring and acoustic measurement sites where Autonomous Terrestrial Acoustic Recorders (ATARs) and video systems had been deployed. Audio recordings were obtained to document launch sounds at several distances from the launch trajectories of the vehicles. The video and visual monitoring provided data on the behavioral reactions of pinnipeds hauled out during launches.

Acoustic Measurements during Vehicle Launches

Vehicle flight sounds were measured as received at various locations on western SNI. AGS launches typically produced lower sounds than other vehicles launched during the monitoring period. For AGS launches, flat-weighted sound pressure levels (SPL-f), measured over the 3–20,000 hertz (Hz) bandwidth, were 103–133 decibels (dB) reference 20 micropascal (re 20 µPa) at sites located 0.3–1.9 kilometers (km) from the closest point of approach (CPA) of the launched vehicle. Low-elevation (8º) Vandals produced low SPL-f (92–107 dB) at sites farthest from the CPA (2.4 km), and SPL-f of 120–139 dB at sites 0.4–1.3 km from the CPA. High-elevation (35º) Vandals produced SPL-f of 93–122 dB at distances of 1.9–2.5 km. At distances of 0.8–1.5 km, the GQM-163A SSSTs produced SPL-f of 125–134 dB, and 82–93 dB at distances ranging from 2.4–3.2 km. Measurements in this report are also presented based on the new M_{pa}- as well as A-weighting.

Behavior of Pinnipeds during Vehicle Launches

Behavior of pinnipeds around the periphery of western SNI during vehicle 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 and in some cases following the launches. Monitoring was typically attempted at three sites during each launch, with launch-to-launch variation in the locations monitored.

For each launch, the number, proportion, and (where determinable) ages of the individual pinnipeds that responded in various ways were extracted from the video, along with comparable data for those that did not respond overtly. No evidence of injury or mortality was observed during or immediately succeeding the launches for any pinniped species. However, during one launch of an AGS slug, an adult male and an adult female sea lion ~464 m from the closest part of the trajectory each knocked over three sea lion pups as the adults moved in response to the launch. The pups were momentarily startled, but did not appear to be injured.

California sea lions

California sea lions were observed during 22 of 25 launches on 12 launch dates (total of 54 site-date-launch combinations). Responses of California sea lions to the launches varied by individual. Most sea lions at locations ~420–2270 m from the CPA exhibited brief startle responses and increased vigilance for a short period (1–2 min) after each launch. Other sea lions appeared to react more vigorously by moving around on the beach. Movement into the water occurred on 21 of 54 occasions, but generally only a small proportion (<35%) of animals entered the water. However, on six occasions, 46–80% of sea lions entered the water.

Northern elephant seals

Elephant seals were observed during 14 launches on eight dates (21 site-date-launch combinations). They were ~420–3270 m from the CPA. 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). However, on six occasions, a small proportion (up to 5%) of northern elephant seals moved a short distance (1–4 m) away from their resting site. On three occasions, up to 43% of seals moved short distances, but total numbers at the haul-out site were small. Elephant seals entered the water on at least two of those occasions (and possibly during a third launch).

Harbor seals

Harbor seals ~1.0–3.3 km from the CPA were observed during nine launches on five dates (13 site-date combinations). Behavior of harbor seals to the launches was variable. On most occasions (10 of 13), the majority of harbor seals rushed from their haul-out sites on rocky ledges to enter the water within seconds of the launch. Occasionally, harbor seals would start hauling out at the same site as soon as several minutes (8 min or longer) after the launch.

Estimated Numbers of Pinnipeds Affected by Vehicle Launches

No evidence of pinniped injuries or fatalities related to vehicle launches was evident, nor was it expected, during the monitoring period. In fact, few if any pinnipeds were exposed to sound levels above 127 dB re $(20\ \mu Pa)^2 \cdot s$ sound exposure level (SEL) on a flat-weighted basis (SEL-f), 119 dB on an M_{pa}-weighted basis (SEL-M), and 111 dB on an A-weighted basis (SEL-A). However, small numbers were exposed to peak pressures as high as 149 dB re 20 µPa during a dual Vandal launch on 11 March 2005. Somewhat higher levels likely occurred at sites closer to the launchers where no measurements were taken. However, few if any pinnipeds have been seen or are known to haul out on beaches immediately next to the launchers.

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. However, this was not always possible, because it was generally unknown which beaches were used as haul-out sites on specific launch dates, and how many animals were hauled out. In addition, data from previous launches were used to estimate the number of pinnipeds affected during launch days when no recordings of that species were possible. We considered pinnipeds that left the haul-out site, exhibited prolonged movement, or entered the water, as affected.

Approximately 1990 California sea lions, 15 northern elephant seals, and 395 harbor seals are estimated to have been affected by launch sounds during the October 2004–October 2005 monitoring period. These numbers may be underestimates, because not all pinniped beaches around western SNI could be monitored during any given launch, even though extrapolation of data for other potential haul-out sites was attempted. However, it is also possible that some proportion of individuals were affected by more than one launch and thus included more than once in the estimates. 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) pinnipeds on SNI 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). Monitoring from August 2001 to July 2002 showed that numbers of pinnipeds occupying haul outs the day after a launch were similar to pre-launch levels (Lawson 2002).

1. VEHICLE LAUNCHES AND MONITORING PROGRAM DESCRIBED

Vehicles are launched from one of two land-based launch complexes on the western part of San Nicolas Island (SNI), California (Fig. 1.1). Building 807 Launch Complex is located on the west coast of SNI, 11 meters (m) above sea level (ASL), and the Alpha Launch Complex is located 190.5 m ASL on the west-central part of SNI (Fig. 1.2). The vehicles pass over or near pinniped haul-out sites located around the periphery of SNI. The pinniped species that commonly occur on SNI include northern elephant seals (*Mirounga angustirostris*), harbor seals (*Phoca vitulina*), and California sea lions (*Zalophus californianus*).

For the period 8 October 2004 to 7 October 2005, Naval Air Warfare Center Weapons Division (NAWCWD) held a Letter of Authorization (LOA) issued by the National Marine Fisheries Service (NMFS) allowing non-lethal takes of pinnipeds incidental to the Navy's vehicle launch operations on SNI (Appendix A). That LOA was the fourth annual incidental take authorization issued to the Navy concerning launches from SNI. Previously, two separate Incidental Harassment Authorizations (IHAs) were issued for the periods August 2001–July 2002 and August 2002–August 2003, and an LOA was issued for the period October 2003–October 2004. These authorizations, issued by NMFS under the Marine Mammal Protection Act (MMPA), allowed the 'take by harassment' of small numbers of northern elephant seals, harbor seals, and California sea lions during routine launches from Navy-owned SNI.

A Marine Mammal Monitoring Plan was proposed in the initial IHA application and slightly updated in the Petition for Regulations under which the LOAs have been issued. The purpose of the monitoring was to characterize any effects of vehicle launch activities on pinnipeds hauled out at SNI. This report describes the results of the marine mammal and associated acoustic monitoring program during the period from October 2004 through October 2005. Twenty-five launches involving 26 vehicles took place from SNI during that period. Results concerning 44 previous launches during the period 2001 through 2004 are reported by Holst et al. (2005).

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 SNI during October 2004–October 2005. This report includes four chapters: (1) background, introduction, and description of the Navy's vehicle launches [this chapter]; (2) acoustical monitoring during the vehicle launches [Chapter 2]; (3) visual monitoring of pinnipeds during those launches [Chapter 3]; and (4) estimated numbers of pinnipeds affected by the vehicle sounds during these launches [Chapter 4].

1.1 Vandal

The Vandal, designated MQM-8G, is a relatively large, air-breathing (ramjet) vehicle designed to provide a realistic simulation of the midcourse and terminal phase of a supersonic anti-ship missile (Fig. 1.3). The Vandal is an evolved version of the (former) Talos missile. The Vandal is 7.7 m long, excluding the booster, and 71 cm in diameter. There are three variants of the Vandal, the standard (no longer used), ER, and EER. The EER variant, including booster, weighs 3674 kilograms (kg). The variants differ primarily in their operational range.

Vandals have no explosive warhead. At launch, the Vandal is accelerated for several seconds by a solid propellant rocket booster, to a speed sufficient for the ramjet engine to start. After several seconds of thrust, the booster is discarded, and the missile continues along its flight path at supersonic speed under ramjet power. The expended booster rocket drops into the water west of SNI.

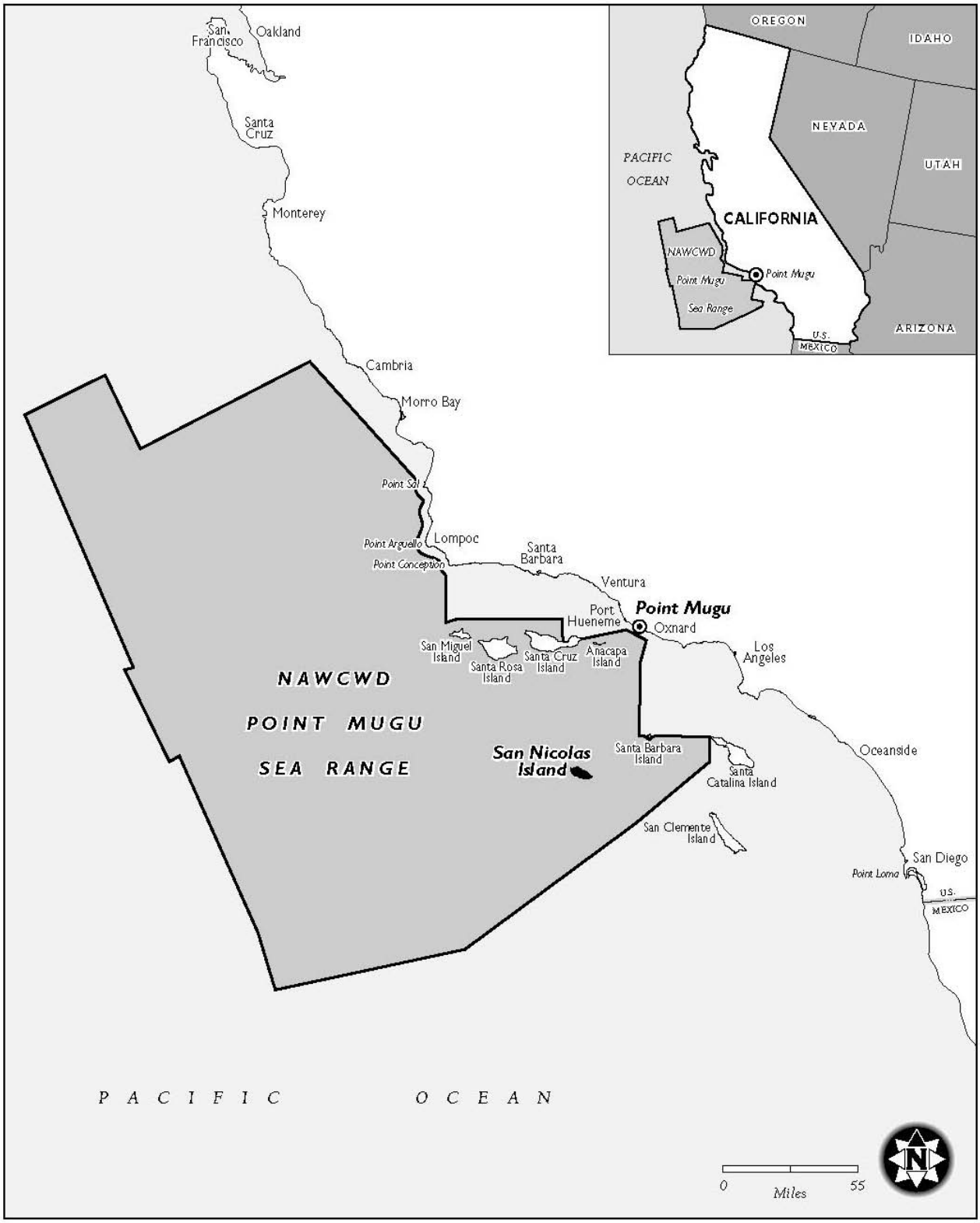

FIGURE 1.1. Regional site map of the Point Mugu Sea Range and San Nicolas Island (map by TEC).

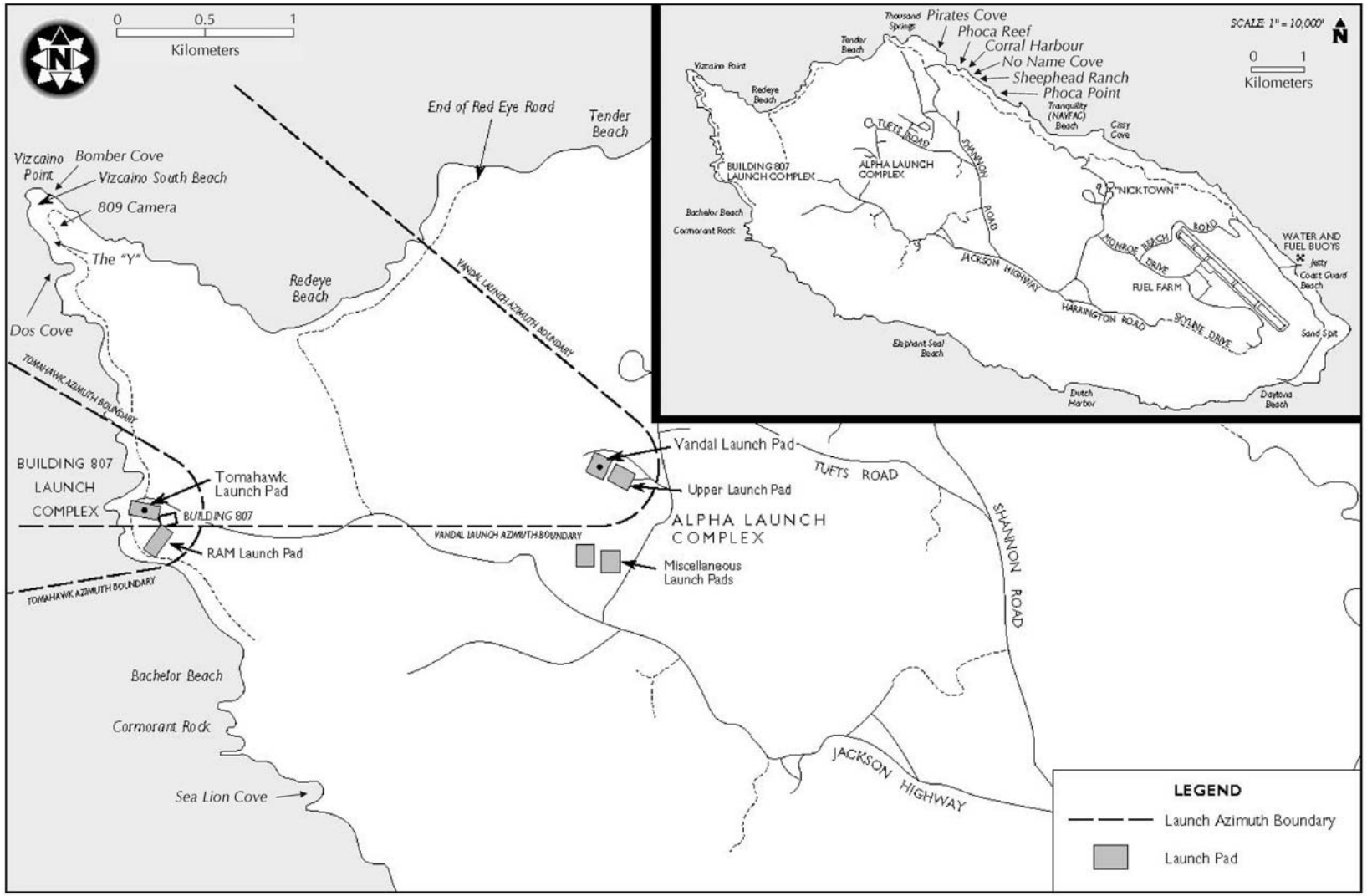

FIGURE 1.2. View of vehicle launch sites on San Nicolas Island. Shown are the Alpha Launch Complex and the Building 807 Launch Complex (at lower elevation near the shoreline). Also shown are the maximum predicted extent of the launch azimuths for vehicles leaving the two launch sites.

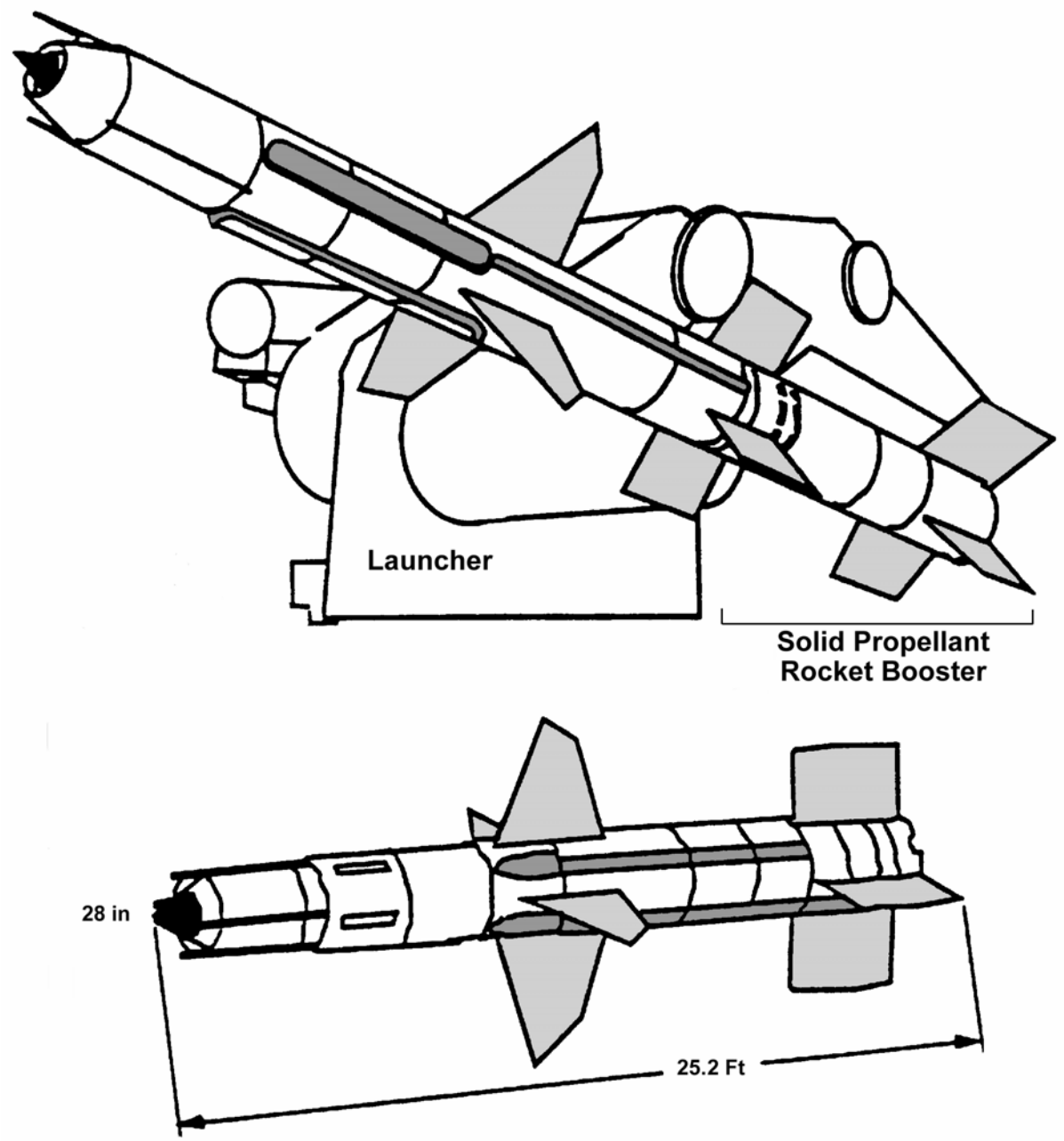

FIGURE 1.3. The Vandal is a supersonic vehicle that is accelerated to ramjet operational speed by a solid propellant rocket booster. The ER (top) and EER (bottom) Vandal variants are identical in dimensions, with the EER having greater range and weight. The Vandal is launched from a dedicated launcher system at the Alpha Launch Complex on San Nicolas Island.

Vandals are remotely controlled, non-recoverable vehicles that are launched from the Alpha Launch Complex (Fig. 1.2). Vandal launch trajectories can vary from near-vertical liftoff, crossing the west end of SNI at an altitude of about 3962 m, to a nearly horizontal launch profile crossing the west end of SNI at an altitude of about 305 m. With a launch angle $\leq 13^{\circ}$, the Vandal can descend to a sea-skimming altitude several kilometers out at sea, or it can continue offshore at higher altitude.

The Vandal is often launched singly, but in some cases, two Vandals are launched sequentially, spaced closely in time (e.g., a dual launch). If launched sequentially, two Vandals are launched in succession from the same pad (Fig. 1.4). During the current monitoring period, up to three Vandals were launched on the same day. However, aside from one closely-spaced dual launch on 11 March, these launches were spaced up to several hours apart. Due to the additional instrumentation and logistical requirements, dual launches are only done when there is an absolute mission requirement. The Vandal has been retired from use, and future Vandal launches from SNI are not anticipated.

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

The Navy/Orbital Sciences Corporation (Corp.) GQM-163A "Coyote" Supersonic Sea-Skimming Target (SSST) is an expendable target powered by a ducted-rocket ramjet (Fig. 1.5). It is capable of flying at low altitudes (4 m cruise altitude) and supersonic speeds (Mach 2.5) over a flight range of 83 kilometers (km). This vehicle is designed to provide a ground launched aerial target system to simulate a supersonic, sea-skimming Anti-Ship Cruise Missile (ASCM) threat. The SSST is being developed as a replacement for the Vandal.

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 46 centimeters (cm) in diameter and is of the type used to launch the Navy's "Standard" surface-to-air missile. The GQM-163A target vehicle is 5.5 m long and 36 cm in diameter, exclusive of its air intakes. It consists of a solid-fuel Ducted Rocket (DR) ramjet subsystem, Control and Fairing Subassemblies, and the Front End Subsystem (FES). Included in the FES is an explosive destruct system to terminate flight if required.

The SSST utilizes the unmodified Vandal launcher, currently installed at the Alpha Launch Complex on SNI with a Launcher Interface Kit (LIK; Fig. 1.5). 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 occurs about 5.5 seconds (s) after launch and about 2.6 km downrange, at which time the vehicle has 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 5 m altitude while maintaining a speed of Mach 2.5. During launches from SNI, the low-altitude phase occurs over water west of the island. The target performs pre-programmed maneuvers during the cruise and terminal phases, as dictated by the loaded mission profile, associated waypoints, and mission requirements. During the terminal phase, the SSST settles down to an altitude of 4 m and Mach 2.3 until DR burnout.

1.3 Advanced Gun System (AGS)

At SNI, a howitzer (Fig. 1.6) has been used to launch test missiles, as the Advanced Gun System (AGS) is still being developed. The 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-millimeter (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 capacity of 600 to 750 projectiles and associated propelling charges. The regular charge for the gun will replace the booster that is usually associated with a surface-launched missile. The gun gets the missile up to speed, at which point the missile's propulsion takes over. The

FIGURE 1.4. View of two Vandals mounted on the launch pad at the Alpha Complex on SNI; solid rocket booster is visible at rear of closer Vandal (photograph by U.S. Navy).

FIGURE 1.5. View of the GQM-163A SSST with booster and launcher at the Alpha Launch Complex on SNI (photograph by U.S. Navy).

missile itself is relatively quiet, as it does not have a booster and is fairly small. However, the gun blast is rather strong. Each missile launch is preceded by one (sometimes two) howitzer firings using a slug. The slug is used to verify that the gun barrel is properly seated and aligned.

FIGURE 1.6. View of the AGS test launcher at the Alpha Complex (now relocated to the Building 807 Launch Complex) on SNI (photograph by U.S. Navy).

During past monitoring periods up to June 2004, AGS launches have occurred from the Alpha Launch Complex. However, the launcher was moved to the Building 807 Launch Complex in July 2004. During the October 2004-October 2005 period, AGS slugs and missiles were launched at an azimuth of 280–287° from the Building 807 Launch Complex.

1.4 Vehicle Launches during the Monitoring Period

During the period from October 2004 to October 2005, there were a total of 25 launches from SNI on 13 separate days (Table 1.1). The launches included one "dual launch" of two Vandals in quick succession, as well as up to three launches of single vehicles on the same day. The dual launch of Vandals on 11 March consisted of two vehicles that were launched within seconds of each other; this launch is counted as a single launch since it is not possible to distinguish pinniped reactions during the launchdes. In addition, two Vandals were launched sequentially on 2 June (2 hours [hr] 20 minutes [min] apart), one Vandal launch occurred on 27 July, and three Vandals were launched sequentially on 28 July (first two Vandals were launched 3 hr 16 min apart, followed by another Vandal 18 min later). Three AGS guided rounds were launched on each of 27 January, 29 June, and 25 August. On 27 January, two AGS slugs were launched 2 hr 42 min apart followed by a missile 1 hr 48 min later. On 29 June, two slugs were launched 2 hr 8 min apart, followed by a missile 3 hr 31 min later. On 25 August, a missile was launched 2 hr 27 min after a slug; the missile was then followed by another missile 2 hr later. Two AGS launches occurred on each of 24 February, 16 June, and 26 July; the first launch always involved a slug and was followed by a missile. The initial slug was followed by a missile 4 hr 11 min later on 24 February. On 16 June, the missile was launched 1 hr 52 min after the slug. On 26 July, the missile and slug were launched 1 hr 57 min apart. In addition, single SSSTs were launched on 24 March, 22 April, and 6 October. Aside from the one dual Vandal launch on 11 March, all multiple launches on the same

day were counted as separate launches. Weather during the launches was usually cool and the winds were variable; conditions ranged from clear to overcast (Table 1.1).

All AGS slugs and missiles were launched from the Building 807 Launch Complex (Figs. 1.2 and 1.6); they had launch azimuths of 280–287º and elevation angles of 50–65º. The SSSTs were launched from the Alpha Launch Complex at an azimuth of 270° and an elevation angle of 14° (Figs. 1.2 and 1.5). The Vandals were also launched from the Alpha Launch Complex (Figs. 1.2 and 1.4), but at azimuths of 270–273° and elevation angles of 8–35°.

These launch azimuths caused the vehicles to pass over or near various acoustic measurement and pinniped monitoring sites where Autonomous Terrestrial Acoustic Recorders (ATARs) and video systems had been deployed. The latter consisted of several wagon- or tripod-mounted cameras. During past monitoring periods, a remote-controlled camera ("809 Camera") that is installed near Building 809 was also used, but this camera was not operational during 2005.

1.5 Acoustical Monitoring of Vehicle 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 vehicles;
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 vehicle 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 pinniped species are variable and context dependent. Lawson et al. (1998) estimated the minimum received level (on an A-weighted Sound Exposure Level or SEL-A basis) that might elicit substantial disturbance as 100 decibels A-weighted (dBA) reference 20 micropascals (re 20 µPa)^2·s. The 100 dBA re (20 µPa)^2·s SEL level pertains to exposures 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 s (Greene and Malme 2002; see also Chapter 2 of this report). In any event, the assumption that reactions might occur at distances up to those where received levels diminished to 100 dBA re (20 µPa)^2·s SEL was one factor in selecting acoustic (and video) monitoring sites during the first year of monitoring in 2001. Sites at distances up to 4 km from the launcher and/or launch trajectory were monitored in the first year.

TABLE 1.1. Details of the 25 launches at SNI during October 2004 – October 2005. The weather data were collected at the SNI airport, which is located at an elevation of 152 m ASL toward the east end of the island; therefore weather conditions at haul-out sites may have differed somewhat.

Launch Date 2005	Launch Time (local)	Vehicle Type	Launch Complex	Launch Azimuth (true)	Elevation Angle/Altitude Over Beach	Weather at SNI Airport	Time of Low Tide	Video Quality	Audio Quality
27 January	08:59	AGS Slug	Building 807	287°	50° / 1372 m	10.6°C; winds 370° at 6 kt; broken clouds	03:57	3 cameras good	2 ATARs OK; 1 malfunctioned
"	11:41	AGS Slug	Building 807	287°	50° / 1372 m	10.6°C; winds 370° at 6 kt; broken clouds	03:57	3 cameras good	2 ATARs OK; 1 malfunctioned
"	13:29	AGS Missile	Building 807	287°	50° / 1372 m	10.6°C; winds 370° at 6 kt; broken clouds	03:57	3 cameras good	2 ATARs OK; 1 malfunctioned
24 February	09:05	AGS Slug	Building 807	286°	50° / 1372 m	N/A	N/A	1 camera good, 1 poor, 1 did not work	3 ATARs OK
"	13:16	AGS Missile	Building 807	286°	50° / 1372 m	N/A	N/A	3 cameras good	3 ATARs OK
11 March	09:30	Dual Vandal	Alpha	273°	8° / 396 m	winds 130° at 12 kt; overcast	03:54	3 cameras good	3 ATARs OK
24 March	08:35	SSST	Alpha	270°	14° / 914 m	23°C; winds 203° at 8 kt; overcast	14:56	3 cameras good	2 ATARs OK
22 April	16:43	SSST	Alpha	270°	14° / 914 m	winds 315° at < 8 kt; variable cloud cover	15:06	3 cameras good; 1 poor	3 ATARs OK
2 June	07:29	Vandal	Alpha	273°	8° / 396 m	winds 270° at 6 kt; overcast	13:02	1 camera good; 2 poor	3 ATARs OK
"	09:49	Vandal	Alpha	273°	8° / 396 m	winds 270° at 6 kt; overcast	13:02	2 cameras good; 1 poor	3 ATARs OK
16 June	10:08	AGS Slug	Building 807	280°	62.5° / 1615 m	15°C; winds 315° at 6 kt	11:25	2 cameras good	2 ATARs OK
"	14:00	AGS Missile	Building 807	280°	62.5° / 1615 m	15°C; winds 315° at 6 kt	11:25	2 cameras good	2 ATARs OK

TABLE 1.1. continued.

Launch Date 2005	Launch Time (local)	Vehicle Type	Launch Complex	Launch Azimuth (true)	Elevation Angle/Altitude Over Beach	Weather at San Nicolas Island Airport	Time of Low Tide	Video Quality	Audio Quality
29 June	08:56	AGS Slug	Building 807	280°	62.5° / 1615 m	15°C; winds 310° at 15 kt; overcast	10:41	4 cameras good	3 ATARs OK
"	11:04	AGS Slug	Building 807	280°	62.5° / 1615 m	16°C; winds 300° at 12 kt; overcast, vis. 8 km	10:41	4 cameras good	2 ATARs OK
"	14:35	AGS Missile	Building 807	280°	62.5° / 1615 m	16°C; winds 300° at 12 kt; overcast, vis. 8 km	10:41	3 cameras good; 1 did not work	1 ATAR OK
26 July	12:56	AGS Slug	Building 807	280°	65° / 1676 m	20°C; winds 210° at 4 kt; scattered clouds	08:09	3 cameras good	3 ATARs OK
"	14:53	AGS Missile	Building 807	280°	65° / 1676 m	20°C; winds 210° at 4 kt; scattered clouds	08:09	3 cameras good	3 ATARs OK
27 July	10:07	Vandal	Alpha	270°	8° / 390 m	16°C	08:52	3 cameras good	2 ATARs OK
28 July	08:04	Vandal	Alpha	270°	8° / 390 m	17°C; winds 270° at 10 kt; overcast	09:41	3 cameras good	3 ATARs OK
"	11:20	Vandal	Alpha	270°	35° / 2591 m	20°C; winds 270° at 10 kt; overcast	09:41	3 cameras good	2 ATARs OK
"	11:38	Vandal	Alpha	270°	35° / 2591 m	20°C; winds 270° at 10 kt; overcast	09:41	3 cameras good	3 ATARs OK
25 August	09:03	AGS Slug	Building 807	280°	62.5° / 1615 m	22°C; winds 320° at 9 kt; clear	07:48	3 cameras good	2 ATARs OK
"	11:30	AGS Missile	Building 807	280°	62.5° / 1615 m	22°C; winds 320° at 9 kt; clear	07:48	3 cameras good	3 ATARs OK
"	13:30	AGS Missile	Building 807	280°	62.5° / 1615 m	22°C; winds 320° at 9 kt; clear	07:48	3 cameras good	3 ATARs OK
6 October	09:30	SSST	Alpha	270°	14° / 914 m	25°C; winds 350° at 2 kt; clear	04:55	1 camera good, 1 poor, 1 without seals	2 ATARs OK

Note: N/A means not available

After reviewing video recordings of launches at SNI during 2001–2002 (Holst and Lawson 2002), the 100-dBA SEL level seemed reasonable as a minimum received level 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 vehicles 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 2002–2005.

1.6 Visual Monitoring of Pinnipeds During Vehicle Launches

The Navy conducted continued video and visual monitoring of pinnipeds during the vehicle launches from SNI in the October 2004 to October 2005 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 SNI during launches. The accumulation of such data across numerous launches is providing the data required to characterize the extent and nature of disturbance effects. In particular, it will provide the information needed to document the nature, frequency, occurrence, and duration of any changes in pinniped behavior resulting from the vehicle launches, including the occurrence of stampedes from haul-out sites if they occur. A detailed description of the methods for the visual monitoring can be found in Section 3.2 of Chapter 3.

The video records 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 the launch day to quantify the interval required for pinniped numbers and behavior to return to normal if there was a change as a result of launch activities;
3. compare received levels of launch sound with pinniped responses, based on acoustic and behavioral data from monitoring sites at different distances from the launch site and flightline during each launch; from the data accumulated across a series of launches, establish the "dose-response" relationship[1] for vehicle 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 vehicle launch sounds and, although unlikely, any mortality or injury.

In the October 2004–October 2005 period, there were 25 launches involving four different types of vehicles (Table 1.1). Determination of the dose-response relationship (objective 3, above) and conditions when pinnipeds were most or least responsive to launch sounds (objective 4) requires consideration of additional data, including data from the previous years of monitoring (Holst et al. 2005) and data from planned future monitoring. Therefore, objectives (3) and (4) are not addressed in the present report. However, a preliminary analysis using data from all previous monitoring years can be found in Holst et al. (2005).

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

1.7 Letter of Authorization (LOA)

The monitoring program for the Navy's vehicle launches in 2001–2005 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 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 SNI during vehicle launches was issued to the Navy on 8 October 2004. Previously, an LOA was issued for October 2003 to October 2004, and two separate IHAs were issued for launches conducted from 2001 to 2003 (NMFS 2001, 2002). Acoustic and visual monitoring has been conducted during launches from SNI from August 2001 to the present. Holst et al. (2005) described the results from the previous monitoring years. This report describes the results from the 2004–2005 monitoring period.

1.8 Summary

From October 2004 through October 2005, NAWCWD conducted 25 launches from SNI on 13 different days. Launches occurred from two areas of the island: the Building 807 Launch Complex near the beach on the west-central part of San Nicolas (15 AGS launches over 6 separate days), and the Alpha Launch Complex farther inland on SNI (a dual Vandal launch on 11 March, as well as six other Vandal launches over 3 days, and three single SSST launches). An acoustic and visual monitoring program took place during these launches to assess the effects of the operations on pinniped species on the island. Monitoring procedures were consistent with those during previous launches during 2001–2004 (see Holst et al. 2005). Monitoring procedures and results of the acoustic and visual monitoring for October 2004–October 2005 are described in Chapters 2 and 3.

2. ACOUSTICAL MEASUREMENTS OF VEHICLE LAUNCHES, OCTOBER 2004 – OCTOBER 2005

2.1 Introduction

A total of 26 vehicles were launched from SNI during the period from 27 January through 6 October 2005, as described in Chapter 1. Table 2.1 lists the launch dates, times, and types of vehicles. Table 2.2 lists the acoustic monitoring locations. Maps of the launch azimuths and monitoring locations for each launch date can be found in Chapter 3 (Fig. 3.1).

The acoustic measurement program during the October 2004–October 2005 period was consistent in approach and methodology with that used during the preceding years (see Holst et al. 2005). The sounds of each vehicle, as well as background sounds, were recorded at up to three sites on the island during each vehicle flight. ATARs, described below, were developed for this purpose by the Navy's acoustical contractor, Greeneridge Sciences Inc. (Greeneridge) of Santa Barbara, California. The ATARs were used to record the launch sounds at places and times where launch safety considerations required that no operator could be present. Of the 75 possible recordings during the present monitoring period (25 launches × three recording sites per launch), 62 recordings were obtained and analyzed (Table 2.1).

TABLE 2.1. Vehicle launches recorded at SNI from October 2004 to October 2005.

Date in 2005	Local Time	Vehicle	Elevation Angle (°)	# of Acoustic Recording Sites	Acoustic Data
27 January	08:59	AGS Slug	50	3	2 OK*
"	11:41	AGS Slug	50	3	2 OK*
"	13:29	AGS Missile	50	3	2 OK*
24 February	09:05	AGS Slug	50	3	3 OK
"	13:16	AGS Missile	50	3	3 OK
11 March	09:30	Dual Vandal	8	3	3 OK
24 March	08:35	SSST	14	3	2 OK*
22 April	16:43	SSST	14	3	3 OK
2 June	07:29	Vandal	8	3	3 OK
"	09:49	Vandal	8	3	3 OK
16 June	10:08	AGS Slug	62.5	3	2 OK*
"	14:00	AGS Missile	62.5	3	2 OK*
29 June	08:56	AGS Slug	62.5	3	3 OK
"	11:04	AGS Slug	62.5	3	2 OK*
"	14:35	AGS Missile	62.5	3	1 OK*
26 July	12:56	AGS Slug	65	3	3 OK
"	14:53	AGS Missile	65	3	3 OK
27 July	10:07	Vandal	8	3	2 OK*
28 July	08:04	Vandal	8	3	3 OK
"	11:20	Vandal	35	3	2 OK*
"	11:38	Vandal	35	3	3 OK
25 August	09:03	AGS Slug	62.5	3	2 OK*
"	11:30	AGS Missile	62.5	3	3 OK
"	13:30	AGS Missile	62.5	3	3 OK
6 October	09:30	SSST	14	3	2 OK*

* ATAR malfunctioned or data could not be interpreted.

TABLE 2.2. Locations of ATAR recording devices during launches from October 2004 through October 2005 (also see Fig. 3.1).

2005 Launch Date	Vehicle	ATAR Locations
27 January	AGS slugs and missile	Redeye I, Bachelor Beach North, Bachelor Beach South*
24 February	AGS slug and missile	Vizcaino Point, Dos Coves South, Bachelor Beach South
11 March	Dual Vandal	809 Camera, The "Y", Dos Coves South
24 March	SSST	809 Camera*, The "Y", Dos Coves South
22 April	SSST	Harbor Seal Overlook, Phoca Reef, Phoca Point
2 June	Vandals	809 Camera, Bomber Cove, The "Y"
16 June	AGS slug and missile	Dos Coves South, Redeye I, Bachelor Beach North*
29 June	AGS slugs and missile	The "Y"†, Dos Coves Gate, Bachelor Beach □
26 July	AGS slug and missile	Bomber Cove, The "Y", Dos Coves South
27 July	Vandal	Bomber Cove, Harbor Seal Overlook*, Phoca Reef
28 July	Vandals	Bomber Cove‡, Harbor Seal Overlook, Phoca Reef
25 August	AGS slug and missiles	Bomber Cove, The "Y", Dos Coves South§
6 October	SSST	Bomber Cove, Dos Coves South, Phoca Reef*

* ATAR malfunctioned or sound could not be analyzed; † ATAR malfunctioned only during last launch at 14:35; □ ATAR malfunctioned at 11:04 and 14:35; ‡ ATAR only malfunctioned at 11:20; § ATAR malfunctioned during first launch at 9:03.

Measured sound levels at various microphone locations can be used to characterize sound exposure vs. distance downrange and laterally from the launch azimuth. Analyses of this type for acoustic data collected for the period August 2001 through January 2005 were reported by Holst et al. (2005). In those analyses, factors that were considered included vehicle type, launch azimuth, launch characteristics (e.g., low- vs. high-angle launch), as well as weather, which is expected to have important effects on the received sounds. Given the limited number and variable types of vehicles launched during the current monitoring period, no corresponding analysis of acoustic data has been done for the specific 1-year period covered in this report. However, an updated across-year analysis taking account of all available acoustic data is anticipated at a future date.

2.2 Field Methods

2.2.1 Deployment of ATARs

During each flight within the present monitoring period, the three ATARs were positioned near pinniped haul out sites at varying distances from the planned launch azimuth. During each of the launches, at least one ATAR was within 1 km (horizontal distance) of the planned azimuth, and during SSST launches on 24 March and 6 October, one ATAR was placed at a pinniped haul-out site directly below the azimuth (Fig. 3.1F and S). 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 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 and ongoing monitoring will be needed in order 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 biologists 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 an SEL of ~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 vehicles 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 hr. 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 hr 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 vehicle 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 is a PCB 106B50 quartz microphone (PCB Piezotronics Inc., Depew, NY). These relatively insensitive microphones, with sensitivity –202 dB re 1 volt per micropascal (V/µPa), were designed for transduction of strong signals with received sound levels up to 185 dB re 20 µPa. To record ambient sounds concurrently, each ATAR includes a more sensitive microphone, the TMS 130P10 (–157 dB re 1 V/µPa). This, in conjunction with the PCB 106B50, provides additional dynamic range. Each microphone signal is sampled at 44.1 kilohertz (kHz) and digitized to a 16-bit two-byte integer.

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 inch (in.) thick and 22 in. 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 (Figs. 2.1 and 2.2).

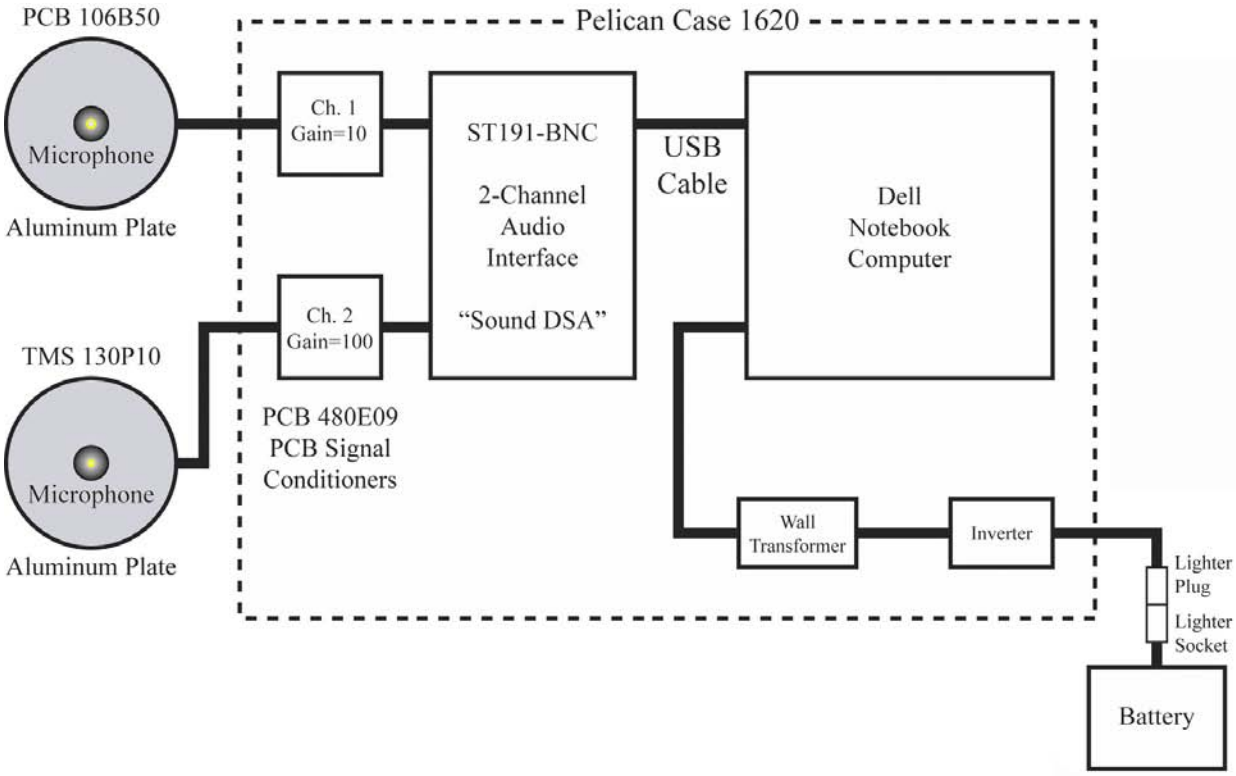

FIGURE 2.1. Block diagram of an Autonomous Terrestrial Acoustic Recorder (ATAR).

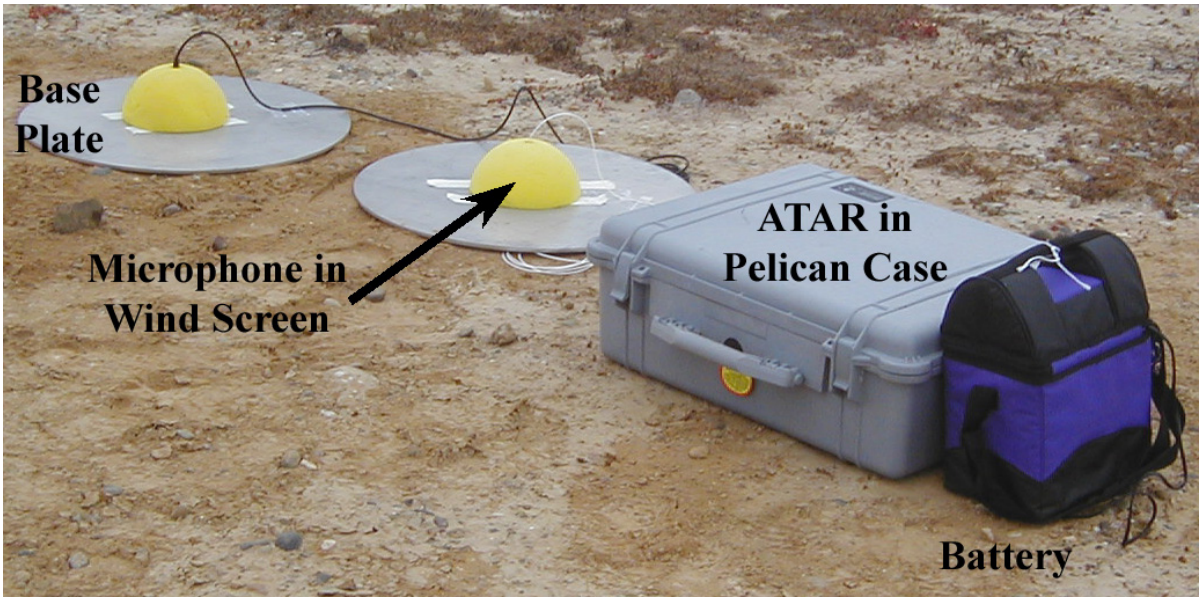

FIGURE 2.2. Typical field installation of an Autonomous Terrestrial Acoustic Recorder (ATAR) at the west end of SNI, California (photograph by J. Lawson, LGL).

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

During previous monitoring periods, it was observed that ATARs would sometimes not operate at certain sites despite repeated attempts, but after being moved a fraction of a kilometer away, they operated successfully on the first try. The ATARs did not fail when tested either in the 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. Therefore, since 2004, shielding and grounding have been applied, and this has been successful in reducing the frequency of ATAR failures.

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, for sound analysis.

Both time-series and frequency-domain analyses were performed on the acoustic data. Time-series results included signal waveform and duration, peak pressure level (peak), root mean square (rms) sound pressure level (SPL) on a flat-weighted (SPL-f), A-weighted (SPL-A), or M_{pa}-weighted (SPL-M) basis, and SEL on a flat- (SEL-f), A- (SEL-A), or M_{pa}- (SEL-M) weighted basis. Frequency-domain results included estimation of sound pressure levels in one-third octave bands for center frequencies from 4 to 16,000 kHz. The following subsections describe how these values are defined and calculated.

2.3.1 Time-Series Analysis

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

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

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** was determined from $10 \cdot \log$ (sound exposure).

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

The **peak instantaneous pressure** was defined as the largest sound pressure magnitude (positive or negative) exhibited by the signal, even if the signal reached that level only momentarily. **Peak instantaneous pressure level** was determined from 20·log (peak instantaneous pressure).

2.3.2 Frequency-Domain Analysis

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

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

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

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

The spectral density values were integrated across standard one-third octave band frequencies to obtain summed 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 Frequency Weighting

Frequency weighting is a form of filtering that serves to measure sounds over a broad frequency band with various schemes for de-emphasizing sounds at frequencies not heard well and retaining sounds at frequencies that animals hear well. The concept is that sound at frequencies not heard by animals is less likely to injure or disturb them, and therefore such sounds should not be included in measurements

relevant to those animals. Time-series results for the full 3 to 20,000 Hz bandwidth were calculated for flat-, A-, and M_{pa}-weightings.

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

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

M_{pa}-weighting is a recent development that arose from the ongoing effort to develop science-based guidelines for regulating sound exposures (Gentry et al. 2004). During this process, separate weighting functions have been developed for five categories of marine mammals, with these functions being appropriate in relation to the hearing abilities of those groups of mammals (Gentry et al. 2004; Miller et al. 2005). Two of these categories are pinnipeds listening in water and in air, for which the weighting functions have been designated M_{pw} and M_{pa}, respectively. The five "M-weighting" functions are almost flat between the known or inferred limits of functional hearing for the species in each group, but down-weight ("attenuate") sounds at higher and lower frequencies. As such, they are analogous to the C-weighting function that is often applied in human noise exposure analyses where the concern is about potential effects of high-level sounds. With M_{pa}-weighting, the lower and upper "inflection points" are 75 Hz and 30 kHz.[2] For each launch whose sounds are reported here, we include the M_{pa}-weighted results as well as flat- and A-weighted results. Acoustic data based on M_{pa}-weighting are included because these values are likely to be needed in the future for purposes of assessing impacts on pinnipeds of sounds with high received levels, such as those during some vehicle overflights.

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

2.3.4 Closest Point of Approach (CPA) by the Vehicle

To relate vehicle sounds to the proximity of the vehicle's trajectory, the 3-dimensional (3-D) distance from the recording site to the CPA of the vehicle was calculated for each launch date and sound monitoring site.

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

2.4 Results

2.4.1 Vehicle Flight Sounds

The results for acoustic monitoring during October 2004 to October 2005 are shown in Fig. 2.3 and Table 2.3. Four parameters are reported for the vehicle flight sounds: peak pressure level, sound pressure level, sound exposure level, and duration. The flight sound durations are sometimes long because of rocket noise and reverberation (Fig. 2.3d).

AGS Slugs and Missiles: Sounds from the powered AGS missiles were typically similar to those from unpowered slugs as received at the same monitoring sites (Table 2.3; Fig. 2.3). Flat-weighted SPLs ranged from 103 to 133 dB re 20 µPa at CPA distances of 0.3–1.9 km, typically with lower SPLs at greater CPA distances (although some variability was evident). Flat-weighted SELs ranged from 96 to 127 dB. Sounds recorded during AGS launches were generally lower compared to other vehicle launches during the monitoring period (Fig. 2.3).

Vandal: The low-elevation (8º) Vandals produced the lowest SPL-f (92–107 dB) at the monitored site that was farthest from the CPA (2.4 km), and higher SPL-f (120–139 dB) at sites 0.4–1.3 km from the CPA (Table 2.3; Fig. 2.3). SEL-f ranged from 90 to 120 dB. The high-elevation (35º) Vandals produced relatively lower SPLs at the same site than the low-elevation Vandals (Table 2.3). At CPA distances of 1.9–2.5 km, the high-elevation Vandals produced SPL-f of 93–122 dB and SEL-f of 93–113 dB.

GQM-163A "Coyote" SSST: The SSSTs (launched at 14º) also produced lower SPLs at sites located farther from the CPA (Table 2.3; Fig. 2.3). At CPA distances of 0.8–1.5 km, the SPL-f was 125–134 dB, and at 2.4–3.2 km, the SPL-f was 82–93 dB. SEL-f was 87–121 dB.

Whereas the above summaries are based on flat-weighting only, Table 2.3 presents the measurements based on flat-, A-, and M_{pa}-weighting. It was to be expected that A- and M_{pa}-weighted levels would almost always be less than flat-weighted levels. Sonic boom noise is strong at frequencies below 1000 Hz, which are de-emphasized with A- and (to a lesser degree) M_{pa}-weighting. A-weighted values were typically lower than M_{pa}-weighted values, consistent with the greater de-emphasis of low frequency components by A-weighting.

Two graphs are presented in Appendix B for each flight recording during the October 2004 through October 2005 period. For each launch, both graphs are based on flat-weighted data; no graphs are presented for A- or M_{pa}-weighted waveforms. One graph presents the pressure signature (pressure vs. time waveform). The second presents the sound exposure levels by one-third octave band for each of three signals: (1) the vehicle sounds; (2) the background instrumentation noise from the low-sensitivity channel (the same sensor used to measure the vehicle sounds but using data recorded before the vehicle 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 vehicle sounds, one can consider the sound pressure levels for ambient noise to be the sound exposure levels in a 1-s period.

TABLE 2.3. Pulse parameters for flat-, A-, and M_{pa}-weighted sound from vehicle flights at SNI during October 2004 to October 2005. The peak levels (Pk) and sound pressure levels (SPL) are in dB relative to 20 µPa, the SELs or energy levels are in dB relative to (20 µPa)^2·s, and the durations (Dur.) are in seconds. The 3-D CPA distance of the vehicle from the monitoring site is given in m. See Chapter 3 (Fig. 3.1) for maps of monitoring locations.

Date				CPA	Flat-weighted sound				A-weighted sound			M_{pa} -weighted sound		
2005	Time	Vehicle	Site	(m)	Pk	SPL	SEL	Dur	SPL	SEL	Dur.	SPL	SEL	Dur.
27 Jan.	08:59	AGSS[a]	Redeye I	1492	108	103	91	0.05	65	56	0.11	79	69	0.11
"	11:41	AGSS[a]	Redeye I	1492	108	103	90	0.05	Not available			83	63	0.01
"	13:29	AGSM[a]	Redeye I	1492	108	103	90	0.05	53	50	0.54	71	68	0.44
"	08:59	AGSS	Bachelor Beach North[†]	753	125	116	103	0.05	84	80	0.40	105	93	0.05
"	11:41	AGSS	Bachelor Beach North	753	123	114	101	0.06	79	77	0.51	103	90	0.05
"	13:29	AGSM	Bachelor Beach North	753	123	112	101	0.07	78	76	0.68	102	90	0.07
24 Feb.	09:05	AGSS[a]	Vizcaino Point	1897	114	108	95	0.06	67	55	0.07	87	73	0.04
"	13:16	AGSM[a]	Vizcaino Point	1897	114	108	95	0.05	69	56	0.06	89	75	0.04
"	09:05	AGSS	Dos Coves South[†]	462	131	126	112	0.04	93	86	0.20	107	96	0.09
"	13:16	AGSM	Dos Coves South[†]	462	131	126	112	0.04	94	84	0.11	109	97	0.07
"	09:05	AGSS	Bachelor Beach South[†]	1203	125	119	104	0.03	96	84	0.07	105	93	0.05
"	13:16	AGSM	Bachelor Beach South[†]	1203	124	106	103	0.45	93	85	0.16	95	92	0.56
11 Mar.	09:30	Vandal[b]	809 Camera[†]	906	143	134	122	0.07	119	106	0.06	125	113	0.06
"	09:30	Vandal	809 Camera[†]	906	143	134	122	0.07	119	106	0.05	126	113	0.05
"	09:30	Vandal	The "Y"[†]	882	142	133	122	0.09	117	106	0.08	123	112	0.08
"	09:30	Vandal	The "Y"[†]	882	144	133	123	0.09	116	106	0.08	123	113	0.08
"	09:30	Vandal	Dos Coves South[†]	420	148	137	127	0.09	122	111	0.08	130	119	0.08
"	09:30	Vandal	Dos Coves South[†]	420	149	139	127	0.06	124	111	0.05	131	118	0.05
24 Mar.	08:35	SSST[c]	The "Y"[†]	1311	138	130	117	0.05	119	100	0.01	124	108	0.02
"	08:35	SSST	Dos Coves South[†]	883	144	134	121	0.05	114	107	0.19	126	114	0.06
22 Apr.	16:43	SSST[c]	Harbor Seal Overlook[†]	1158	138	128	117	0.07	107	96	0.08	123	105	0.02
"	16:43	SSST	Phoca Reef	2446	103	82	90	6.20	56	65	7.88	66	74	7.40
"	16:43	SSST	Phoca Point	3236	102	93	87	0.28	54	46	0.13	60	60	0.96
2 Jun.	07:29	Vandal[d]	809 Camera[†]	925	143	135	122	0.05	120	106	0.04	126	112	0.04
"	09:49	Vandal[d]	809 Camera	925	135	128	123	0.30	88	84	0.43	104	99	0.35
"	07:29	Vandal	Bomber Cove[†]	1165	141	133	120	0.05	117	103	0.04	124	110	0.04
"	09:49	Vandal	Bomber Cove	1165	138	130	125	0.28	92	87	0.31	106	101	0.31

Note: AGSS = AGS slug; AGSM = AGS missile. [a]Vehicle launched at a 50° angle. [b]Dual Vandals launched ~4 s apart at an angle of 8°. [c]Vehicles launched at an angle of 14°. [d]Vehicles launched at an angle of 8°. [†] Sonic boom evident.

TABLE 2.3. (cont'd). Pulse parameters from vehicle flight sounds at SNI during October 2004 to October 2005.

Date				CPA	Flat-weighted sound				A-weighted sound			M_{pa}-weighted sound		
2005	Time	Vehicle	Site	(m)	Pk	SP	SEL	Dur	SPL	SEL	Dur.	SPL	SEL	Dur.
2 Jun.	07:29	Vandal[d]	The "Y"[†]	705	144	135	123	0.07	120	107	0.06	126	114	0.06
"	09:49	Vandal[d]	The "Y"	705	134	126	120	0.28	83	78	0.35	100	96	0.33
16 Jun.	10:08	AGSS[e]	Dos Coves South[†]	461	133	126	112	0.04	95	89	0.27	112	100	0.06
"	14:00	AGSM[e]	Dos Coves South[†]	461	132	125	112	0.05	99	88	0.08	111	99	0.07
"	10:08	AGSS	Redeye I	1459	111	106	93	0.05	56	50	0.25	84	70	0.04
"	14:00	AGSM	Redeye I	1459	110	104	92	0.06	58	48	0.09	81	67	0.05
29 Jun.	08:56	AGSS[e]	The "Y"	1222	138	133	120	0.05	92	83	0.12	113	100	0.05
"	11:04	AGSS[e]	The "Y"	1222	139	133	120	0.05	95	85	0.08	117	103	0.04
"	14:35	AGSM[e]	The "Y"						Not Available					
"	08:56	AGSS	Dos Coves Gate	265	131	125	112	0.05	85	84	0.75	106	96	0.11
"	11:04	AGSS	Dos Coves Gate[†]	265	135	126	113	0.04	95	91	0.38	114	102	0.06
"	14:35	AGSM	Dos Coves Gate[†]	265	135	127	113	0.04	104	92	0.07	114	103	0.07
"	08:56	AGSS	Bachelor Beach[†]	925	125	117	105	0.06	96	86	0.09	104	93	0.08
"	11:04	AGSS	Bachelor Beach						Not Available					
"	14:35	AGSM	Bachelor Beach						Not Available					
26 Jul.	12:56	AGSS[f]	Bomber Cove	1707	119	113	99	0.05	65	65	0.93	95	81	0.04
"	14:53	AGSM[f]	Bomber Cove	1707	117	111	98	0.05	70	60	0.09	91	78	0.05
"	12:56	AGSS	The "Y"[†]	1222	124	117	104	0.05	91	80	0.09	99	89	0.10
"	14:53	AGSM	The "Y"	1222	122	116	103	0.05	86	74	0.06	93	86	0.16
"	12:56	AGSS	Dos Coves South[†]	461	135	127	113	0.04	99	92	0.23	116	102	0.05
"	14:53	AGSM	Dos Coves South	461	134	126	113	0.05	104	91	0.06	114	102	0.06
27 Jul.	10:07	Vandal[d]	Bomber Cove[†]	1278	138	131	118	0.05	112	98	0.04	121	107	0.04
"	10:07	Vandal	Harbor Seal						Not available					
"	10:07	Vandal	Phoca Reef	2411	112	92	96	2.87	54	61	4.72	66	72	4.68

Note: AGSS = AGS slug; AGSM = AGS missile. [a]Vehicle launched at a 50° angle. [b]Dual Vandals launched ~4 s apart at an angle of 8°. [c]Vehicles launched at an angle of 14°. [d]Vehicles launched at an angle of 8°. [e]Vehicles launched at 62.5°. [f]Vehicles launched at an angle of 65°. [g]Vandal launched at an angle of 35°. [†] Sonic boom evident.

TABLE 2.3. (cont'd). Pulse parameters from vehicle flight sounds at SNI during October 2004 to October 2005.

Date				CPA	Flat-weighted sound				A-weighted sound			M_{pa}-weighted sound		
2005	Time	Vehicle	Site	(m)	Pk	SPL	SEL	Dur	SPL	SEL	Dur.	SPL	SEL	Dur.
28 Jul.	08:04	Vandal[d]	Bomber Cove[†]	1287	140	131	119	0.05	116	101	0.03	123	109	0.04
"	11:20	Vandal[g]	Bomber Cove						Not Available					
"	11:38	Vandal[g]	Bomber Cove	2489	126	122	113	0.13	82	81	0.93	92	92	0.93
"	08:04	Vandal[d]	Harbor Seal Overlook[†]	964	138	120	119	0.79	107	101	0.27	109	108	0.71
"	11:20	Vandal[g]	Harbor Seal Overlook	1915	111	93	101	5.42	81	89	5.81	87	95	6.73
"	11:38	Vandal[g]	Harbor Seal Overlook	1915	113	93	101	5.76	82	90	6.09	88	96	7.25
"	08:04	Vandal[d]	Phoca Reef	2411	112	107	96	0.07	58	48	0.10	78	67	0.08
"	11:20	Vandal[g]	Phoca Reef	2411	110	104	93	0.08	61	52	0.14	74	65	0.12
"	11:38	Vandal[g]	Phoca Reef	2411	110	104	93	0.09	60	51	0.12	73	64	0.13
25 Aug.	09:03	AGSS[e]	Bomber Cove	1672	117	111	98	0.05	66	63	0.48	87	79	0.14
"	11:30	AGSM[e]	Bomber Cove	1672	116	110	98	0.06	68	64	0.38	82	77	0.35
"	13:30	AGSM[e]	Bomber Cove	1672	118	111	98	0.06	70	65	0.31	88	80	0.18
"	09:03	AGSS	The "Y"	1261	123	116	103	0.05	77	73	0.40	99	88	0.07
"	11:30	AGSM	The "Y"	1261	121	115	102	0.05	73	66	0.23	94	84	0.11
"	13:30	AGSM	The "Y"	1261	123	117	104	0.05	81	71	0.10	99	88	0.07
"	09:03	AGSS	Dos Coves South						Not available					
"	11:30	AGSM	Dos Coves South	460	133	126	112	0.04	101	89	0.06	113	100	0.05
"	13:30	AGSM	Dos Coves South	460	133	127	112	0.04	98	87	0.07	112	100	0.06
6 Oct.	09:30	SSST[c]	Bomber Cove[†]	1511	136	125	113	0.07	113	96	0.02	116	105	0.07
"	09:30	SSST	Dos Coves South[†]	884	136	127	117	0.10	108	102	0.31	117	109	0.17

Note: AGSS = AGS slug; AGSM = AGS missile. [a]Vehicle launched at a 50° angle. [b]Dual Vandals launched ~4 s apart at an angle of 8°. [c]Vehicles launched at an angle of 14°. [d]Vehicles launched at an angle of 8°. [e]Vehicles launched at 62.5°. [f]Vehicles launched at an angle of 65°. [g]Vandal launched at an angle of 35°. [†] Sonic boom evident.

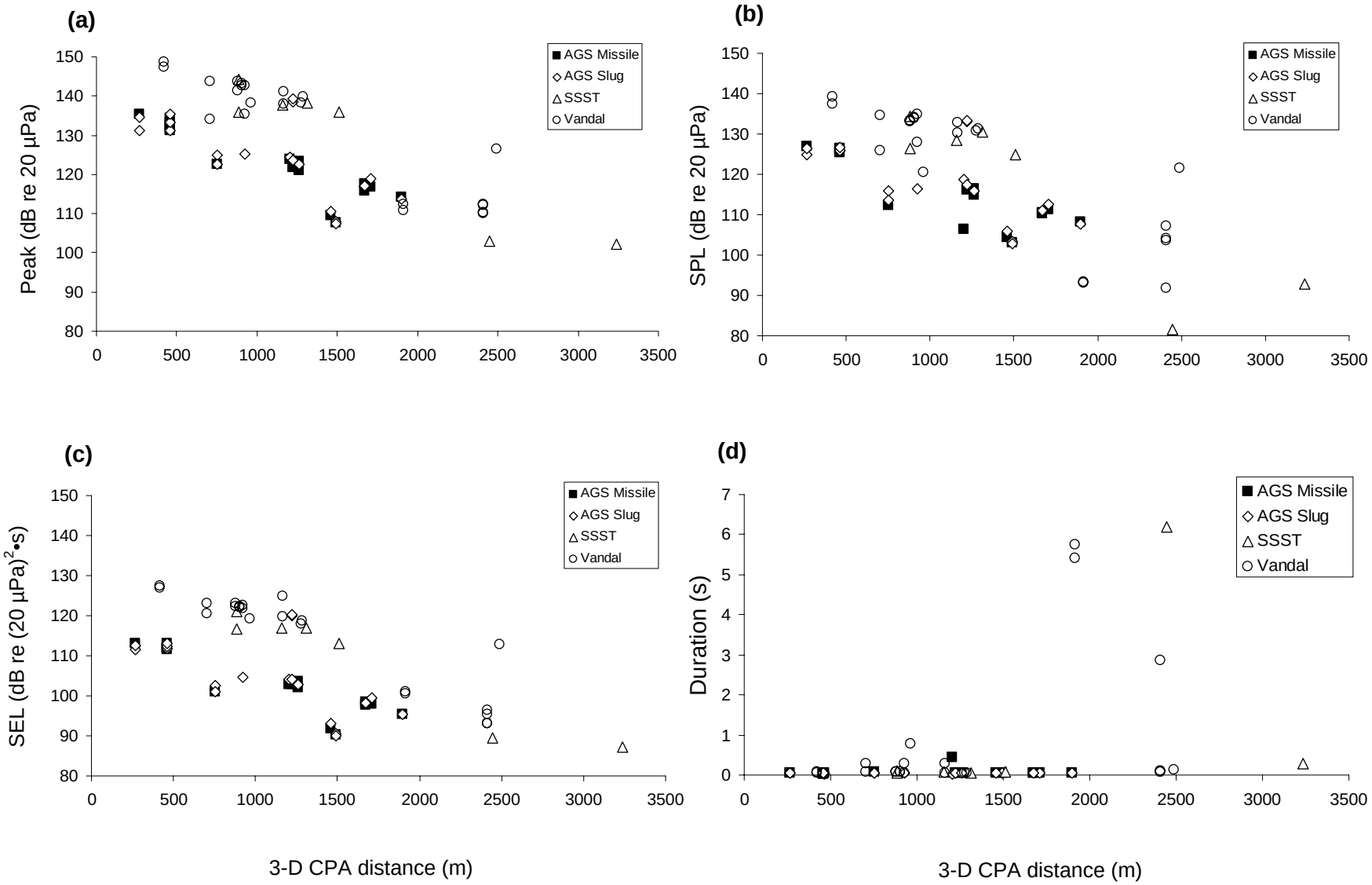

Figure 2.3. Flat-weighted sounds from vehicle launches relative to the 3-D CPA distance: (a) Peak sound pressure, (b) SPL, (c) SEL, and (d) Duration.

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 vehicle 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 2.4 for the current monitoring period. The averaging time was 4.0 s.

The considerable effect of A- and M_{pa}-weighting as compared to flat-weighting is evident by inspecting Table 2.4. A- and M_{pa}-weighted levels of ambient sound averaged 16.6 dB (range 4.5–32.2 dB) and 10.7 dB (range 0.7–28.0 dB) less, respectively, than flat-weighted levels. The measured A-weighted values, which averaged 47.5 $\pm$ s.d. 9.0 dB, were generally quite low, and comparable to sound levels expected in quiet residential areas. M_{pa}-weighted values average 53.5 dB $\pm$ s.d. 8.0, and the mean flat-weighted value was 64.3 $\pm$ 7.5 dB. 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 2.4 for the 10–20,000 Hz band.

2.5 Discussion and Summary

During 25 launches, 26 vehicles of a variety of types were launched from SNI from 27 January to 6 October 2005. The sound levels received from AGS slugs and missiles, Vandal targets, and SSSTs were comparable to those recorded previously for these vehicles (see Holst et al. 2005).

Of the sounds recorded, none exceeded 135 dBA re $(20\ \mu Pa)^2 \cdot s$ SEL. The 135 dBA value is a level above which pinnipeds might experience TTS, as noted by J. Francine, quoted in NMFS (2001:41837). Unpublished data indicate that the TTS threshold on an SEL basis may actually be around 129–131 dB re $(20\ \mu Pa)^2 \cdot s$ for harbor seals for sounds within their frequency range of good hearing (A. Bowles et al. pers. comm.; D. Kastak et al. pers. comm.; see also Kastak et al. 2004). The same two research teams have found that the TTS thresholds of California sea lions and elephant seals are higher.

During the present monitoring period, the highest measured values on beaches were 127 dB re $(20\ \mu Pa)^2 \cdot s$ SEL on a flat-weighted basis, 119 dB on an M_{pa}-weighted basis, and 111 dBA SEL (Table 2.3). These levels were recorded at haul-out sites near the AGS launcher. However, somewhat higher levels likely occurred at sites closer to the AGS launcher where no measurements were taken. Nonetheless, few if any pinnipeds have been seen or are known to haul out on beaches immediately next to the AGS launcher. During launches monitored from August 2001 to May 2005, the highest measured values on beaches were 129 dB re $(20\ \mu Pa)^2 \cdot s$ SEL on a flat-weighted basis, and 118 dBA SEL (Holst et al. 2005). Chapter 4 discusses this topic further.

TABLE 2.4. Broadband (10–20,000 Hz) sound levels (in dB re 20 µPa) as recorded before the launch by the high-sensitivity sensor designed to measure ambient sounds. See Chapter 3 (Fig. 3.1) for maps of monitoring locations.

Date 2005	Time	Vehicle	Site	Flat-weighted	A-weighted	M_{pa}-weighted
27 Jan.	08:59	AGS Slug	Redeye I	73.2	64.8	69.1
"	11:41	AGS Slug	Redeye I	72.3	Not available	68.9
"	13:29	AGS Missile	Redeye I	69.6	60.0	64.8
"	08:59	AGS Slug	Bachelor Beach North	65.2	54.1	60.3
"	11:41	AGS Slug	Bachelor Beach North	68.1	55.4	62.2
"	13:29	AGS Missile	Bachelor Beach North	65.4	53.7	60.0
24 Feb.	09:05	AGS Slug	Vizcaino Point	76.3	47.5	55.7
"	13:16	AGS Missile	Vizcaino Point	61.5	43.4	51.2
"	09:05	AGS Slug	Dos Coves South	70.5	63.3	64.6
"	13:16	AGS Missile	Dos Coves South	78.2	57.6	61.1
"	09:05	AGS Slug	Bachelor Beach South	68.9	59.3	65.0
"	13:16	AGS Missile	Bachelor Beach South	66.1	54.8	60.4
11 Mar.	09:30:00	Dual Vandal	809 Camera	64.7	40.1	49.5
"	09:30:04	Dual Vandal	809 Camera	64.7	40.1	49.5
"	09:30:00	Dual Vandal	The "Y"	62.3	37.5	51.2
"	09:30:04	Dual Vandal	The "Y"	62.4	37.5	51.2
"	09:30:00	Dual Vandal	Dos Coves South	81.9	53.1	59.3
"	09:30:04	Dual Vandal	Dos Coves South	82.0	53.1	59.3
24 Mar.	08:35	SSST	The "Y"	54.5	36.9	47.0
"	08:35	SSST	Dos Coves South	68.9	56.8	62.2
22 Apr.	16:43	SSST	Harbor Seal Overlook	52.2	35.8	45.1
"	16:43	SSST	Phoca Reef	55.7	47.7	51.4
"	16:43	SSST	Phoca Point	47.7	37.6	43.0
2 Jun.	07:29	Vandal	809 Camera	56.7	40.4	46.4
"	09:49	Vandal	809 Camera	63.7	40.5	47.5
"	07:29	Vandal	Bomber Cove	60.7	41.8	50.5
"	09:49	Vandal	Bomber Cove	69.1	41.5	50.9
"	07:29	Vandal	The "Y"	62.1	49.3	55.3
"	09:49	Vandal	The "Y"	67.7	50.9	57.7
16 Jun.	10:08	AGS Slug	Dos Coves South	76.5	72.0	75.8
"	14:00	AGS Missile	Dos Coves South	73.4	57.1	60.5
"	10:08	AGS Slug	Redeye I	62.2	45.0	51.0
"	14:00	AGS Missile	Redeye I	68.8	41.5	53.2
29 Jun.	08:56	AGS Slug	The "Y"	67.1	46.8	49.7
"	11:04	AGS Slug	The "Y"	64.0	44.4	47.3
"	14:35	AGS Missile	The "Y"		Not available	
"	08:56	AGS Slug	Dos Coves Gate	67.9	56.4	59.9
"	11:04	AGS Slug	Dos Coves Gate	71.1	51.5	56.0
"	14:35	AGS Missile	Dos Coves Gate	73.3	55.1	58.5
"	08:56	AGS Slug	Bachelor Beach	61.8	52.4	57.7
"	11:04	AGS Slug	Bachelor Beach		Not available	
"	14:35	AGS Missile	Bachelor Beach		Not available	
26 Jul.	12:56	AGS Slug	Bomber Cove	68.4	55.2	60.6
"	14:53	AGS Missile	Bomber Cove	68.9	46.1	50.3

TABLE 2.4. (cont'd). Broadband (10–20,000 Hz) sound levels (in dB re 20 µPa) as recorded before the launch by the high-sensitivity sensor designed to measure ambient sounds.

Date 2005	Time	Vehicle†	Site	Flat-weighted	A-weighted	M_{pa}-weighted
26 Jul.	12:56	AGS Slug	The "Y"	66.9	60.5	62.8
"	14:53	AGS Missile	The "Y"	67.1	57.3	60.3
"	12:56	AGS Slug	Dos Coves South	60.7	54.0	57.2
"	14:53	AGS Missile	Dos Coves South	64.3	59.2	62.0
27 Jul.	10:07	Vandal	Bomber Cove	53.3	40.0	45.2
"	10:07	Vandal	Harbor Seal Overlook		Not Available	
"	10:07	Vandal	Phoca Reef	49.9	42.1	46.5
28 Jul.	08:04	Vandal	Bomber Cove	50.3	39.1	42.8
"	11:20	Vandal	Bomber Cove		Not Available	
"	11:38	Vandal	Bomber Cove	59.8	46.0	48.2
"	08:04	Vandal	Harbor Seal Overlook	52.2	37.3	43.4
"	11:20	Vandal	Harbor Seal Overlook	59.4	33.3	40.6
"	11:38	Vandal	Harbor Seal Overlook	59.3	31.2	39.6
"	08:04	Vandal	Phoca Reef	59.8	39.6	43.1
"	11:20	Vandal	Phoca Reef	71.2	39.4	44.5
"	11:38	Vandal	Phoca Reef	68.5	36.2	40.5
25 Aug.	09:03	AGS Slug	Bomber Cove	55.3	36.1	41.4
"	11:30	AGS Missile	Bomber Cove	55.1	36.1	45.1
"	13:30	AGS Missile	Bomber Cove	56.6	37.4	46.4
"	09:03	AGS Slug	The "Y"	59.5	49.7	53.0
"	11:30	AGS Missile	The "Y"	62.8	46.2	52.0
"	13:30	AGS Missile	The "Y"	60.2	53.3	56.1
"	09:03	AGS Slug	Dos Coves South		Not Available	
"	11:30	AGS Missile	Dos Coves South	58.1	49.1	52.8
"	13:30	AGS Missile	Dos Coves South	64.8	46.4	50.9
6 Oct.	09:30	SSST	Bomber Cove	61.6	39.9	47.9
"	09:30	SSST	Dos Coves South	64.3	54.0	57.5

3. BEHAVIOR OF PINNIPEDS DURING VEHICLE LAUNCHES

3.1 Introduction

A total of 25 launches occurred from the west end of SNI, California, during October 2004 through October 2005, on 13 separate dates. One launch was a dual launch of two vehicles within ~4 s of one another, so a total of 26 vehicles were launched. Specific information about each of the launches is given in Chapter 1. Chapter 2 documents the sounds measured at various sites on western SNI during each launch. Corresponding information concerning previous launches during 2001–2004 is reported by Lawson et al. (2002), Holst and Greene (2004), and Holst et al. (2005). This chapter documents the behavioral reactions of pinnipeds exposed to the launch sounds during the October 2004 to October 2005 monitoring period.

Three species of pinnipeds are common on the beaches of SNI: California sea lion, harbor seal, and northern elephant seal. No other species were recorded during the monitoring work, either during the present monitoring period or during previous monitoring efforts since August 2001.

In January and February 2005, AGS missiles and slugs flew high over haul-out sites occupied by pupping/breeding northern elephant seals and non-breeding California sea lions and harbor seals. Vehicles launched in March and April flew over pupping/breeding harbor seals, and non-breeding sea lions and elephant seals. During launches in June and July, vehicles flew over haul-out sites occupied by molting harbor and elephant seals, as well as pupping/breeding California sea lions. The period from August to October does not coincide with the pupping season for any of the three pinniped species, and there are relatively few pinnipeds ashore. During launches in August and October, only non-breeding sea lions and harbor seals were monitored.

No evidence of injury or mortality was observed on the day of any launch during the monitoring period. However, during an AGS slug launch, an adult male sea lion knocked over three sea lion pups as he moved in response to the launch, and an adult female knocked over another three pups. The pups were momentarily startled, but did not appear to be injured.

In most cases, elephant seal and sea lion behavior returned to pre-launch states within seconds or minutes following the launches. In fact, as in previous years, most northern elephant seals demonstrated little or no reaction to the vehicle 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 usually did not return during the duration of the video-recording period. However, 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 vehicle 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

Table 3.1. Video data collected for California sea lions, northern elephant seals, and harbor seals during vehicle launches at SNI, October 2004–October 2005. Multiple launches are indicated by (x2) or (x3); dual launch is denoted by (d).

	Launch Date in 2005/ Vehicle Type & Number												
Video Recording Location	**27 Jan. AGS (x3)**	**24 Feb. AGS (x2)**	**11 Mar. Van (d)**	**24 Mar. SSST**	**22 Apr. SSST**	**2 June Van (x2)**	**16 June AGS (x2)**	**29 June AGS (x3)**	**26 July AGS (x2)**	**27 July Van**	**28 July Van (x3)**	**25 Aug. AGS (x3)**	**6 Oct. SSST**
California Sea Lion													
809 Camera	-	-	x	x	x	x	-	x	x	x	x	x	x
The "Y"	-	-	x	x	-	x	-	-	x	-	-	x	-
Bomber Cove	-	-	-	-	-	x[3]	-	x	-	-	-	-	-
Dos Coves South	-	x	x	x	-	-	x	x[6]	x	-	-	x	x
Harbor Seal Overlook	-	-	-	-	-	-	-	-	-	x	x	-	-
Bachelor Beach North	-	-	-	-	-	-	x[4]	x	-	-	-	-	-
Northern Elephant													
Bachelor Beach North	x	-	-	-	-	-	x	x	-	-	-	-	-
Bachelor Beach South	x	x[1]	-	-	-	-	-	-	-	-	-	-	-
Redeye I	x	-	-	-	-	-	-	-	-	-	-	-	-
Dos Coves South	-	-	x	x	-	-	x[5]	-	-	-	-	-	x
Phoca Point	-	-	-	-	x[2]	-	-	-	-	-	-	-	-
The "Y"	-	-	-	-	-	-	-	-	-	-	-	x[8]	-
Harbor Seal													
Harbor Seal Overlook	-	-	-	-	x	-	-	-	-	x	x[7]	-	-
Bomber Cove	-	x[1]	-	-	-	x	-	-	-	-	-	-	-
Phoca Reef	-	-	-	-	x	-	-	-	-	x	x	-	x[9]
Phoca Point	-	-	-	-	x	-	-	-	-	-	-	-	-

Note: Van = Vandal. [1] Only monitored during second launch. [2] Present before launch and possibly during launch (difficult to see). [3] Three sea lions present during first launch only. [4] One or more sea lions present during both launches. [5] One elephant seal present during second launch only. [6] Sea lions only observed during first two launches. [7] Harbor seals were monitored at Harbor Seal Overlook during the first two launches; no seals were present during the third launch. [8] One elephant seal present during the second and third launch. [9] Only present before the launch.

number of video systems deployed during each launch (Table 3.1). During the current monitoring period, a single species was observed during five of 25 launches. Only elephant seals were observed during the three AGS launches on 27 January, and only California sea lions were observed during the two AGS launches on 26 July. All three species were monitored during the two AGS launches on 24 February. During the remaining 18 launches, two species were monitored.

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 vehicle during each launch from SNI. Video data are generally obtained via three portable cameras that can be set up temporarily at any site. On two launch days during the current monitoring period (22 April and 29 June), four cameras were used at four different sites. In the past, a permanent ("fixed") camera that is installed near Building 809 has also been used, but it was not operational during the current monitoring period.

During the day of each launch, Navy biologists placed the cameras at locations overlooking haul-out sites. Placement was such that disturbance to pinnipeds was minimal. The entire haul-out aggre-

gation 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. Thus, the cameras were set to record a focal subgroup within the haul-out aggregation. It was more effective to obtain a higher-magnification view of a sample of the animals at each site.

During most launches, one monitoring location was near the planned launch azimuth; the other monitoring sites were some distance from the launch azimuth. Figure 3.1 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 vehicles launched at SNI, in sound propagation, and in pinniped behavioral reactions, this analysis requires data from a relatively large number of launches. The limited number of launches (of diverse types) during the current monitoring period did not, by itself, provide sufficient data for such an analysis. To investigate the dose–response relationships, acoustic and pinniped response data from the present monitoring period will need to be combined with corresponding data from previous monitoring during 2001–2004 (Lawson et al. 2002; Holst and Greene 2004; Holst et al. 2005), and future monitoring. A preliminary analysis of dose–response relationships using data collected from 2001 to 2004 was presented by Holst et al. (2005).

3.2.1 Fixed Camera

A permanent, fixed camera is installed in an elevated position at Building 809 at the west end of SNI (Fig. 3.2). This camera, designated "809 Camera", is situated on a metal tower overlooking Vizcaino Point (see 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. Although 809 Camera was not in operation during the current monitoring period, ATARs and/or mobile cameras set up near this location were designated as "809 Camera".

3.2.2 Mobile Cameras

During the day of each launch, Navy biologists placed up to two portable Sony Hi-8 digital video cameras on tripods that overlooked haul-out sites (Fig. 3.1). Vehicle 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 vehicle passed, but were uncalibrated and not of sufficient quality to provide launch sound information).

3.2.3 Wagoncam

One or two "wagoncams" (or Camera Carts) were also used on several occasions (Fig. 3.3). 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.

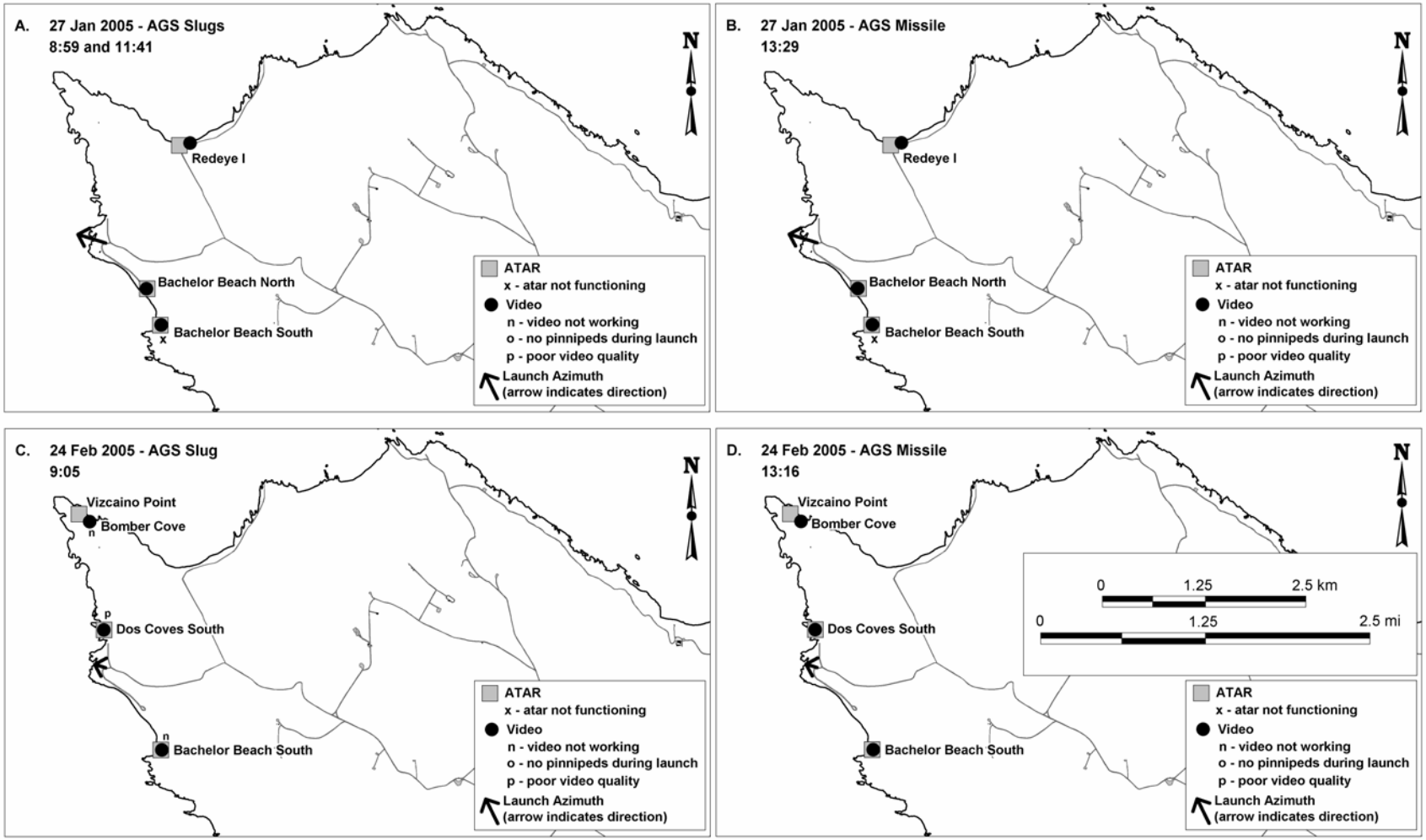

FIGURE 3.1. Launch azimuths, acoustic recording sites (ATARs), and video recording sites for all launches at SNI from 27 January to 6 October 2005.

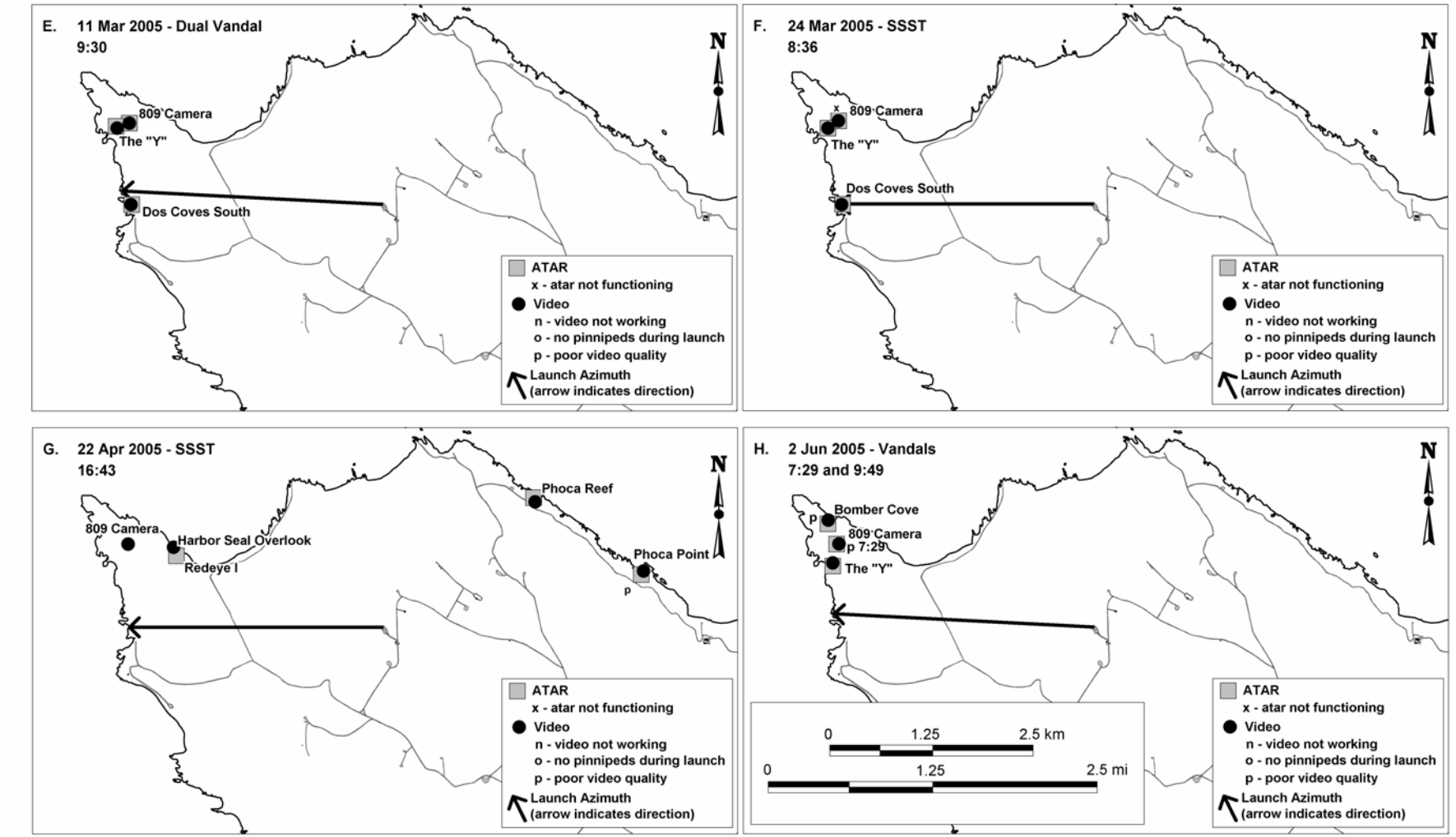

FIGURE 3.1. (cont'd) Launch azimuths, acoustic recording sites (ATARs), and video recording sites for all launches at SNI from 27 January to 6 October 2005.

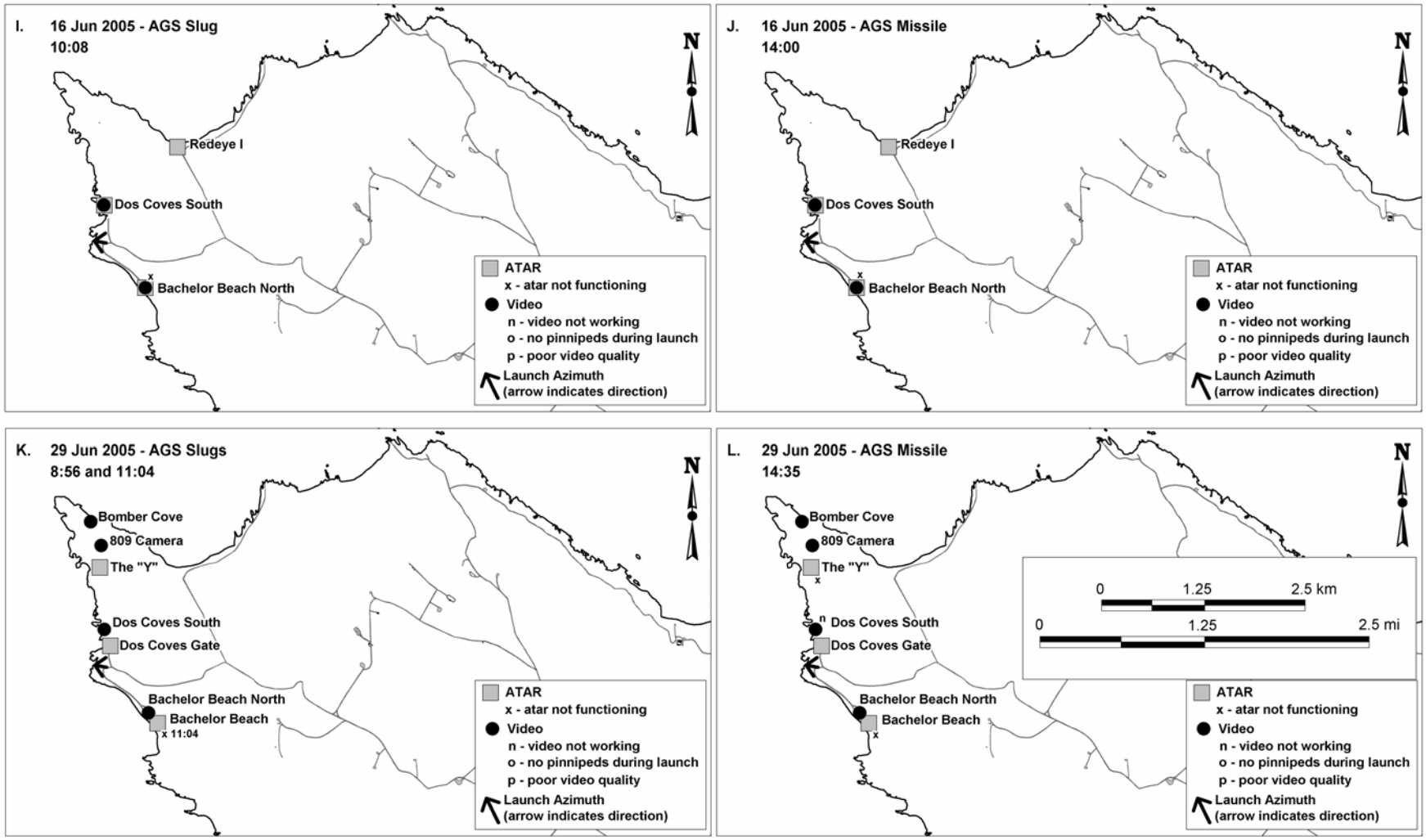

FIGURE 3.1. (cont'd) Launch azimuths, acoustic recording sites (ATARs), and video recording sites for all launches at SNI from 27 January to 6 October 2005.

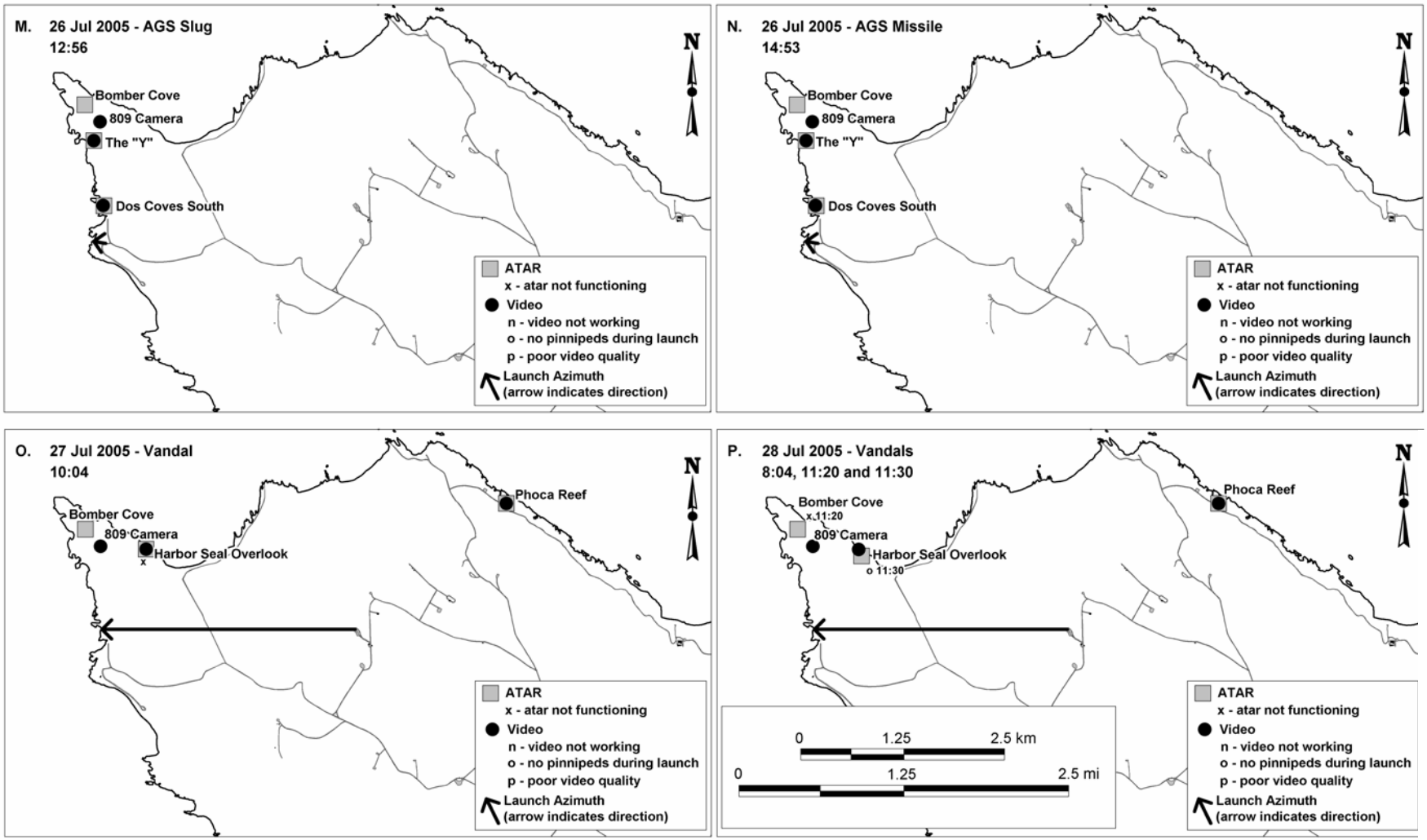

FIGURE 3.1. (cont'd) Launch azimuths, acoustic recording sites (ATARs), and video recording sites for all launches at SNI from 27 January to 6 October 2005.

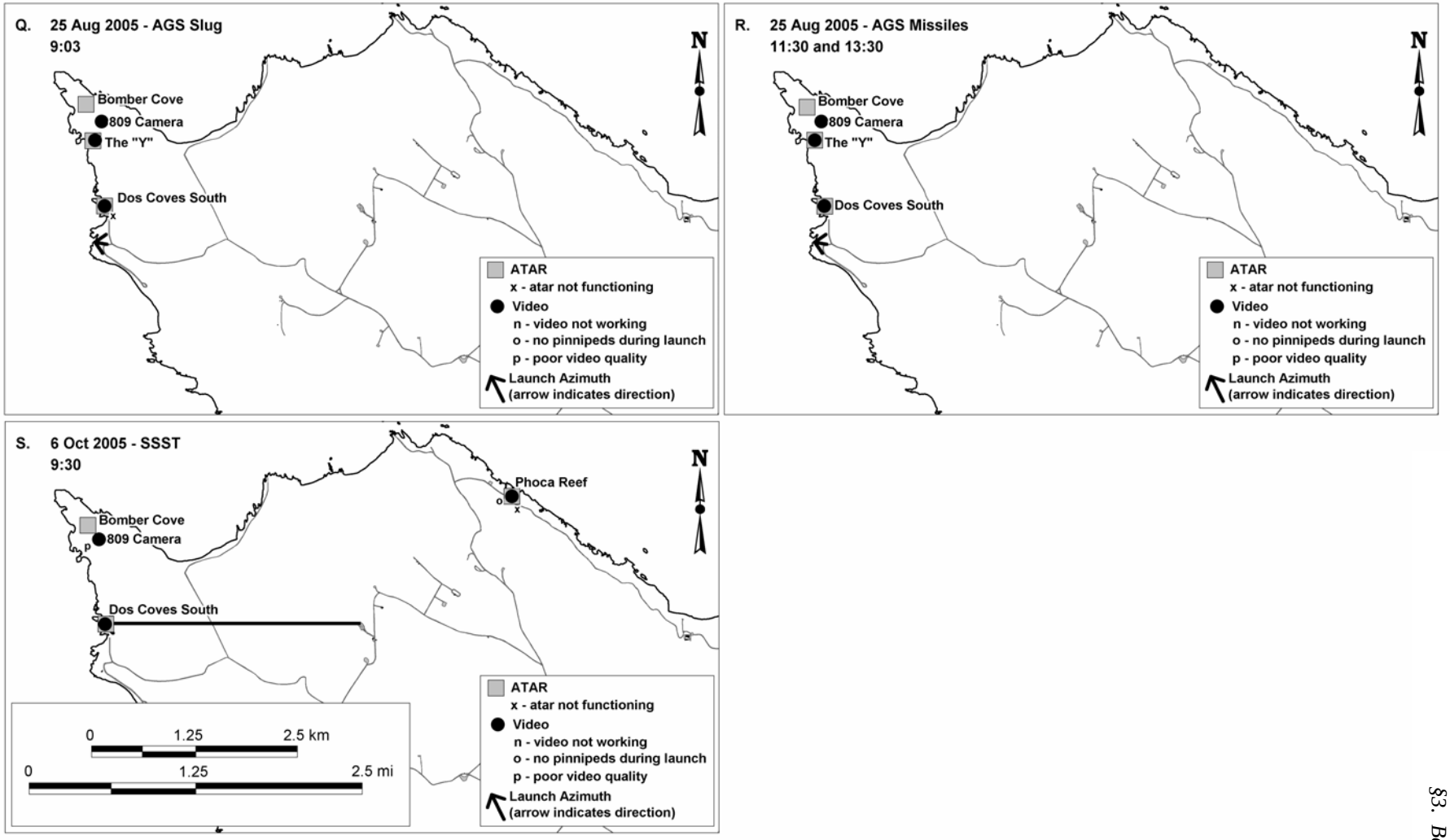

FIGURE 3.1. (cont'd) Launch azimuths, acoustic recording sites (ATARs), and video recording sites for all launches at SNI from 27 January to 6 October 2005.

FIGURE 3.2. 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 3.3. 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)

3.2.4 Visual Observations

Navy biologists from the Naval Air Warfare Center Weapons Division, Point Mugu, Range Department, 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. The video continued recording for 1–2 hr after the launch, and occasionally, the observers returned to the monitoring sites for follow-up monitoring several hours after the launch. These observation helped determine whether the numbers of pinnipeds at the haul-out site had changed, and if there was obvious evidence of recent injury or mortality. 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 (LGL), 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 2 hr 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 (vehicle 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 (in 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 m) around the focal subgroup of pinnipeds, as determined by meteorological conditions and/or physical obstructions; this was estimated by identifying the farthest visible object relative to the interacting pinnipeds, as evident from the known positions of local objects and accounting for obstructing terrain, and
7. tide state—exact time for local high tide was determined from relevant tide tables.

To relate pinniped behavior to the proximity of the vehicle launch, the 3-D distance from the recording site to the CPA of the vehicle was calculated.

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 2001–2004 are reported by Holst and Lawson (2002), Holst (2004a), and Holst et al. (2005).

Video recordings of pinniped behavior during launches in the October 2004–October 2005 period were collected on 12 dates for California sea lions, 8 dates for elephant seals, and 5 dates for harbor seals (Table 3.1). During the monitoring period, sea lions were observed at six different sites (total of 54 site-date-launch combinations), elephant seals were monitored at five different sites (21 site-date-launch combinations), and harbor seals were observed at four different sites (13 site-date-launch combinations; Table 3.1). The video recordings generally provided data on the responses of a sample of the total pinnipeds present on a given beach.

3.4.1 Three AGS Launches, 27 January 2005

Two AGS slugs and one AGS missile were launched from the 807 Building Launch Complex, with an azimuth of 287º and a 50º elevation angle (Fig. 3.1A and B). The two slugs were launched sequentially, 2 hr 42 min apart, followed by the AGS missile 1 hr 48 min later. During all three launches, video recordings of elephant seals were obtained at Bachelor Beach South (CPA = 1.2 km; behind launcher), Bachelor Beach North (CPA = 0.7 km; behind launcher), and at Redeye I (CPA = 1.6 km), located northeast of launcher (Table 3.1).

ATARs were deployed at the same three sites (Fig. 3.1A and B), but only two provided quantitative data (Tables 2.2 and 2.3). The ATAR at Bachelor Beach South malfunctioned during all three launches. Launch sounds during all three launches were audible on the audio channel of the video recording at Bachelor Beach South. The wagoncams used to monitor seals at the other sites did not have a microphone.

Elephant Seals.—During the first launch of an AGS slug, 100 elephant seals were monitored at Bachelor Beach South. In response to the launch, all elephant seals looked, but only 3 of the 100 seals moved ~1 m, and none entered the water (Table 3.2). During the second launch, most of the same animals were monitored, although only 90 animals were left in the field of view. Most animals looked up during the launch, although some did not show any overt reaction. Of the 90 elephant seals monitored, 3 moved a short distance (<2 m) and none entered the water. During the third launch, most of the same 90 seals were observed. Again, most animals looked during the launch, but several showed no reaction. Only one seal moved a short distance (<2 m). After all three launches, the elephant seals settled back to their resting positions within ~30 s after the launch.

At Bachelor Beach North, 50 elephant seals were observed during all three launches. During the first launch, all seals looked, but only 2 of 50 seals moved a short (<2 m) distance (Table 3.2). During the second launch, most of the seals looked in response to the launch, but none moved. During the third launch, only ~10 of 50 seals looked in response to the launch, but no seals moved. No seals entered the water during any of the launches.

At Redeye I, up to 30 seals were observed during the three launches. On all three occasions, no seals showed overt reactions in response to the launches (Table 3.2).

3.4.2 Two AGS Launches, 24 February 2005

An AGS slug and a missile were launched from the Building 807 Launch Complex, with an azimuth of 286° and an elevation angle of 50º (Fig. 3.1C and D). The missile was launched 4 hr 11 min after the slug. At Dos Coves South (CPA = 0.5 km), video recordings of California sea lions were made during both launches The camera got wet during the first launch, which made observations more difficult. Northern elephant seals were only monitored during the second launch (due to problems with the video equipment during the first launch) at Bachelor Beach South (CPA = 1.2 km; behind the launcher). Similarly, harbor seals were only monitored during the second launch at Bomber Cove, located 1.8 km from CPA (Table 3.1).

Launch sound was audible on the audio track of the video recording during the first launch at Dos Coves South, but was inaudible during the second launch, probably because of strong winds. Launch sound was barely audible at Bomber Cove. A wagoncam, which did not have a microphone, was used at Bachelor Beach South. Launch sounds were also recorded via ATARs at Vizcaino Point (near Bomber Cove), Dos Coves South, and Bachelor Beach South (Tables 2.2 and 2.3; Figs. 3.1C and D).

Northern Elephant Seals.—Fifteen elephant seals were observed at Bachelor Beach South, although more seals were likely present outside of the field of view. Elephant seals showed no reaction to the launch (Table 3.2).

TABLE 3.2. Details of vehicle launches, SELs, and *northern elephant seal* reactions at SNI during October 2004–October 2005. AGS slugs and missiles were launched from Building 807 Launch Complex; Vandals and SSSTs were launched from Alpha Launch Complex.

Launch Date 2005	Launch Time (local)	Vehicle Type	Launch Azimuth	Elevation Angle / Altitude Over Beach	Pinniped Monitoring Site	3-D CPA Distance (m)	SELs [dB re (20 μPa)^2·s] flat-/M_{pa}-weighted	Behavioral Reaction of Animals to Launch
27 Jan.	08:59	AGS Slug	287°	50° / 1372 m	Redeye I[n]	1597	91/69	15 monitored; no reaction
"	11:41	AGS Slug	287°	50° / 1372 m	Redeye I[n]	1597	90/63	30 monitored; no reaction
"	13:29	AGS Missile	287°	50° / 1372 m	Redeye I[n]	1597	90/68	30 monitored; no reaction
"	08:59	AGS Slug	287°	50° / 1372 m	Bachelor Beach North[s]	746	103/93	50 monitored; all startled and looked; 4% (2 males) moved 1–2 m in response to the launch
"	11:41	AGS Slug	287°	50° / 1372 m	Bachelor Beach North[s]	746	101/90	50 monitored; all looked but none moved
"	13:29	AGS Missile	287°	50° / 1372 m	Bachelor Beach North[s]	746	101/90	50 monitored; ~10 looked, others showed no reaction
"	08:59	AGS Slug	287°	50° / 1372 m	Bachelor Beach South[s]	1206	Launch sounds audible on video recording	100 monitored; all looked and 3 moved ~1 m
"	11:41	AGS Slug	287°	50° / 1372 m	Bachelor Beach South[s]	1204	Launch sounds audible on video recording	90 monitored; most looked and 3% moved 1–2 m
"	13:29	AGS Missile	287°	50° / 1372 m	Bachelor Beach South[s]	1204	Launch sounds audible on video recording	90 monitored; most looked and 1 moved ~1 m
24 Feb.	13:16	AGS Missile[†]	286°	50° / 1372 m	Bachelor Beach South[s]	1212	103/92	15 monitored; no reaction
11 Mar.	09:30	Dual Vandal[†]	273°	8° / 396 m	Dos Coves South[s]	421	127/119	3 observed; 2 looked and 1 moved 1 m; 1 entered FOV and then water
24 Mar.	08:35	SSST[†]	270°	14° / 914 m	Dos Coves South[d]	886	121/114	14 observed; all looked but none moved; 1 seal entered area

[†] Sonic boom evident. [s] monitoring site was located south of the launch azimuth. [n] monitoring site was located north of the launch azimuth. [d] monitoring site was directly below launch azimuth. N.A. = not available. FOV = field of view.

TABLE 3.2. (cont'd)

Launch Date 2005	Launch Time (local)	Vehicle Type	Launch Azimuth	Elevation Angle / Altitude Over Beach	Pinniped Monitoring Site	3-D CPA Distance (m)	SELs [dB re (20 μPa)^2·s] flat-/ M_{pa}-weighted	Behavioral Reaction of Animals to Launch
22 Apr.	16:43	SSST	270	14° / 914 m	Phoca Point[b]	3273	87/60	1 unidentified seal (possibly elephant seal pup) entered water
16 June	14:00	AGS Missile[†]	280	62.5° / 1615 m	Dos Coves South[n]	464	112/99	1 seal entered area just before launch and moved 1.5 m in response to launch
"	10:08	AGS Missile	280	62.5° / 1615 m	Bachelor Beach North[s]	726	Launch sounds audible on video recording	100 seals monitored; all looked up and 5 moved ~1 m, but none entered water
"	14:00	AGS Missile	280	62.5° / 1615 m	Bachelor Beach North[s]	726	Launch sounds audible on video recording	70 seals monitored; all looked up but none moved
29 June	08:56	AGS Slug[†]	280	62.5° / 1615 m	Bachelor Beach North[s]	755	105/93*	1 seal monitored; looked but did not move
"	11:04	AGS Slug	280	62.5° / 1615 m	Bachelor Beach North[s]	755	N.A.	4 monitored, all looked but did not move
"	14:35	AGS Missile	280	62.5° / 1615 m	Bachelor Beach North[s]	755	N.A.	11 monitored; 8 looked during launch and 3 showed no reaction, 2 seals moved 1-4 m, but did not enter water
25 Aug.	11:30	AGS Missile	280	62.5° / 1615 m	The "Y" [n]	1264	102/84	1 seal observed; looked but did not move during launch
"	13:30	AGS Missile	280	62.5° / 1615 m	The "Y" [n]	1264	104/88	Same seal observed as during previous launch; showed no reaction to launch
6 Oct.	09:30	SSST[†]	270	14° / 914 m	Dos Coves South[d]	886	117/109	35 monitored; all looked, some moved and entered water, 13 seals entered water, 2 moved short distances

[†] Sonic boom evident. [n] monitoring site was located north of the launch azimuth. [s] monitoring site was located south of the launch azimuth. [d] monitoring site was directly below launch azimuth. [b] monitoring site was behind launch pad. * acoustic recording was made at Bachelor Beach, just south of Bachelor Beach North. N.A. = not available. FOV = field of view.

California Sea Lions.—During the first launch, 75 sea lions were observed at Dos Coves South. All animals startled and looked up during the launch. In total, 40 sea lions entered the water (up to 12 m away), although it took a few animals up to 1.5 min to do so (Table 3.3). In addition, another five sea lions moved short distances (<5 m) in response to the launch. The remaining sea lions settled within 30 s. During the second launch, 60 sea lions were observed at Dos Coves South, although more sea lions were likely present outside of the field of view (at least 40 more). During the launch, all sea lions startled and looked up. Fifty percent of sea lions moved towards the water (>5 m away), although it could not be determined from the video whether these individuals actually entered the water (Table 3.3). Most sea lions settled within 30 s after the launch and remained vigilant (continued looking around) for as long as 3 min.

Harbor Seals.—At Bomber Cove, 1.8 km from the CPA location, 15 seals were observed during the second launch. Most seals showed minimal reaction to the launch; the majority of seals merely raised their heads, whereas a few (at least two) did not react at all (Table 3.4). Received sound levels were low (Table 3.4).

3.4.3 Dual Vandal Launch, 11 March 2005

Dual Vandals were launched from the Alpha Launch Complex 4 s apart, at an azimuth of 273º and an elevation angle of 8º (Fig. 3.1E). Video recordings of California sea lions were made near 809 Camera and at The "Y" (both with a CPA of ~0.9 km), and at Dos Coves South, located 0.4 km from the CPA (Table 3.1).

Launch sound was audible on the audio track of the video recordings at The "Y" and at Dos Coves South. A wagoncam, which did not have a microphone, was used near 809 Camera. However, launch sounds were recorded and characterized via ATARs at all three locations (Tables 2.2 and 2.3; Fig. 3.1E).

Northern Elephant Seals.—During monitoring of sea lions at Dos Coves South, three elephant seals were also in the field of view. During the launch, two of those seals looked up, and the third one moved 1 m (Table 3.2). Another seal appeared in the field of view during the launch and entered the water 2.5 min after the launch.

California Sea Lions.—At all three sites that were monitored, sea lions responded more vigorously when the second Vandal was launched. At The "Y", 35 sea lions were observed, although there were ~250 animals in the immediate area. When the first Vandal was launched, all sea lions startled and most moved a short distance (up to 5 m), but when the second Vandal was launched 4 s later, all animals moved at least 20 m, until there were no longer in the field of view (Table 3.3). However, no sea lions entered the water. In addition, 25 sea lions entered the field of view. The remaining sea lions settled within ~1 min, although they remained vigilant.

Near 809 Camera, 100 sea lions were observed. When the first Vandal was launched, the majority of sea lions moved, but when the second Vandal was launched 4 s later, nearly all (99%) animals moved along the beach. Sixty animals left the field of view (~10 m or more), and 39 moved only short distances along the beach (<10 m). However, no sea lions entered the water. In addition, 32 sea lions (mainly juveniles) entered the area during the launch. The sea lions settled within ~1 min, but remained vigilant for the next 10 min.

TABLE 3.3. Details of vehicle launches, sound exposure levels (SEL), and *California sea lion* reactions at SNI during October 2004–October 2005. AGS slugs and missiles were launched from Building 807 Launch Complex; Vandals and SSSTs were launched from Alpha Launch Complex.

Launch Date 2005	Launch Time (local)	Vehicle Type	Launch Azimuth	Elevation Angle / Altitude Over Beach	Pinniped Monitoring Site	3-D CPA distance (m)	SELs [dB re (20 μPa)^2·s] flat-/ M_{pa} weighted	Behavioral Reaction of Animals to Launch
24 Feb.	09:05	AGS Slug[†]	286°	50° / 1372 m	Dos Coves South[n]	464	112/96	75 monitored; 40 entered water and 5 moved <5 m; rest settled in 30 s
"	13:16	AGS Missile[†]	286°	50° / 1372 m	Dos Coves South[n]	464	112/97	60 monitored; 50% moved towards water (>5 m away), unknown whether they entered; remained vigilant for ~3 min after
11 Mar.	09:30	Dual Vandal[†]	273°	8° / 396 m	The "Y"[n]	864	123/113	35 monitored; all moved at least 20 m in response to launch, none entered water; settled in ~1 min but remained vigilant
"	09:30	Dual Vandal[†]	273°	8° / 396 m	809 Camera[n]	906	122/113	100 monitored; 99 moved; 60 left FOV (~10 m), 32 others entered; settled in ~1 min
"	09:30	Dual Vandal[†]	273°	8° / 396 m	Dos Coves South[s]	421	127/119	100 monitored; 85 moved and 80 of those entered the water; settled within ~2 min
24 Mar.	08:35	SSST[†]	270°	14° / 914 m	Dos Coves South[d]	886	121/114	51 monitored; all startled, 73% moved up to 5 m
"	08:35	SSST[†]	270°	14° / 914 m	The "Y"[n]	1311	117/108	50 monitored; all startled, 10 moved <5 m , 4 of those entered water; settled in ~1 min
"	08:35	SSST	270°	14° / 914 m	809 Camera[n]	1338	117/108*	85 monitored, all startled, most (82%) moved >2 m but < 10 m
22 Apr.	16:43	SSST	270	14° / 914 m	809 Camera[n]	1337	N.A.	70 monitored; 22 entered the water and another 23 moved >10 m along the beach
2 June	07:29	Vandal[†]	273	8° / 396 m	The "Y"[n]	736	123/114	30 monitored; all looked up, 4 moved 10-20 m, 8 moved <4 m, none entered water
"	09:49	Vandal	273	8° / 396 m	The "Y"[n]	736	120/96	30 monitored; all looked up, 3 moved 1-3 m, none entered the water
"	07:29	Vandal[†]	273	8° / 396 m	809 Camera[n]	929	122/112	30 monitored; 15 moved, 6 of those moved out of view and the rest moved 2-5 m
"	09:49	Vandal	273	8° / 396 m	809 Camera[n]	929	123/99	50 monitored; all looked up, but only 2 moved ~2 m

[†] Sonic boom evident. [n] monitoring site was located north of the launch azimuth. [s] monitoring site was located south of the launch azimuth. [d] monitoring site was directly below launch azimuth. * Launch sounds not available for that site, but for The "Y", slightly south of the monitored site. N.A. = not available, FOV = field of view.

TABLE 3.3. cont'd….

Launch Date 2005	Launch Time (local)	Vehicle Type	Launch Azimuth	Elevation Angle / Altitude Over Beach	Pinniped Monitoring Site	3-D CPA distance (m)	SELs [dB re (20 μPa)^2·s] flat-/ M_{pa}-weighted	Behavioral Reaction of Animals to Launch
2 June	07:29	Vandal[†]	273	8° / 396 m	Bomber Cove[n]	1210	120/110	3 monitored; all startled and looked up; 1 entered water ~6 m away
16 June	10:08	AGS Slug[†]	280	62.5° / 1615 m	Dos Coves South[n]	464	112/100	83 monitored; all startled and looked up, 93% moved 1-6 m, 33 of those left FOV
"	14:00	AGS Missile[†]	280	62.5° / 1615 m	Dos Coves South[n]	464	112/99	15 monitored; all startled, but only 3 moved ~1 m; 4 moved into FOV and entered water
"	10:08	AGS Missile	280	62.5° / 1615 m	Bachelor Beach North[s]	726	Launch sounds audible on video recording	1 sea lions observed; looked up during launch
"	14:00	AGS Missile	280	62.5° / 1615 m	Bachelor Beach North[s]	726	Launch sounds audible on video recording	3 sea lions observed; looked up during launch
29 June	8:56	AGS Slug	280	62.5° / 1615 m	Dos Coves South[n]	464	112/96[†]	111 monitored; all startled and looked, 2 pups moved ~2 m; none entered water; adults knocked over pups
"	11:04	AGS Slug[†]	280	62.5° / 1615 m	Dos Coves South[n]	464	113/102[†]	80 monitored; all startled and looked; 7 moved 1-2 m, none entered water
"	08:56	AGS Slug[†]	280	62.5° / 1615 m	Bachelor Beach North[s]	755	105/93*	16 monitored; all looked, 13 left FOV (~2-12 m), 2 did not move, and 1 moved ~6 m
"	11:04	AGS Slug	280	62.5° / 1615 m	Bachelor Beach North[s]	755	N.A.	14 monitored; all looked, but none moved
"	14:35	AGS Missile	280	62.5° / 1615 m	Bachelor Beach North[s]	755	N.A.	12 monitored; all startled and looked up, but did not move
"	08:56	AGS Slug	280	62.5° / 1615 m	Bomber Cove[n]	1789	Launch sounds audible on video recording	38 monitored; 34 looked up during launch and 4 did not react
"	11:04	AGS Slug	280	62.5° / 1615 m	Bomber Cove[n]	1789	Launch sounds audible on video recording	26 monitored; most did not look up, 7 pups moved ~2 m, none entered water
"	14:35	AGS Missile	280	62.5° / 1615 m	Bomber Cove[n]	1789	Launch sounds audible on video recording	50 monitored; most did not react to the launch, 6 looked up
"	08:56	AGS Slug	280	62.5° / 1615 m	809 Camera[n]	1489	120/100[‡]	42 monitored; all startled and left FOV, moved up to 25 m
"	11:04	AGS Slug	280	62.5° / 1615 m	809 Camera[n]	1489	120/103[‡]	73 monitored; all startled and looked; 82% moved up to 20 m; 7 entered FOV

[†] Sonic boom evident. [n] monitoring site was north of launch azimuth. [s] monitoring site was south of launch azimuth. [†] audio recorded at Dos Coves Gate, just south of Dos Coves South. * audio recorded at Bachelor Beach, just south of Bachelor Beach North. [‡] audio recorded at The "Y", ~200 m from 809 Camera. N.A. = not available. FOV = field of view.

TABLE 3.3. (cont'd)

Launch Date 2005	Launch Time	Vehicle Type	Launch Azimuth	Elevation Angle / Altitude Over Beach	Pinniped Monitoring Site	3-D CPA distance (m)	SELs [dB re (20 μPa)^2·s] flat-/M M_{pa}-weighted	Behavioral Reaction of Animals to Launch
29 June	14:35	AGS Missile	280	62.5° / 1615 m	809 Camera[n]	1489	N.A.	56 monitored, most (95%) looked, 9 moved 1-4 m, 2 moved ~20 m; settled in ~1 min
26 July	12:56	AGS Slug[†]	280	65° / 1676 m	Dos Coves South[n]	464	113/102	170 monitored; 48% moved <10 m, including 26 juveniles that entered water
"	14:53	AGS Missile	280	65° / 1676 m	Dos Coves South[n]	464	113/102	120 monitored; 56% moved, 35 entered water; settled in 1 min but remained vigilant
"	12:56	AGS Slug[†]	280	65° / 1676 m	The "Y"[n]	1261	104/89	300 monitored; 18 entered water, 5 moved <5 m; remain vigilant 10 min after
"	14:53	AGS Missile	280	65° / 1676 m	The "Y"[n]	1261	103/86	180 monitored; all look, 1 moved 2 m and another moved out of FOV (~10 m)
"	12:56	AGS Slug	280	65° / 1676 m	809 Camera[n]	1485	104/89*	90 monitored; all startled and looked, 2 moved 2-3 m
"	14:53	AGS Missile	280	65° / 1676 m	809 Camera[n]	1485	104/86*	250 monitored; all startled and looked but none moved
27 July	10:04	Vandal	270	8° / 390 m	809 Camera[n]	1079	118/107[†]	180 monitored; all startled and 40 moved 5-8 m; none entered the water
"	10:04	Vandal	270	8° / 390 m	Harbor Seal Overlook[b]	1043	Launch sounds audible on video recording	3 sea lions monitored; all startled and 2 moved 2-9 m; settled within 1 min
28 July	08:04	Vandal	270	8° / 390 m	809 Camera[n]	1079	119/109[†]	200 monitored; all startled and 49 moved; 23 moved > 8 m
"	11:20	Vandal	270	35° / 2591 m	809 Camera[n]	2272	N.A.	90 monitored; all startled, 57 moved 1-6 m and 8 of those entered water
"	11:38	Vandal	270	35° / 2591 m	809 Camera[n]	2272	113/92[†]	70 monitored; 41 moved 1-8 m, 18 moved >8 m, 6 entered water, 7 pups came on land from water
"	08:04	Vandal[†]	270	8° / 390 m	Harbor Seal Overlook[n]	1040	119/108	11 monitored; all startled, 3 entered water, 1 left FOV (~8 m), 5 moved 1-4 m; 2 entered FOV and then entered water
"	11:20	Vandal	270	35° / 2591 m	Harbor Seal Overlook[n]	1972	101/95	3 monitored; all startled and 1 moved 1.5 m
"	11:38	Vandal	270	35° / 2591 m	Harbor Seal Overlook[n]	1972	101/96	2 monitored; both looked up during launch and 1 moved 20 s later

[†] Sonic boom evident. [n] monitoring site was north of the launch azimuth. [b] monitoring site was behind launch pad. * audio recorded at The "Y", just south of 809 Camera. [†] audio recorded at Bomber Cove, just northwest of 809 Camera. N.A. = not available. FOV = field of view.

TABLE 3.3. (cont'd)

Launch Date 2005	Launch Time (local)	Vehicle Type	Launch Azimuth	Elevation Angle / Altitude Over Beach	Pinniped Monitoring Site	3-D CPA distance (m)	SELs [dB re (20 μPa)^2·s] flat-/M M_{pa}-weighted	Behavioral Reaction of Animals to Launch
25 Aug.	09:03	AGS Slug	280	62.5° / 1615 m	The "Y" [n]	1264	103/88	94 monitored; 12 entered the water, and another 17 moved <8 m; 11 entered FOV and 7 of those entered water
"	11:30	AGS Missile	280	62.5° / 1615 m	The "Y" [n]	1264	102/84	110 monitored; 42 entered water and another 16 moved <10 m; settled in ~1 min
"	13:30	AGS Missile	280	62.5° / 1615 m	The "Y" [n]	1264	104/88	165 monitored; 6 entered water, 1 moved ~2 m, 2 pups moved ~10 m; settled in 1 min
"	09:03	AGS Slug	280	62.5° / 1615 m	809 Camera[n]	1486	98/79	60 monitored; all startled and looked, but none entered water, 8 moved 1-8 m
"	11:30	AGS Missile	280	62.5° / 1615 m	809 Camera[n]	1486	98/77	60 monitored; some sea lions looked, 2 entered water, no other sea lions moved
"	13:30	AGS Missile	280	62.5° / 1615 m	809 Camera[n]	1486	98/80	60 monitored; most looked, 10 entered water, 3 moved <3 m
"	09:03	AGS Slug	280	62.5° / 1615 m	Dos Coves South[n]	464	Launch sounds audible on video recording	84 monitored; 44 entered water, 13 moved 1-6 m, 14 entered FOV; settled in 1 min but remained vigilant
"	11:30	AGS Missile	280	62.5° / 1615 m	Dos Coves South[n]	464	112/100	115 monitored, 53 entered water, another 44 moved 1-6 m; settled within 1 min
"	13:30	AGS Missile	280	62.5° / 1615 m	Dos Coves South[n]	464	112/100	100 monitored; 58 entered water, 20 moved 1-2 m, 22 did not move but looked
6 Oct.	09:30	SSST	270	14° / 914 m	809 Camera[n]	1343	113/105	130 monitored; all startled and moved, most (120) moved >10 m (up to ~50 m), 10 moved <8 m; most left FOV within 2 min
"	09:30	SSST[†]	270	14° / 914 m	Dos Coves South[d]	886	117/109	57 monitored; all startled and looked, 31 entered water, 15 moved 1-10 m, 5 moved >10 m, 6 did not move

[†] Sonic boom evident. [n] monitoring site was north of the launch azimuth. [b] monitoring site was behind launch pad. [d] monitoring site was directly below launch azimuth. N.A. = not available. FOV = field of view.

TABLE 3.4. Details of vehicle launches, sound exposure levels (SEL), and *harbor seal* reactions at SNI during October 2004–October 2005. AGS slugs and missiles were launched from Building 807 Launch Complex; Vandals and SSSTs were launched from Alpha Launch Complex.

Launch Date 2005	Launch Time (local)	Vehicle Type	Launch Azimuth	Elevation Angle / Altitude Over Beach	Pinniped Monitoring Site	3-D CPA distance (m)	SELs [dB re (20 μPa)^2·s] flat-/M_{pa}-weighted	Behavioral Reaction of Animals to Launch
24 Feb.	13:16	AGS Missile	286°	50° / 1372 m	Bomber Cove[n]	1789	95/75*	15 monitored; hardly reacted, most merely raised head
22 Apr.	16:43	SSST[†]	270	14° / 914 m	Harbor Seal Overlook[n]	1246	117/105	15 monitored; all startled and 12 rushed into water (~2-5 m away), the remaining 3 seals moved 1-2 m
"	16:43	SSST	270	14° / 914 m	Phoca Reef[b]	2427	90/74	8 monitored; all looked and 6 entered water
"	16:43	SSST	270	14° / 914 m	Phoca Point[b]	3273	87/60	At least 1 seal entered the water in response to the launch
2 June	07:29	Vandal[†]	273	8° / 396 m	Bomber Cove[n]	1210	120/110	20 monitored; all looked but none moved
"	09:49	Vandal	273	8° / 396 m	Bomber Cove[n]	1210	125/101	20 monitored; all looked but none moved
27 July	10:04	Vandal	270	8° / 390 m	Phoca Reef[b]	2412	96/72	30 monitored; all looked, 13 moved (1-2 m), but only 3 entered the water
"	10:04	Vandal	270	8° / 390 m	Harbor Seal Overlook[n]	1043	Launch sounds audible on video recording	17 seals monitored; all entered the water
28 July	08:04	Vandal	270	8° / 390 m	Phoca Reef[b]	2412	96/67	40 monitored; all startled and moved; 21 entered water and 19 moved 1-2 m
"	11:20	Vandal	270	35° / 2591 m	Phoca Reef[b]	2412	93/65	38 monitored; all startled and moved; 12 entered water, 10 moved 1-2 m
"	11:38	Vandal	270	35° / 2591 m	Phoca Reef[b]	2412	93/64	28 seals monitored; all startled but only 9 entered the water
"	08:04	Vandal[†]	270	8° / 390 m	Harbor Seal Overlook[n]	1972	119/108	5 seals monitored; all entered water (~4 m away)
"	11:20	Vandal	270	35° / 2591 m	Harbor Seal Overlook[n]	1972	101/95	12 monitored; all entered water (~2 m away)

[†] Sonic boom evident. [n] monitoring site was north of launch azimuth. [b] monitoring site was behind launch pad. * audio recorded at Vizcaino Point, just north of Bomber Cove.

N.A. = not available.

At Dos Coves South, the site closest to the launch azimuth, 100 sea lions were monitored. When the first Vandal was launched, all animals startled, but mainly juveniles moved in response to the launch. When the second Vandal was launched 4 s later, the majority (80%) of sea lions moved down the beach and into the water (~30 m away). Another five sea lions moved short distances (up to 5 m) and did not enter the water. In addition, at least another 70 sea lions that were not previously observed entered the field of view when the Vandals were launched. The animals settled within ~2 min after the launch.

3.4.4 SSST Launch, 24 March 2005

A SSST was launched from the Alpha Launch Complex, with an azimuth of 270º and an elevation angle of 14º (Fig. 3.1F). Video recordings of California sea lions were made near 809 Camera and at The "Y" (both with a CPA of ~1.3 km), and at Dos Coves South, located directly underneath the path of the vehicle flight and 0.9 km from the CPA (Table 3.1).

Launch sound was audible on the audio track of the video recording at The "Y" and at Dos Coves South. A wagoncam, which did not have a microphone, was used near 809 Camera. Launch sounds were recorded via ATARs at the first two of those locations; the ATAR placed near 809 Camera malfunctioned (Tables 2.2 and 2.3; Fig. 3.1F).

Northern Elephant Seals.—During monitoring of sea lions at Dos Coves South, 14 elephant seals were also seen in the field of view. During the launch, all seals looked up, but none moved (Table 3.2). Immediately after the launch, one seal entered the field of view from elsewhere.

California Sea Lions.— At Dos Coves South, 51 sea lions were monitored, although there were at least 100 in the immediate area. All animals startled and looked up during the launch. The majority of sea lions (73%) moved out of the field of view (2–5 m) in response to the launch, and another two sea lions moved only a short distance (1–2 m), but none entered the water (Table 3.3). The sea lions settled within ~1 min after the launch. At The "Y", 50 sea lions were observed. During the launch, all sea lions startled and got up: 10 sea lions moved; 4 entered the water (~5 m away), 4 left the field of view (moved at least 5 m), and 2 others moved short (up to 2 m) distances (Table 3.3). Sea lions settled within ~1 min. Eighty-five California sea lions were monitored near 809 Camera. All startled during the launch, and most (82%) moved 2–10 m, although some (30) left the field of view. However, none entered the water. The sea lions settled within 90 s.

3.4.5 SSST Launch, 22 April 2005

A SSST was launched from the Alpha Launch Complex, with an azimuth of 270º and an elevation angle of 14º (Fig. 3.1G). Video recordings of harbor seals were made at Harbor Seal Overlook (CPA = 1.2 km), Phoca Reef (CPA = 2.4 km), and Phoca Point, located 3.3 km from the CPA of the target (Table 3.1). California sea lion observations were made 1.3 km from the CPA, near 809 Camera (Table 3.1).

Launch sound was audible on the audio track of the video recording at Phoca Point and Phoca Reef. Wagoncams, which did not have microphones, were used near 809 Camera and at Harbor Seal Overlook. Launch sounds were recorded via ATARs at Phoca Point, Phoca Reef, and at Redeye I near Harbor Seal Overlook (Tables 2.2 and 2.3; Fig. 3.1G).

Northern Elephant Seals.—Before the launch, numerous elephant seals were hauled out at Phoca Point. However, just before the launch, most seals left the haul-out site. In addition, the video was not focused on the hauled out group, so it was difficult to identify individuals to species. However, during

the launch, one harbor seal was seen entering the water, and one unidentified seal entered the water (possibly an elephant seal pup or a harbor seal).

California Sea Lions.—Approximately 70 California sea lions were monitored near 809 Camera on a rocky outcrop. The camera was not zoomed in on the hauled out group, so it was difficult to observe detailed behavior. Nonetheless, during the launch, 22 sea lions were observed to enter the water (most individuals moved 1–10 m), and another 23 sea lions moved >10 m in response to the launch. Most sea lions settled within 1 min.

Harbor Seals.—At Harbor Seal Overlook, the site closest to the trajectory, 15 harbor seals were monitored. During the launch, all seals startled and 12 rushed into the water, ~2–5 m away. The remaining three seals moved 1–2 m, but did not enter the water. Approximately 8 min after the launch, a seal hauled out, and more seals started hauling out at the site ~13 min after the launch. At Phoca Reef, eight seals were observed. During the launch, six seals entered the water; the remaining two seals did not move but looked up during the launch. Another seal entered the water ~7 min after the launch. No seals were hauled out on the beach at the end of the video recording, 1 hr 40 min after the launch. The recording at Phoca Point showed one harbor seal entering the water during the launch, and one unidentified seal entering the water, which could possibly have been an elephant seal pup or a harbor seal.

3.4.6 Two Vandal Launches, 2 June 2005

Two Vandals were launched in sequence 2 hr 20 min apart from the Alpha Launch Complex, with an azimuth of 273º and an elevation angle of 8º (Fig. 3.1H). Video recordings of harbor seals were made at Bomber Cove, located 1.2 km from the CPA. California sea lions were recorded during both launches at The "Y" (CPA = 0.7 km) and near 809 Camera (CPA = 0.9 km), as well as at Bomber Cove, but only during the second launch (Table 3.1).

Launch sound was audible on the audio track of the video recording at The "Y" and for the second launch at 809 Camera. A wagoncam, which did not have a microphone, was used near 809 Camera during the first launch and at Bomber Cove. However, launch sounds were recorded via ATARs at the same three locations (Tables 2.2 and 2.3; Fig. 3.1H).

California Sea Lions.—Near 809 Camera, California sea lions seemed to react more strongly during the first launch than the second launch. During the first launch, 30 sea lions were monitored near 809 Camera using a wagoncam, but the video was of poor quality, and detailed individual behavior could not be observed. Nonetheless, it could be observed that ~50% of animals reacted by moving along the beach; six moved out of the field of view (>5 m), whereas the other sea lions moved 2–5 m (Table 3.3). It could not be determined from the video whether any sea lions entered the water. During the second launch, a mobile camera was used to monitor 50 sea lions that were hauled out near 809 Camera. All looked up during the launch, but only two moved ~2 m.

During the first launch monitored at The "Y", 30 sea lions were observed. However, the camera was not zoomed in on the hauled out animals, so it was difficult to observer their behavior. Nonetheless, it was observed that all startled during the launch, and 12 animals moved in response to the launch. Four of those moved distances of 10–20 m, and eight moved short distances of up to 4 m. During the second launch, 30 sea lions were monitored at The "Y". All sea lions looked up in response to the launch, but only three moved 1–3 m. No sea lions entered the water during either launch.

During monitoring of harbor seals at Bomber Cove during the first launch, three California sea lions were also seen in the field of view. During the launch, all three sea lions startled and looked up, but only one moved ~6 m and then entered the water (Table 3.3).

Harbor Seals.—At Bomber Cove, 20 harbor seals were monitored during each launch. During both launches, all seals looked up but did not move.

3.4.7 Two AGS Launches, 16 June 2005

An AGS slug and a missile were launched from the Building 807 Launch Complex, with an azimuth of 280º and an elevation angle of 62.5º (Fig. 3.1I,J). The missile was launched 1 hr 52 min after the slug. Video recordings of California sea lions were made during both launches at Dos Coves South (CPA = 0.5 km), and northern elephant seals were observed during both launches at Bachelor Beach North, located 0.7 km from the CPA (Table 3.1). Also, one elephant seal was present during the second launch at Dos Coves South, and one California sea lion was observed during the first launch at Bachelor Beach North. A third site could not be monitored, because the other cameras were not operational.

Launch sound was audible on the audio track of the video recordings at Dos Coves South and at Bachelor Beach North. Launch sounds were recorded via ATARs at Dos Coves South and Redeye I. An audio recording was also attempted at Bachelor Beach North, but the ATAR malfunctioned (Tables 2.2, 2.3; Fig. 3.1I,J).

Northern Elephant Seals.—During the AGS slug launch, 100 elephant seals were monitored at Bachelor Beach North, although ~300 were in the immediate area. During the launch, all seals looked up, but only five moved a short distance (~1 m). During the AGS missile launch, 70 seals were monitored, although there were still ~300 seals in the area. All seals looked up during the launch, but none moved. At least 15 elephant seals were present at Dos Coves South before the second launch. During the launch, however, only one elephant seal was in the field of view. The seal moved 1.5 m in response to the launch.

California Sea Lions.—During the AGS slug launch at Dos Coves South, 83 sea lions were monitored. During the first launch, all animals startled and looked up. The majority (93%) of sea lions moved only a short distance (1–6 m), but 33 of those left the field of view, and it could not be determined whether they entered the water or not. Six sea lions merely looked up but did not move. All sea lions settled within ~1 min, but some remained vigilant. During the second launch, 15 sea lions were monitored. During the launch, all sea lions startled and looked up, but only three individuals moved a short distance (~1 m). Although none of the monitored sea lions entered the water, four other sea lions moved into the area during the launch and entered the water. All sea lions settled within ~1 min. During a post-scan of Dos Coves South several hours after the launch, many sea lions were hauled out on the beach.

One adult male sea lion was hauled out at Bachelor Beach North during monitoring of elephant seals during the first launch. During the launch, the sea lion merely looked up. During the second launch, three sea lions males were hauled out at Bachelor Beach North. Again, all three sea lions merely looked up in response to the launch, but did not move.

3.4.8 Three AGS Launches, 29 June 2005

Two AGS slugs and one AGS missile were launched from the Building 807 Launch Complex, with an azimuth of 280º and a 62.5º elevation angle (Fig. 3.1K,L). The two slugs were launched sequentially, 2 hr 8 min apart, followed by the AGS missile 3 hr 31 min later. Video recordings of elephant seals and

California sea lions were obtained at Bachelor Beach North (CPA = 0.8 km). California sea lions were also monitored at Dos Coves South (CPA = 0.5 km), near 809 Camera (CPA = 1.5 km), and at Bomber Cove, located 1.8 km from the CPA (Table 3.1). Except for Dos Coves South, all sites were monitored during all three launches. A recording was attempted at Dos Coves South during the AGS missile launch, but the video malfunctioned.

ATARs were deployed at Dos Coves Gate, The "Y" (near 809 Camera), and Bachelor Beach (Fig. 3.1K,L; Tables 2.2, 2.3). ATARs failed to record during the second and third launch at Bachelor Beach, and during the missile launch at The "Y". Launch sounds were audible on the audio channel of the video recording at Dos Coves South and Bomber Cove. The wagoncams used to monitor pinnipeds at the other sites did not have a microphone.

Northern Elephant Seals.— A single elephant seal was hauled out at Bachelor Beach North during the first launch. This seal looked in response to the launch, but did not move. During the second launch, four elephant seals were monitored at the same location. All looked during the launch, but none moved. During the third launch, 11 elephant seals were observed. All but three looked up in response to the launch, and two moved short distances (1–4 m).

California Sea Lions.—During the first AGS slug launch, 111 sea lions were monitored at Dos Coves South, although several hundred (~300) were hauled out in the area. All sea lions startled and looked up in response to the launch, but only two pups moved ~2 m. The sea lions settled quickly after the launch, but a few remained vigilant. Sea lions seemed to exhibit a slightly greater reaction to the second launch at Dos Coves South; all sea lions startled and looked up, and 7 of 80 sea lions moved short distances (1–2 m) along the beach. One of those individuals, an adult female, knocked over three pups when she moved in response to the launch. In addition, an adult male sea lion entered the area during the launch and knocked over another three pups. However, none of the pups appeared to be injured. Sea lions settled within 1.5 min, although a few remained vigilant.

During the first launch at Bomber Cove, 38 sea lions were monitored, although ~300 were in the immediate area. Most (89%) of sea lions looked up in response to the launch, and the remaining sea lions did not react. None of the sea lions moved or entered the water in response to the launch. During the second launch, 26 sea lions were monitored. Only seven pups moved (~2 m) in response to the launch, but most sea lions showed no reaction to the launch. Fifty sea lions were monitored at Bomber Cove during the AGS missile launch. Few sea lions showed any reaction to the launch; six looked up, but none moved.

Forty-two sea lions were monitored during the first launch near 809 Camera. All sea lions were startled by the launch. A few individuals started moving along the beach, and eventually all sea lions moved out of the field of view, up to ~25 m. During the next launch, the camera focused on a slightly different location than before, so that sea lions could be observed. In this location, 73 sea lions were monitored. Most sea lions startled and got up in response to the launch, but did not move initially. Then, one sea lion moved and 82% of the monitored sea lions moved as well. Seventeen sea lions moved out of the field of view (~10–20 m), whereas the other individuals moved up to 8 m along the beach. In addition, seven individuals entered the area during the launch. All settled within ~1 min. Fifty-six sea lions were monitored during the AGS missile launch. Almost all (95%) looked up, and 11 of those moved along the beach. Nine individuals moved 1–4 m, and two moved ~20 m. Sea lions settled quickly after the missile launch.

During the first launch, 16 sea lions were monitored at Bachelor Beach North. All sea lions looked up in response to the launch, and most of them left the field of view (moving distances of 2–12 m). One other sea lion moved ~6 m during the launch, and two others did not move at all. During the second launch, 14 sea lions were observed. All looked during the launch, but none moved. All sea lions settled within 1 min. Twelve sea lions were observed at Bachelor Beach North during the last (missile) launch. All sea lions startled during the launch and looked and/or got up, but none moved.

3.4.9 Two AGS Launches, 26 July 2005

An AGS slug and a missile were launched from the Building 807 Launch Complex, with an azimuth of 280º and a 65º elevation angle (Figs. 3.1M and N). The AGS missile was launched 1 hr 57 min after the slug. Video recordings of California sea lions were obtained at Dos Coves South, (CPA = 0.5 km), The "Y" (CPA = 1.3 km), and near 809 Camera, located 1.5 km from the CPA.

ATARs were deployed at Dos Coves South, The "Y", and Bomber Cove (Figs. 3.1M and N; Tables 2.2 and 2.3). Launch sounds were audible on the audio channel of the video recording at Dos Coves South and The "Y". A wagoncam was used to monitor sea lions at Bomber Cove.

California Sea Lions.—During the AGS slug launch, 93 sea lions were monitored near 809 Camera. Most, if not all, sea lions startled and looked up in response to the launch. Two individuals moved 2–3 m, but no others sea lions moved. During the AGS missile launch, 250 sea lions were monitored near 809 Camera. All sea lions startled and looked up in response to the launch; none moved. Sea lions settled quickly after the launches.

At Dos Coves South, 170 sea lions were monitored during the first launch. All startled during the launch and 48% moved. Twenty of those moved short distances (2–6 m), whereas the other animals moved up to 10 m down to the water. Twenty-six juveniles entered the water. During the second launch, 120 sea lions were monitored. All startled in response to the launch, and 56% moved; 25 moved 10–15 m, 7 moved 1–2 m, and 35 entered the water. After both launches, most sea lions settled within 1 min, but many remained vigilant, looking around.

At the "Y", 300 sea lions were monitored during the first launch, but there were at least 1000 sea lions in the area. During the launch, all sea lions looked up, but did not respond further initially. About 10–15 s after the launch, 43 sea lions entered the field of view, which initiated the movement of some of the monitored sea lions (6%) into the water. An additional five sea lions that were monitored moved short distances (<5 m) along the beach. About 1 min after the launch, the sea lions stopped entering the water, and those that remained on the beach had settled but remained vigilant. During the second launch, 180 sea lions were monitored at the "Y". All sea lions looked up in response to the launch, but only two moved (2 and 10 m, respectively), and none entered the water.

3.4.10 Vandal Launch, 27 July 2005

A Vandal was launched from the Alpha Launch Complex, with an azimuth of 270º and an 8º elevation angle (Fig. 3.1O). Video recordings of California sea lions were made near 809 Camera (CPA = 1.1 km) and Harbor Seal Overlook (CPA = 1.0), and harbor seals were monitored at Harbor Seal Overlook and Phoca Reef (CPA = 2.4 km).

ATAR recordings were attempted near 809 Camera, Harbor Seal Overlook, and Phoca Reef (Fig. 3.1O; Tables 2.2 and 2.3). However, the ATAR at Harbor Seal Overlook failed to function. Launch sounds were audible on the audio channel of the video recordings from Harbor Seal Overlook and Phoca Reef; a wagoncam was used to monitor sea lions near 809 Camera.

California Sea Lions.—During observations of harbor seals at Harbor Seal Overlook, three sea lions were also monitored. Two of the animals moved in response to the launch (2–9 m), and the other sea lion startled and looked up. They did not enter the water, and settled within 1 min of the launch. Near 809 Camera, 180 sea lions were monitored. During the launch, all startled and looked up; 40 individuals moved 5–8 m, but none entered the water. Most sea lions settled within 1 min.

Harbor Seals.—Seventeen harbor seals were monitored at Harbor Seal Overlook. All seals entered the water (1–2 m away) in response to the launch. However, harbor seals started to haul out again at the same location ~30 min after the launch, and 1 hr 15 min after the launch seven harbor seals were hauled out at Harbor Seal Overlook. Thirty seals were monitored at Phoca Reef during the launch. All seals looked up in response to the launch, and three entered the water. An additional 10 animals moved short distances (1–2 m).

3.4.11 Three Vandal Launches, 28 July 2005

Three Vandals were launched from Alpha Launch Complex. The Vandals were launched sequentially; the first two were launched 3 h 16 min apart, followed by another Vandal 18 min later. All Vandals were launched at an azimuth of 270º. The first Vandal was launched at an elevation angle of 8º, and the other two Vandals were launched at 35º (Fig. 3.1P). During the first launch, video recordings of California sea lions were made near 809 Camera (CPA = 1.1 km) and Harbor Seal Overlook, located at a CPA of 1.0 km (Table 3.1). During the second and third launches, sea lions were also monitored at 809 Camera and Harbor Seal Overlook, but the CPAs were different because of the higher elevation angles of the launches (2.3 and 2.0 km, respectively). Harbor seals were also monitored at Harbor Seal Overlook, as well as at Phoca Reef. At Phoca Reef, the CPA was the same during all three launches (2.4 km), as Phoca Reef is located behind the launch pad. No harbor seals were present during monitoring at Harbor Seal Overlook during the third launch.

ATAR recordings were attempted at Harbor Seal Overlook, Bomber Cove, and Phoca Reef (Fig. 3.1P; Tables 2.2 and 2.3). The ATAR deployed at Bomber Cove did not function properly during the launch at 11:20. Launch sounds were audible on the audio channel of the video recording at Harbor Seal Overlook. Wagoncams were used to monitor pinnipeds at the other two sites.

California Sea Lions.—During the first launch, 200 California sea lions were monitored near 809 Camera. All sea lions startled during the launch, 25% moved, and 23 of those moved more than 8 m towards the water, although it could not be determined whether they actually entered the water. Although sea lions settled relatively quickly (~1 min), 50% of animals were still vigilant (looking around) 10 min after the launch. During the second launch, all sea lions startled again. Fifty-seven individuals moved up to 6 m, and eight entered the water. Most sea lions settled within 30 s, but some remained vigilant. During the last launch, all sea lions startled, and most (41 of 70) moved a short distance (1–8 m) along the beach. Another 18 sea lions moved out of the field of view (> 8 m), and 6 (2 females and 4 pups) entered the water. In addition, seven pups came up onto land from the water.

At Harbor Seal Overlook, 11 California sea lions were observed at Harbor Seal Overlook during the first launch. All startled and nine moved in response to the launch. Three of those entered the water, and the other animals moved 1–8 m. In addition, two other sea lions moved into the area during the launch and subsequently entered the water. All sea lions settled within 1 min. During the next launch, three sea lions were observed. All startled during the second launch and looked up, but only one moved by ~1.5 m. Both sea lions that were observed during the third launch looked up but did not move right away. One of the sea lions moved 20 s after the launch occurred.

Harbor Seals.—During the first launch, 40 harbor seals were monitored at Phoca Reef. All startled and moved in response to the launch, but only 21 entered the water (the other seals moved 1–2 m). During the second launch, all 38 seals that were monitored startled: 12 entered the water, 10 moved 1–2 m, and the rest merely looked up. The remaining seals settled within 30 s. During the third launch, 28 harbor seals were monitored. All startled during the launch, and nine seals entered the water. None of the other seals moved. All seals settled within 30 s.

All five seals that were observed at Harbor Seal Overlook during the first launch entered the water. By the time of the second launch, harbor seals were hauled out at the same site again. All of the 12 seals that were monitored entered the water in response to the launch. No harbor seals were at the haul-out site during the third launch, but one seal was seen in the water along the beach 10 min after the third launch, and 1 h 40 min after the launch, three harbor seals were hauled out.

3.4.12 Three AGS Launches, 25 August 2005

One AGS slug and two missiles were launched from the Building 807 Launch Complex, with an azimuth of 280º and a 62.5º elevation angle (Figs. 3.1Q and R). The first missile was launched 2 hr and 27 min after the slug, and the second missile followed 2 hr after that. Video recordings of California sea lions were obtained at Dos Coves South (CPA = 0.5 km), The "Y" (CPA = 1.3 km), and Bomber Cove (CPA = 1.5 km).

ATARs were deployed at Dos Coves South, The "Y", and at Bomber Cove (Figs. 3.1Q and R; Tables 2.2 and 2.3). The ATAR at Dos Coves South failed to record during the first launch. Launch sounds were audible on the audio channel of the video recordings at The "Y" and Dos Coves South. A wagoncam was used to monitor sea lions near 809 Camera.

Northern Elephant Seals.—During monitoring of sea lions at The "Y", the same single elephant seal was observed during the second and third launch. The elephant seal looked up during the second launch, but did not show any overt reaction to the third launch.

California Sea Lions.—About 1 hr before the first launch, a helicopter passing over the beaches where sea lions were hauled out disturbed at least 500 sea lions. This resulted from a mis-communication between the helicopter pilot and the launch operations conductor. The sea lions moved quickly along the beach and towards the water during the disturbance, but it could not be determined whether the animals actually entered the water.

During the first AGS slug launch, 84 sea lions were monitored at Dos Coves South, although at least 200 were in the area. All sea lions startled and looked up in response to the launch. Initially, only nine animals moved in response the launch, most of them pups. However, eventually, most (68%) sea lions moved towards the water 18 s after the launch; this movement appeared to have been started by a single individual. In total, 44 animals entered the water ~6 m away from most sea lions. The other 13 sea lions that moved traveled only short distances (1–6 m). During the launch, another 14 sea lions entered the field of view from the upper part of the beach. After the launch, some sea lions (at least six) remained vigilant for up to 10 min, looking around the beach. During the following AGS missile launch (second launch), 115 sea lions were monitored at the same site. Most sea lions startled during the launch, and 84% moved along the beach; 53 of those entered the water and the rest moved only short distances (1–6 m). All sea lions settled within 1 min. During the third launch, 100 sea lions were monitored, most of which startled: 58 sea lions entered the water in response to the launch, another 20 animals moved short distances (1–2 m) along the beach, and 22 did not move but looked up during the launch. Two sea lions entered the field of view during the launch. Most individuals settled within ~1 min after the launch.

During the first launch, 94 sea lions were monitored at The "Y", but there were at least 1000 sea lions in the area. Most sea lions initially looked up in response to the launch, but they did not react further. However, as soon as other (11) sea lions entered the area, 7 of which entered the water, 12 of the monitored sea lions also entered the water. In addition, another 19 sea lions monitored on the beach moved short distances (<8 m) in response to the launch. All sea lions settled within ~1 min. During the second launch, 110 sea lions were monitored at The "Y". Most looked up during the launch, and 42 entered the water (~2 m away), and another 16 animals moved short distances (<10 m). All animals settled within 1 min after the launch. During the third launch, 165 sea lions were monitored. All startled and looked up in response to the launch, and one female and five pups entered the water. Another three seal lions moved distances of 2–10 m. All sea lions settled within 1 min of the launch.

Near 809 Camera, 60 sea lions were monitored during each of the three launches. During the first launch, all sea lions startled and eight moved short distances (1–8 m), but none entered the water. During the second launch, two sea lions entered the water, but no other sea lions moved. During the third launch, 10 sea lions entered the water, and another three moved a short distance (<3 m).

3.4.13 SSST Launch, 6 October 2005

One SSST was launched from the Alpha Launch Complex at a launch azimuth of 270º and an elevation angle of 14º (Fig. 3.1S). Video recordings of California sea lions were made at Dos Cove South (immediately below the launch azimuth with a CPA of 0.9 km) and near 809 Camera (CPA = 1.3 km). Northern elephant seals were also monitored at Dos Coves South. A recording of harbor seals was attempted at Phoca Reef (CPA = 2.4 km), but no seals were hauled out at the time of the launch.

ATAR recordings were attempted at three sites: Bomber Cove, Dos Coves South, and at Phoca Reef, but the ATAR at Phoca Reef malfunctioned (Fig. 3.1S; Tables 2.2 and 2.3). Launch sounds were audible on the audio channel of the video recording at Dos Coves South and Phoca Reef. A wagoncam was used to monitor sea lions near 809 Camera.

Northern Elephant Seals.—Thirty-five elephant seals were observed at Dos Coves South. During the launch, all seals looked up and several slowly proceeded to enter the water. Over a 5-min period, 13 elephant seals entered the water—an unusual observation for elephant seals. The first ones entered the water ~45 s after the launch, and the majority of the 13 seals had entered the water within 1.5 min of the launch. Another two seals moved short distances (2–5 m) along the beach. The measured sound level, on an SEL basis, was 117 dB re $(20\ \mu Pa)^2 \cdot s$ flat-weighted and 109 dB with M_{pa} weighting (Table 3.2).

California Sea Lions.—During the launch, 57 sea lions were monitored at Dos Coves South. All startled and looked up in response to the launch. Nearly all sea lions (89%) moved in response to the launch, and more than half (54%) entered the water (~10 m away). Of those that moved but did not enter the water, three moved ~10 m, 12 moved a short distance (1–2 m), and five moved >10 m down the beach. Approximately 1.5 min after the launch, several sea lions entered the monitored area from elsewhere and sea lions continued to enter the area (and subsequently the water) for a total of 9 min. At the end of the monitoring period (~30 min after the launch), sea lions were still hauled out at the beach. Near 809 Camera, 130 sea lions were monitored. During the launch, all sea lions startled and most of the 120 sea lions that left the haul-out site had done so within 2 min after launch, although sea lions were still leaving the area 2–4 min after the launch. The remaining 10 sea lions only moved a short distance (<10 m) in response to 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). Statistical comparisons are not justified based on these data alone. However, these data—along with comparable data from launches in earlier and later monitoring periods—will be evaluated in a future across-year analysis.

TABLE 3.5. Description of pinniped behavior and distribution prior to and after launches, October 2004 – October 2005. *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	458	0.09	0.35	437	0.22	0.60
Northern Elephant Seals	154	0.06	0.26	153	0.06	0.05
Harbor Seals	113	0.06	0.27	72	0.10	0.30
Total Distance Moved (m)						
California Sea Lions	458	0.15	0.94	437	0.59	2.10
Northern Elephant Seals	154	0.06	0.32	153	0.05	0.24
Harbor Seals	113	0.04	0.21	72	0.05	0.15
Distance to Neighbor (m)						
California Sea Lions	458	0.42	0.92	437	0.47	0.89
Northern Elephant Seals	155	0.16	0.41	153	0.14	0.39
Harbor Seals	113	0.93	1.16	71	0.71	0.91

3.6 Summary

Pinniped behavioral responses to launch sounds during the October 2004–October 2005 period were, with the exception of some responses by harbor seals, usually brief and not severe. These responses were similar to those for the 2001–2004 monitoring periods (Holst et al. 2005). 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.

Northern elephant seals generally exhibited little reaction to launch sounds. Most individuals merely raised their heads briefly upon hearing the launch sounds and then quickly returned to their previous activity pattern (usually sleeping). However, during several launches, a small proportion of

northern elephant seals on the beach moved a short distance away from their resting site, and on two occasions (and possibly three), elephant seals entered the water.

Responses of California sea lions to the vehicle launches varied by individual. Some sea lions exhibited brief startle responses and increased vigilance for a short period (1–2 min) after each launch. Other sea lions, particularly pups, appeared to react more vigorously by moving around on the beach. Movement into the water occurred on 21 of 54 site-date-launch combinations, but generally only a small proportion of animals entered the water.

Behavior of harbor seals to the launches was variable. On most occasions (10 of 13 site-date-launch combinations), the majority of harbor seals rushed from their haul-out sites on rocky ledges to enter the water within seconds of the launch. Occasionally, harbor seals would start to haul out again at the same site as soon as several minutes (8 min or longer) after the launch.

No evidence of injury or mortality was observed during or immediately succeeding the launches. However, during an AGS slug launch, an adult male sea lion knocked over three sea lion pups as he moved in response to the launch, and an adult female knocked over an additional three pups. The pups were momentarily startled, but did not appear to be injured.

4. ESTIMATED NUMBERS OF PINNIPEDS AFFECTED BY VEHICLE LAUNCHES, OCTOBER 2004 – OCTOBER 2005

This chapter provides estimates of the numbers of pinnipeds affected by the Navy's vehicle launches on SNI from October 2004 through October 2005, based mainly on information provided in previous chapters of this report.

4.1 Pinniped Behavioral Reactions to Noise and Disturbance

Some of the pinnipeds on the beaches at SNI show disturbance reactions to vehicle 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. Thus, responses are not expected to be a direct function of received sound level. However, some correlation between pinniped responses and received sound level is considered likely. Results from correlation analyses performed on 2001–2003 data provided the first direct evidence for such relationships at SNI, at least for California sea lions and (weakly) for elephant seals (Holst 2004a). Analyses performed on data collected up to January 2005 showed similar results, based on larger sample sizes than the previous analyses, with some allowance for additional factors influencing received sound levels (Holst et al. 2005).

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).

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, several sea lion pups were knocked over by adult sea lions as the adults moved along the beach in response to a launch. The pups were momentarily startled, but did not appear to be injured.

Since no injuries or deaths were observed during the monitored launches in either the present monitoring period or earlier monitoring back to August 2001, disturbance rather than injury or mortality is the primary concern in this project. The minimum numbers of pinnipeds on the monitored beaches that might have been affected significantly by the 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 (Holst et al. 2005), 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 strong enough to cause TTS; and
3. pinnipeds that left the haul-out site, or exhibited prolonged movement or prolonged behavioral changes (such as pups separated from mothers) relative to their behavior immediately prior to the launch.

In practice, no pinnipeds are known or suspected to have been injured or killed, and few if any are believed to have received sounds strong enough to elicit TTS (see § 4.2, below). Thus, the number of pinnipeds counted as potentially affected was based on criterion (3) – the number that left the haul-out site, or exhibited prolonged movement or other behavioral changes.

The numbers of such affected pinnipeds were calculated for the periods during and immediately following the 25 launches (including one dual Vandal launch) on 13 separate days from January through October 2005. 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. The majority of harbor seals left their haul-out site during most launches. However, seals were occasionally seen to haul out again at the same site as soon as several minutes (8 min or longer) after the launch, and often started to haul out again within 1–2 hr after the launch.

4.2 Possible Effects on Pinniped Hearing Sensitivity

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

The maximum measured levels of launch sounds as received on beaches where pinnipeds might occur are summarized below.

- 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 flat-weighted SELs of about 131 dB re $(20\ \mu Pa)^2 \cdot s$ (Table 1 in Greene 1999). A-weighted values were lower.
- During the August 2001–August 2003 monitoring periods, the maximum SEL values measured for 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; Holst et al. 2005).
- During the October 2003–October 2004 period, the maximum SEL value measured near a pinniped haul-out site was 119+ dB flat-weighted and 103+ dBA re $(20\ \mu Pa)^2 \cdot s$ (Holst et al. 2005).
- During the current monitoring period, October 2004–October 2005, the maximum SEL value measured was 127 dB flat-weighted, 119 dB M_{pa}, and 111 dBA, in each case re $(20\ \mu Pa)^2 \cdot s$ (see Chapter 2).
- The sounds received from missile and target launches were sometimes impulse sounds (when there was a sonic boom). At other times and locations they were non-impulsive.

There are few published data on TTS thresholds for pinnipeds in air exposed to impulsive or brief non-impulsive sounds. J. Francine, quoted in NMFS (2001: 41837), has mentioned evidence of mild TTS in captive California sea lions exposed to a 0.3 s transient sound with an SEL of 135 dB re $(20\ \mu Pa)^2 \cdot s$ (see also Bowles et al. 1999). However, mild TTS may occur in harbor seals exposed to received levels lower than 135 dB SEL (A. Bowles, pers. comm., 2003). Unpublished data indicate that the TTS threshold on an SEL basis may actually be around 129–131 dB re $(20\ \mu Pa)^2 \cdot s$ for harbor seals, within their frequency range of

good hearing (A. Bowles et al. pers. comm.; D. Kastak et al. pers. comm.; see also Kastak et al. 2004). The same research teams have found that the TTS thresholds of California sea lions and elephant seals are higher. The measured SEL values near pinniped beaches during vehicle launches on SNI from October 2004–October 2005, were below the 135-dB level, and few if any pinnipeds were exposed to sound levels above 127 dB re $(20\ \mu Pa)^2 \cdot s$ SEL on a flat-weighted basis, 119 dB on an M_{pa}-weighted basis, and 111 dBA SEL. The M_{pa} values are probably the ones most directly relevant in relation to the approximate TTS threshold of 129–131 dB re $(20\ \mu Pa)^2 \cdot s$ mentioned above. Thus, few if any of the recorded sound pressures appear to have been sufficiently strong to have induced even slight TTS.

At least for the non-impulsive launch sounds, PTS would not be expected unless the received energy levels were considerably higher than the TTS threshold. The relationship between TTS and PTS onset was discussed at the NMFS-organized "Acoustic Criteria" workshop (see Gisiner 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 (March 2006), an expert panel is again 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 well above an SEL level of 135 dB re $(20\ \mu Pa)^2 \cdot s$. For impulse sounds, e.g., sonic booms and artillery shots, the PTS threshold may be lower, although still above 135 dB re $(20\ \mu Pa)^2 \cdot s$.

In the case of pinnipeds exposed to impulsive sound, e.g., from a sonic boom or close to an artillery shot, it is possible that there might be PTS as a result of the high peak pressure even if the received energy did not exceed the criterion for PTS onset.

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

If there is any reason to be concerned about auditory effects, it would be during either of two types of launches: (1) When artillery shots (i.e., AGS launches) occur at beach locations and pinnipeds are present nearby, should this ever occur. (2) When a Vandal or perhaps some "other large" vehicle travels at supersonic speed over a pinniped beach at relatively low altitude (i.e., when the elevation angle at launch was low). These cases should be re-considered when specific noise exposure criteria become available for possible PTS in pinnipeds in air 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 vehicle 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 2004–October 2005 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 vehicle sounds recorded near pinniped haul-out locations around western SNI during launch operations in the present monitoring period were up to above 127 dB re $(20\ \mu Pa)^2 \cdot s$ SEL on a flat-weighted basis, 119 dB on an M_{pa}-weighted basis, and 103 dBA on an A-weighted 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 2004 through October 2005 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 for the periods during and immediately following the 25 launches. Disturbance reactions for northern elephant seals and California sea lions were short-lived and did not appear to extend into subsequent hours or days. Most 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 the remainder of the video recording or during post monitoring.

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 2001–2004 monitoring periods. That is, the number of affected animals for the corresponding season and vehicle type was used, if possible.

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

TABLE 4.1. Minimum estimated numbers of California sea lions potentially (poten.) affected by launch sounds from the Navy's vehicle launch program on SNI, October 2004–October 2005 during the first (1), second (2), and/or third (3) launch. Some individuals were probably affected during more than one launch on a given day.

Launch Date 2005	Vehicle Type	Monitoring Site	Total # in Area			# of Focal Animals Poten. Affected			Total # Poten. Affected in Area		
			1	2	3	1	2	3	1	2	3
27 Jan.	AGS	Unmonitored haul-outs*								*80*	
24 Feb.	AGS	Dos Coves South	75	100	-	40	30	-	40	50	-
11 Mar.	Vandal	809 Camera	100	-	-	60	-	-	92	-	-
"	"	The "Y"	250	-	-	35	-	-	60	-	-
"	"	Dos Coves South	>155	-	-	100	-	-	155	-	-
24 Mar.	SSST	809 Camera	85	-	-	30	-	-	30	-	-
"	"	The "Y"	50	-	-	8	-	-	13	-	-
"	"	Dos Coves South	100	-	-	35	-	-	69	-	-
22 Apr.	SSST	809 Camera	70	-	-	45	-	-	45	-	-
2 June	Vandal	809 Camera	30	50	-	6	0	-	6	0	-
"	"	The "Y"	30	30	-	4	0	-	4	0	-
"	"	Bomber Cove	3	-	-	1	-	-	1	-	-
16 June	AGS	Dos Coves South	83	15	-	33	0	-	33	4	-
"	"	Bachelor Beach North	1	3	-	0	0	-	0	0	-
29 June	AGS	Bachelor Beach North	16	14	12	13	0	0	17	0	0
"	"	809 Camera	42	73	56	42	24	2	42	24	2
"	"	Bomber Cove	300	26	50	0	0	0	0	0	0
"	"	Dos Coves South	300	300	-	0	0	-	0	0	-
26 July	AGS	809 Camera	90	250	-	0	0	-	0	0	-
"	"	The "Y"	1000	1000	-	18	1	-	78	6	-
"	"	Dos Coves South	170	120	-	61	60	-	61	60	-
27 July	Vandal	809 Camera	180	-	-	0	-	-	0	-	-
"	"	Harbor Seal Overlook	3	-	-	0	-	-	0	-	-
28 July	Vandal	809 Camera	200	90	70	23	8	24	23	8	31
"	"	Harbor Seal Overlook	11	3	2	5	0	0	7	0	0
25 Aug.	AGS	809 Camera	60	60	60	0	2	10	0	2	10
"	"	The "Y"	1000	1000	1000	12	42	8	139	423	40
"	"	Dos Coves South	200	115	102	44	53	58	66	53	60
6 Oct.	SSST	809 Camera	130	-	-	120	-	-	120	-	-
"	"	Dos Coves South	57	-	-	36	-	-	36	-	-
Total number of sea lions potentially affected									**1990**		

Note: Numbers in italics are estimates derived from data previously collected during the 2001–2003 monitoring programs (Lawson 2002; Holst 2004b; Holst et al. 2005), 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. A dash (-) shows that that launch did not occur.

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).

TABLE 4.2. Minimum estimated numbers of northern elephant seals and harbor seals potentially affected by launch sounds from the Navy's vehicle launch program on SNI, October 2004–October 2005 during the first (1), second (2), and/or third (3) launch. Some individuals were probably affected during more than one launch on a given day.

Launch Date 2005	Vehicle Type	Monitoring Site	Total # in Area			# of Focal Animals Poten. Affected			Total # Poten. Affected in Area		
			1	2	3	1	2	3	1	2	3
Northern elephant seals											
27 Jan.	AGS	Bachelor Beach North		>1000		0	0	0	0	0	0
"	"	Bachelor Beach South		>1000		0	0	0	0	0	0
"	"	Redeye I		>700		0	0	0	0	0	0
24 Feb.	AGS	Bachelor Beach South	-	15	-	-	0	-	-	0	-
11 Mar.	Vandal	Dos Coves South	3	-	-	0	-	-	0	-	-
24 Mar.	SSST	Dos Coves South	14	-	-	0	-	-	1	-	-
22 Apr.	SSST	Unmonitored haul-outs*								1[†]	
2 June	Vandal	Unmonitored haul-outs*								*0*	
16 June	AGS	Dos Coves South	-	1	-	-	0	-	-	0	-
"	"	Bachelor Beach North	300	300	-	0	0	-	0	0	-
29 June	AGS	Bachelor Beach North	1	4	11	0	0	0	0	0	0
26 July	AGS	Unmonitored haul-outs*								*0*	
27 July	Vandal	Unmonitored haul-outs*								*0*	
28 July	Vandal	Unmonitored haul-outs*								*0*	
25 Aug.	AGS	The "Y"	-	1	1	-	0	0	-	0	0
6 Oct.	SSST	Dos Coves South	35	-	-	13	-	-	13	-	-
Total number of elephant seals potentially affected										**15**	
Harbor Seals											
27 Jan.	AGS	Unmonitored haul-outs*								*25*	
24 Feb.	AGS	Bomber Cove	-	15	-	-	0	-	-	0	-
11 Mar.	Vandal	Unmonitored haul-outs*								*53*	
24 Mar.	SSST	Unmonitored haul-outs*								*53*	
22 Apr.	SSST	Harbor Seal Overlook	15	-	-	12	-	-	12	-	-
"	"	Phoca Reef	8	-	-	6	-	-	6	-	-
"	"	Phoca Point	1	-	-	1	-	-	2[‡]	-	-
2 June	Vandal	Bomber Cove	20	20	-	0	0	-	0	0	-
16 June	AGS	Unmonitored haul-outs*								*20*	
29 June	AGS	Unmonitored haul-outs*								*20*	
26 July	AGS	Unmonitored haul-outs*								*58*	
27 July	Vandal	Harbor Seal Overlook	22	-	-	17	-	-	22	-	-
"	"	Phoca Reef	30	-	-	3	-	-	3	-	-
28 July	Vandal	Harbor Seal Overlook	20	12	-	5	12	-	20	12	-
"	"	Phoca Reef	40	38	28	21	12	9	21	12	9
25 Aug.	AGS	Unmonitored haul-outs*								*22*	
6 Oct.	SSST	Unmonitored haul-outs*								*25*	
Total number of harbor seals potentially affected										**395**	

Note: Numbers in italics are estimates derived from data previously collected during the 2001–2003 monitoring programs (Lawson 2002; Holst 2004b; Holst et al. 2005), 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, or no seals were present at monitored sites. [†] Potential take of an elephant seal, but unidentified species. [‡] At least one and maybe two harbor seals were affected. A dash (-) shows that that launch did not occur or that no seals were monitored during a particular launch

4.5 Summary

No evidence of pinniped injuries or fatalities related to launch noises was evident, nor was it expected. Few if any pinnipeds were exposed to levels above 135 dB SEL re $(20\ \mu Pa)^2 \cdot s$ or 131 dBA SEL. The 135 dBA value is a level above which pinnipeds might experience TTS (see NMFS 2001). The specific received levels of transient airborne sound that cause the onset of TTS in pinnipeds are not well documented. However, few if any of the recorded sound pressures appears to have been sufficiently strong to have induced TTS if TTS onset occurs at about the level indicated by Bowles et al. (1999, pers. comm.) and Kastak et al. (2004). Any TTS would presumably be mild and quickly recoverable. PTS is unlikely to have occurred.

At least 1990 California sea lions, 15 northern elephant seals, and 395 harbor seals are estimated to have been affected by launch sounds during the October 2004–October 2005 period. These figures are very approximate, because they (a) include extrapolations for pinnipeds on beaches that were not monitored on any given launch day, (b) very likely count some of the same individuals more than once, and 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. It is not likely that any of these pinnipeds on SNI 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, occasionally seals started to haul out at the monitored sites as soon as several minutes (8 min or longer) after the launch.

5. ACKNOWLEDGEMENTS

The 2004–2005 acoustical and marine mammal monitoring work was funded and in part conducted by NAWCWD, Point Mugu, California. It was done under the provisions of an LOA issued by NMFS on 8 October 2004. We thank Alex Stone, Steve Schwartz, Grace Smith, Gina Smith, Sandra Harvill, Tony Parisi, and many others at Point Mugu and on SNI for their support, assistance, and very positive approach to the monitoring and mitigation effort. In particular, Grace Smith, Sandra Harvill, and Steve Schwartz of NAWCWD have been instrumental in acquiring and providing the sound and video recordings from SNI, 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 SNI were responsible for setting out the ATARs and video cameras, and for transferring the sound and video data to Greeneridge and LGL, respectively.

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

Peer Amble, TEC Inc., prime contractor for this work, assisted with management and logistical matters, and Rick Spaulding, TEC Inc., reviewed the draft report.

We are grateful to all concerned.

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APPENDIX A:
LETTER OF AUTHORIZATION FOR 8 OCTOBER 2004 – 7 OCTOBER 2005

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 8, 2004, through October 7, 2005.

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. 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). 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.

(c). 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.

(d). The draft 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

OCT 8 2004

Laurie K. Allen
Director
Office of Protected Resources

Date

APPENDIX B: ACOUSTIC DATA FROM INDIVIDUAL LAUNCHES FOR OCTOBER 2004 – OCTOBER 2005

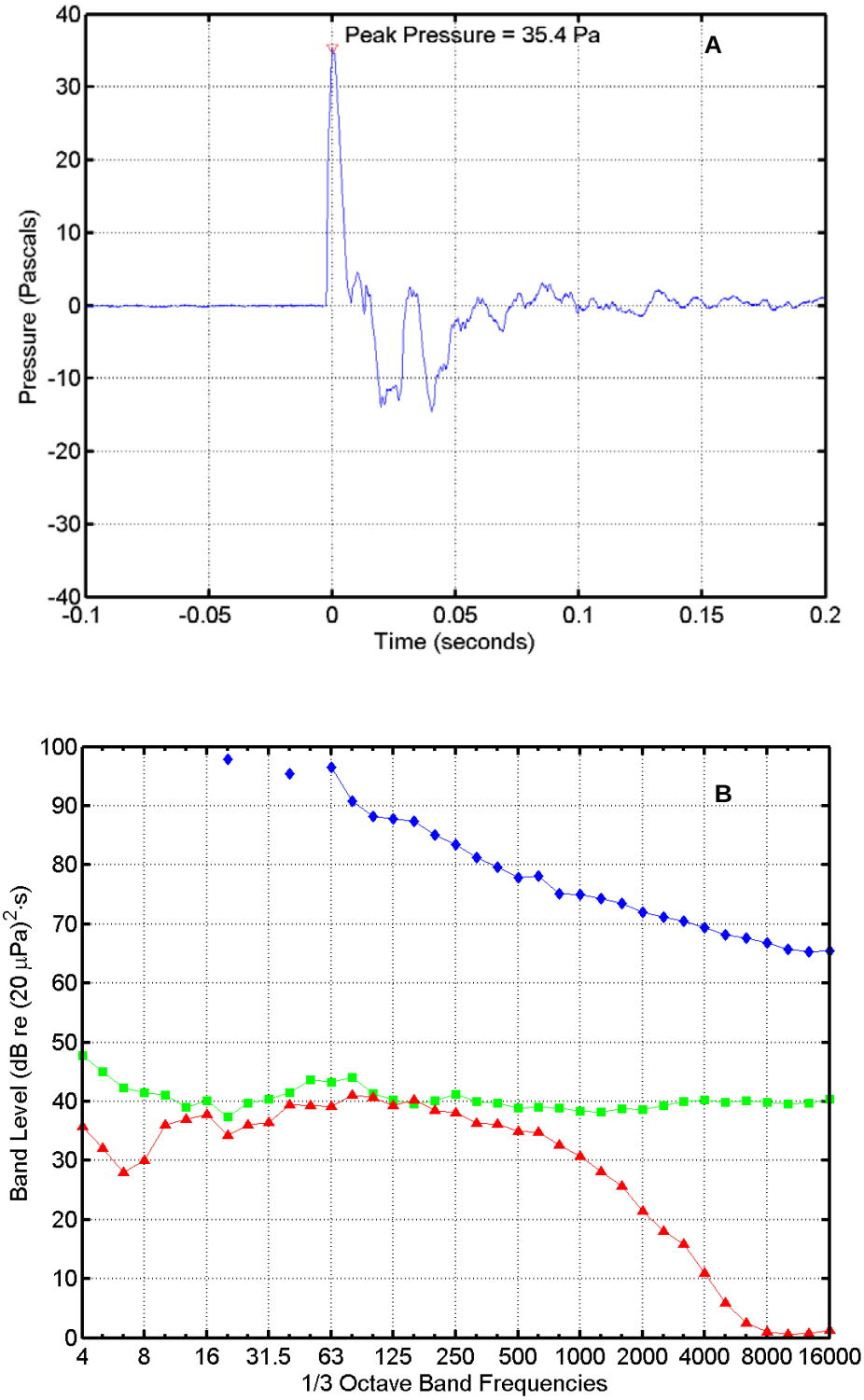


FIGURE B-1. (A) Pressure waveform and (B) one-third octave band levels for an AGS Slug flight at 08:59:00 on 27 January 2005 recorded at "Bachelor Beach North". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

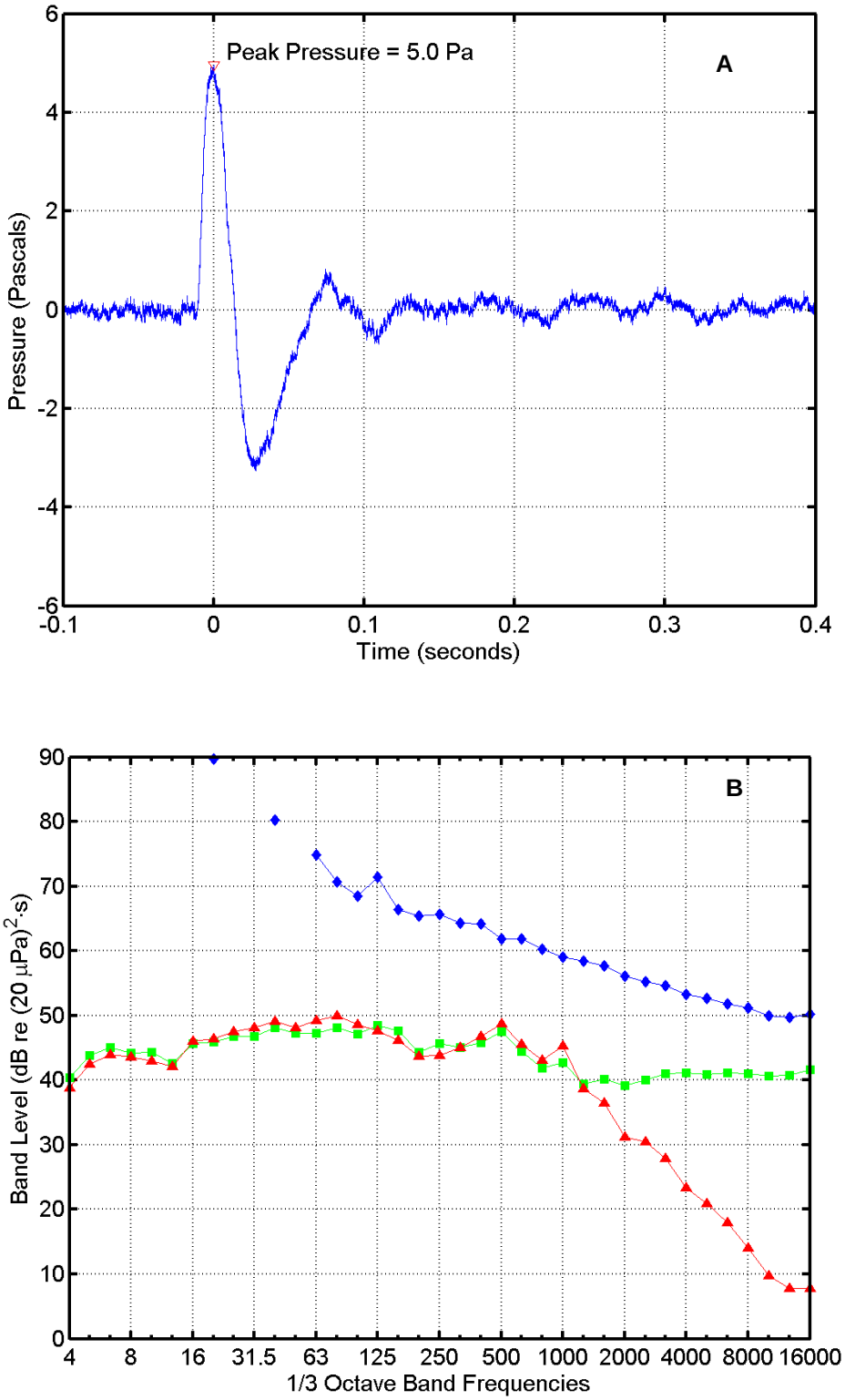


FIGURE B-2. (A) Pressure waveform and (B) one-third octave band levels for an AGS Slug flight at 08:59:00 on 27 January 2005 recorded at "Redeye I". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

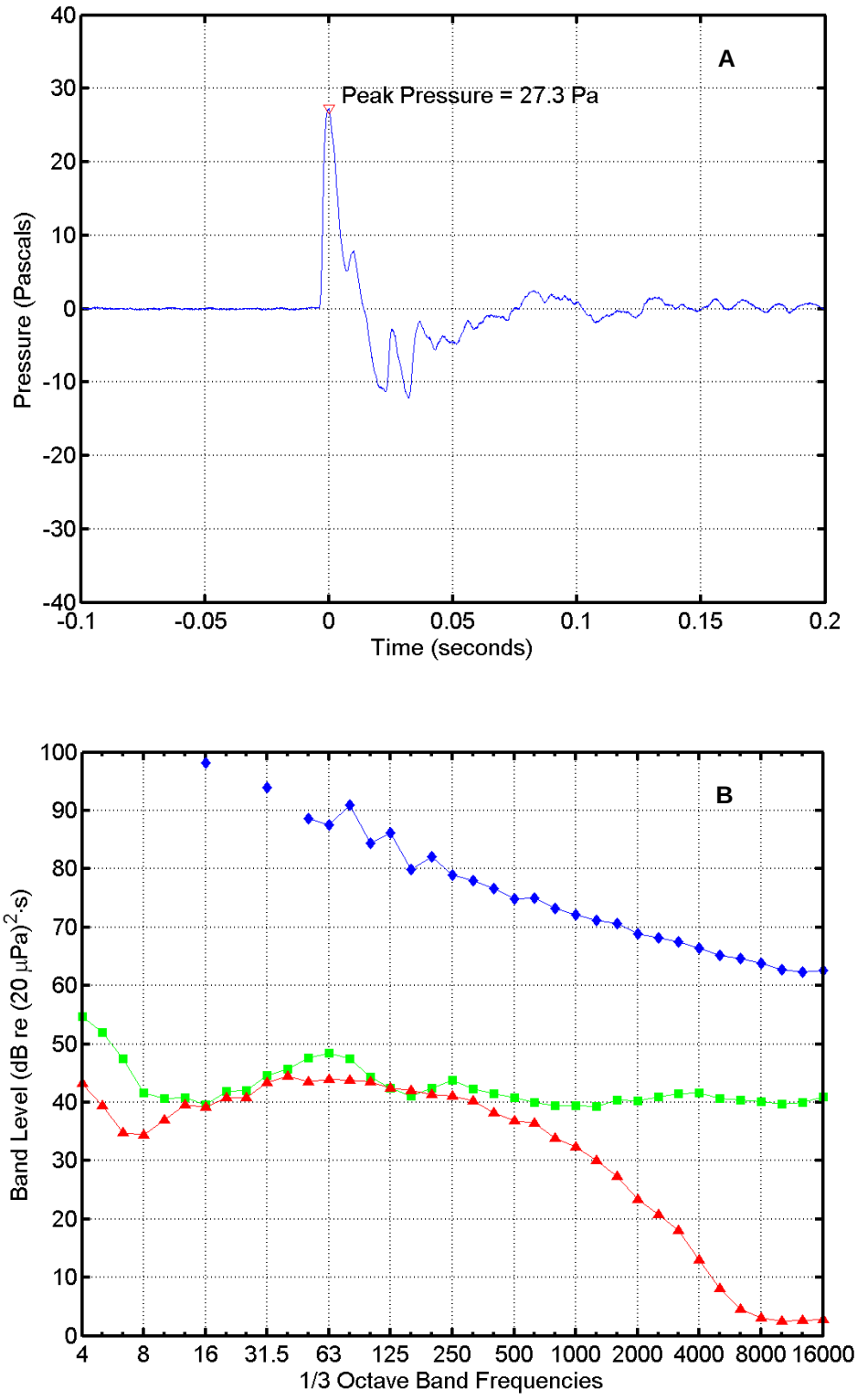


FIGURE B-3. (A) Pressure waveform and (B) one-third octave band levels for an AGS Slug flight at 11:40:46 on 27 January 2005 recorded at "Bachelor Beach North". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

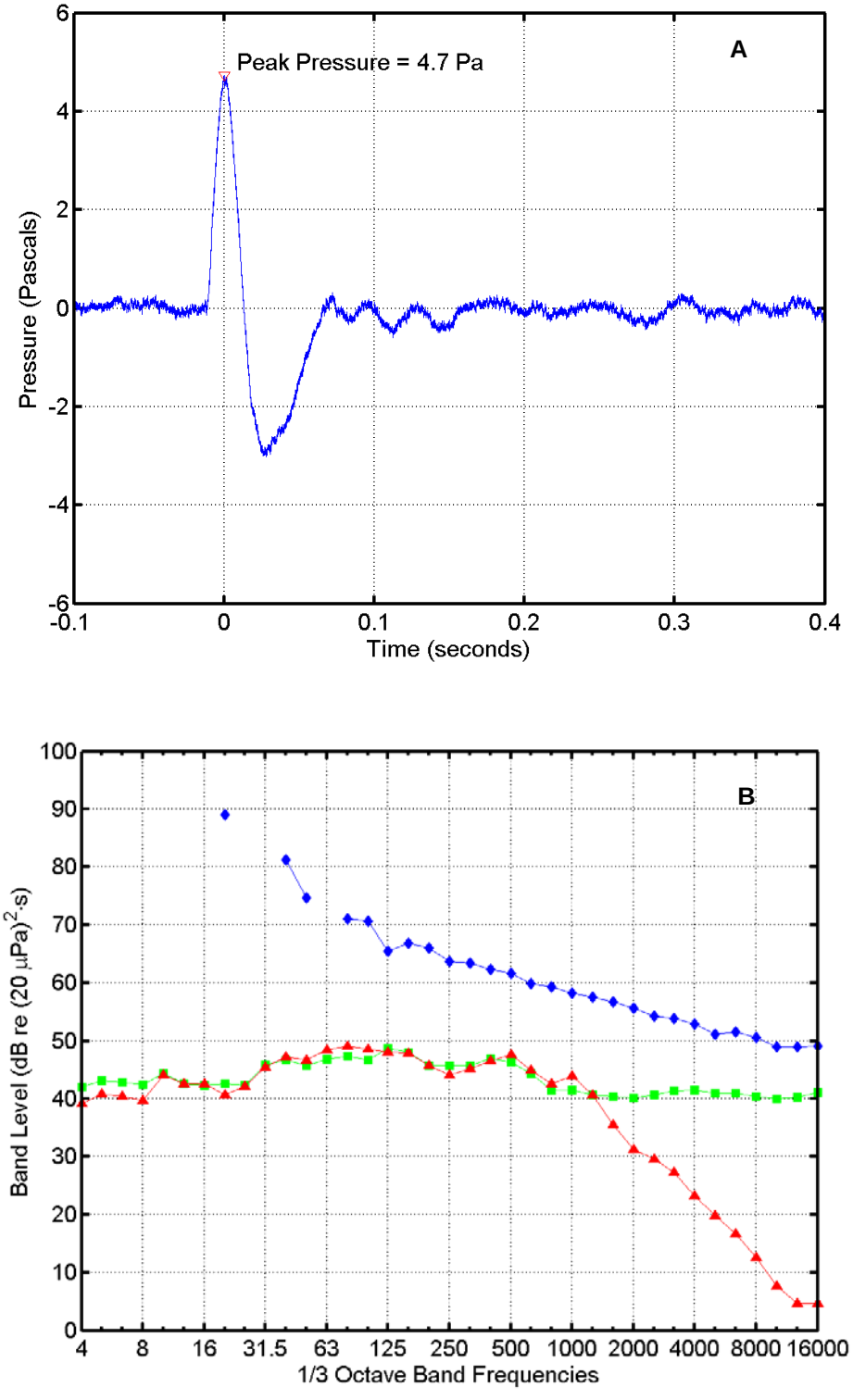


FIGURE B-4. (A) Pressure waveform and (B) one-third octave band levels for an AGS Slug flight at 11:40:46 on 27 January 2005 recorded at "Redeye I". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

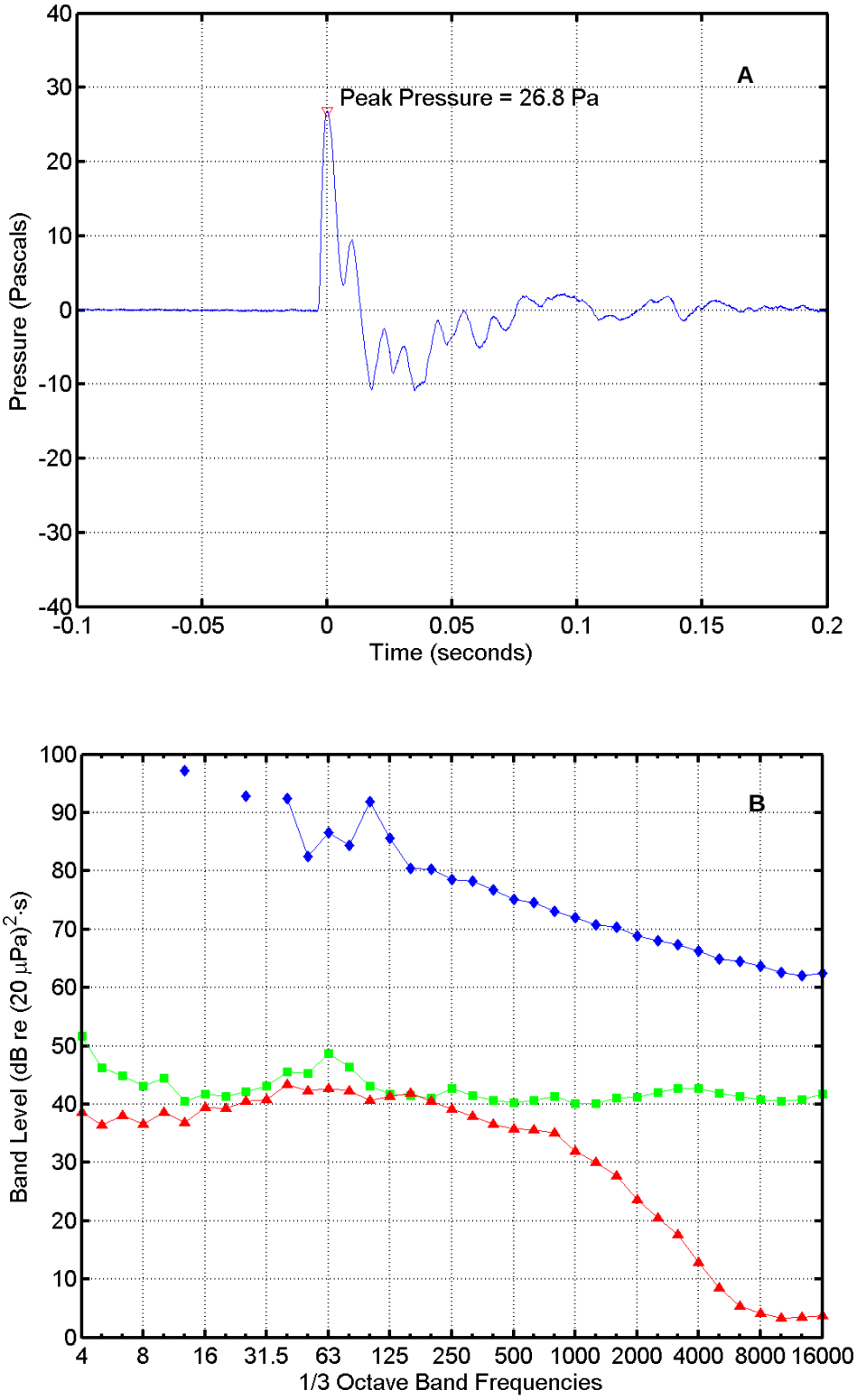


FIGURE B-5. (A) Pressure waveform and (B) one-third octave band levels for an AGS Missile flight at 13:29:20 on 27 January 2005 recorded at "Bachelor Beach North". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power.

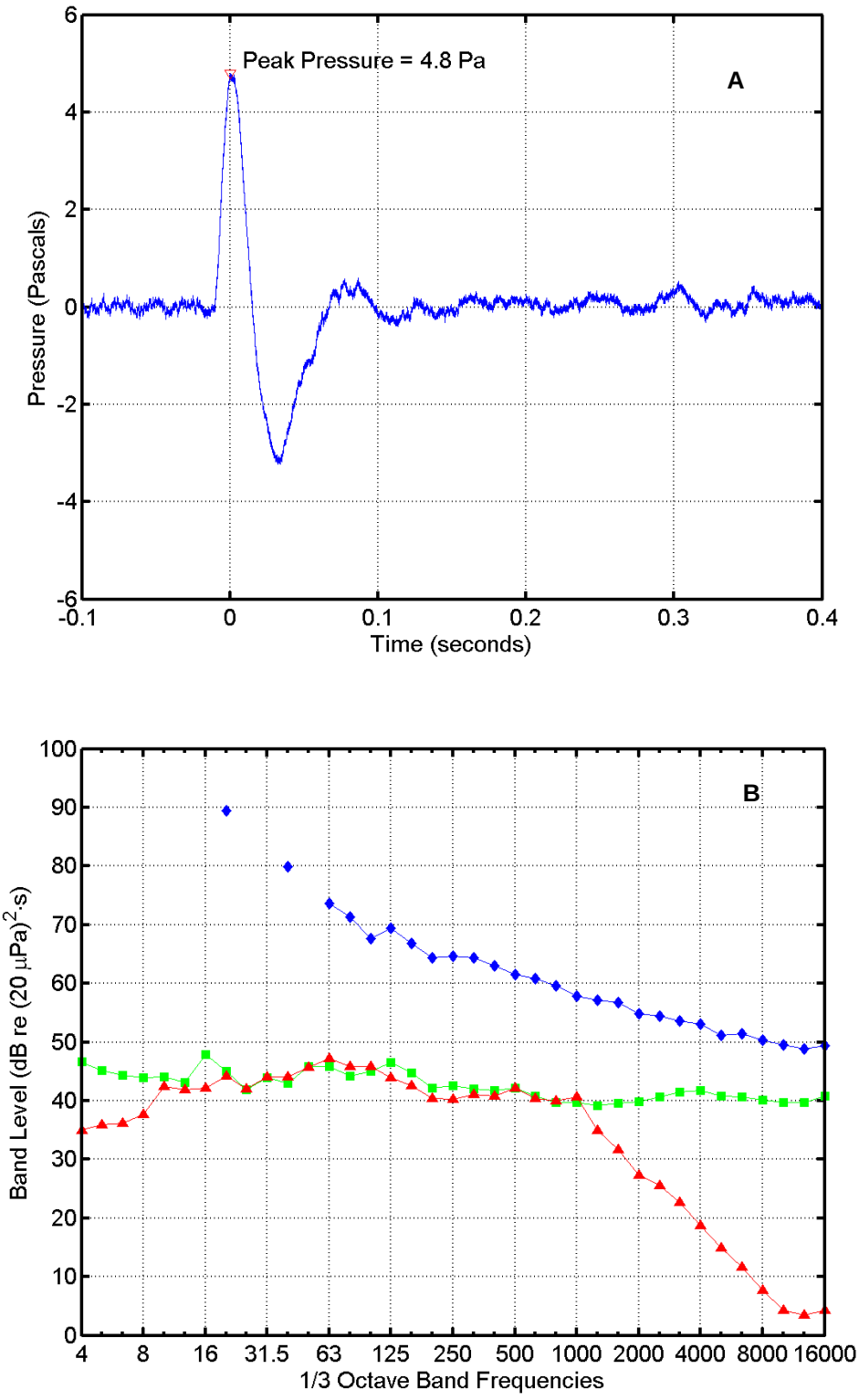


FIGURE B-6. (A) Pressure waveform and (B) one-third octave band levels for an AGS Missile flight at 13:29:20 on 27 January 2005 recorded at "Redeye I". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

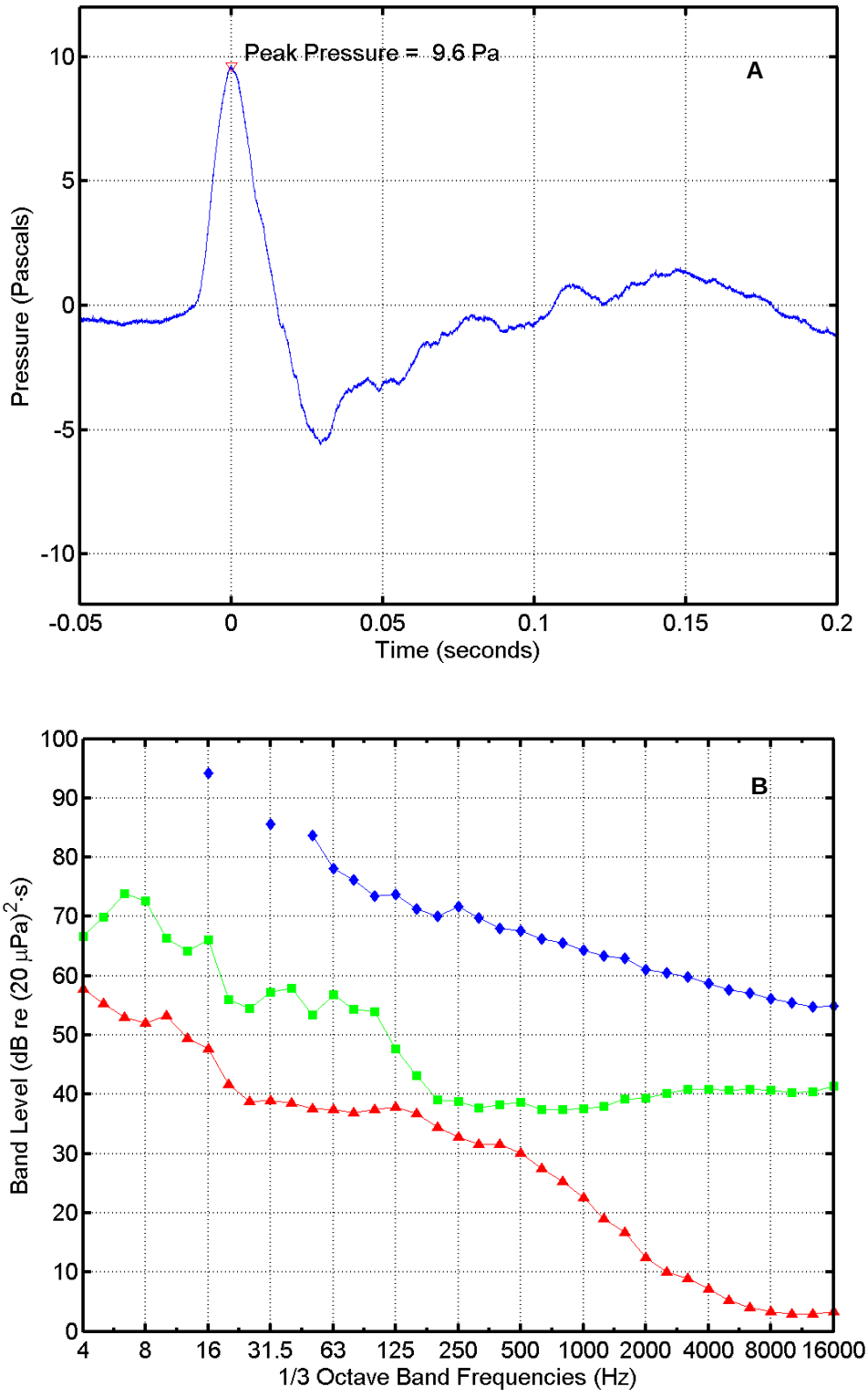


FIGURE B-7. (A) Pressure waveform and (B) one-third octave band levels for an AGS Slug flight at 09:05 on 24 February 2005 recorded at "Vizcaino Point". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

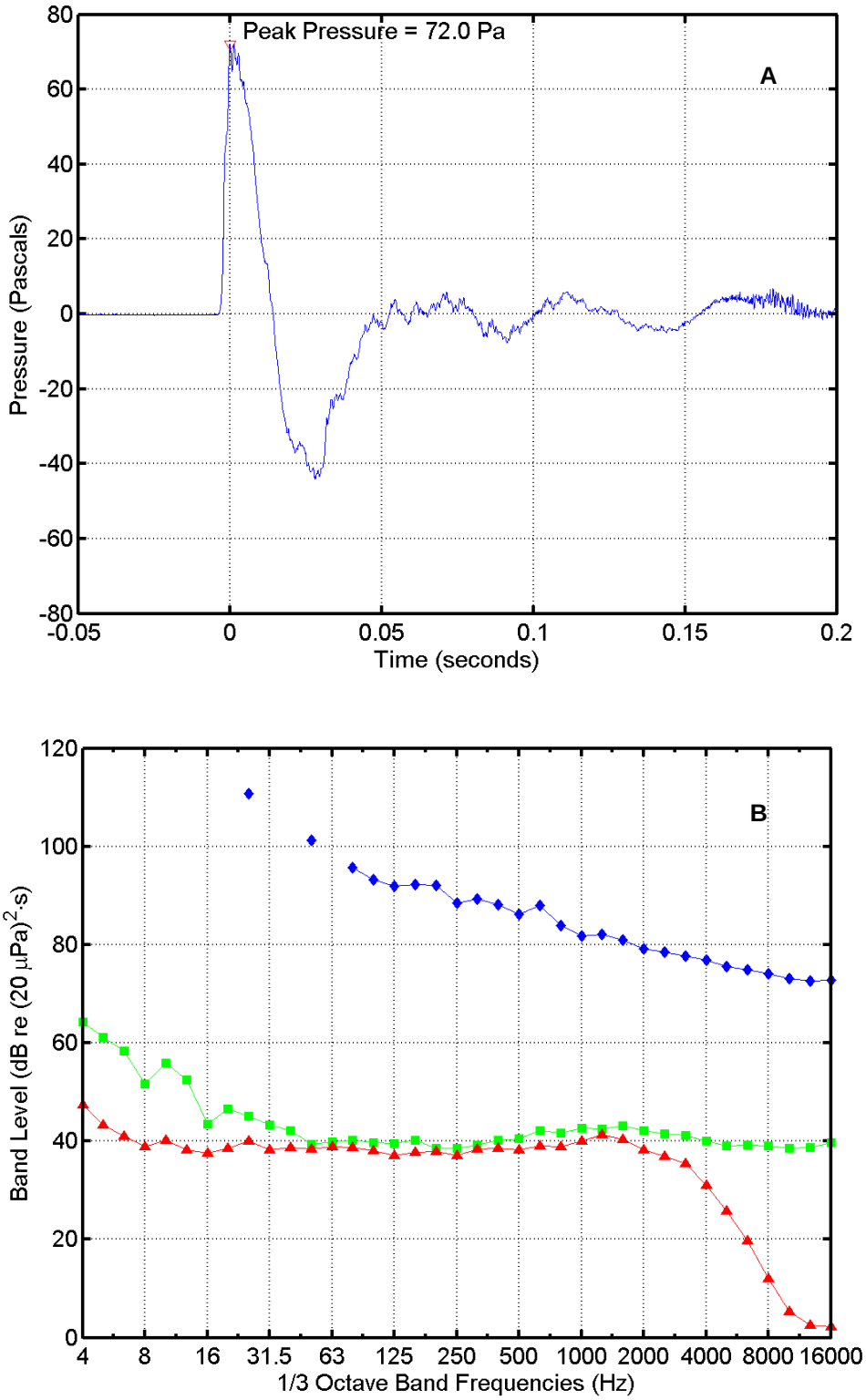


FIGURE B-8. (A) Pressure waveform and (B) one-third octave band levels for an AGS Slug flight at 09:05 on 24 February 2005 recorded at "Dos Coves South". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

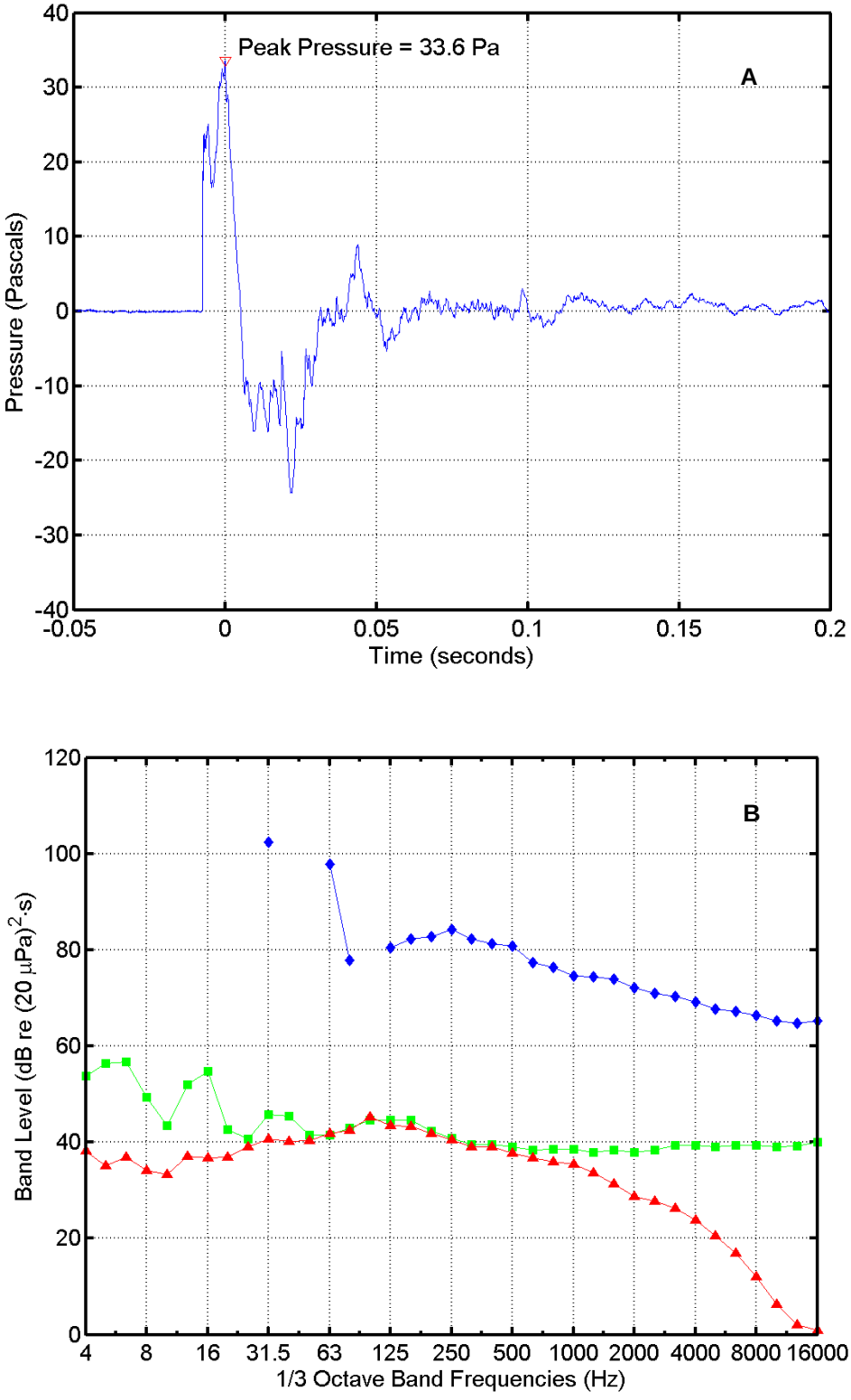


FIGURE B-9. (A) Pressure waveform and (B) one-third octave band levels for an AGS Slug flight at 09:05 on 24 February 2005 recorded at "Bachelor Beach South". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

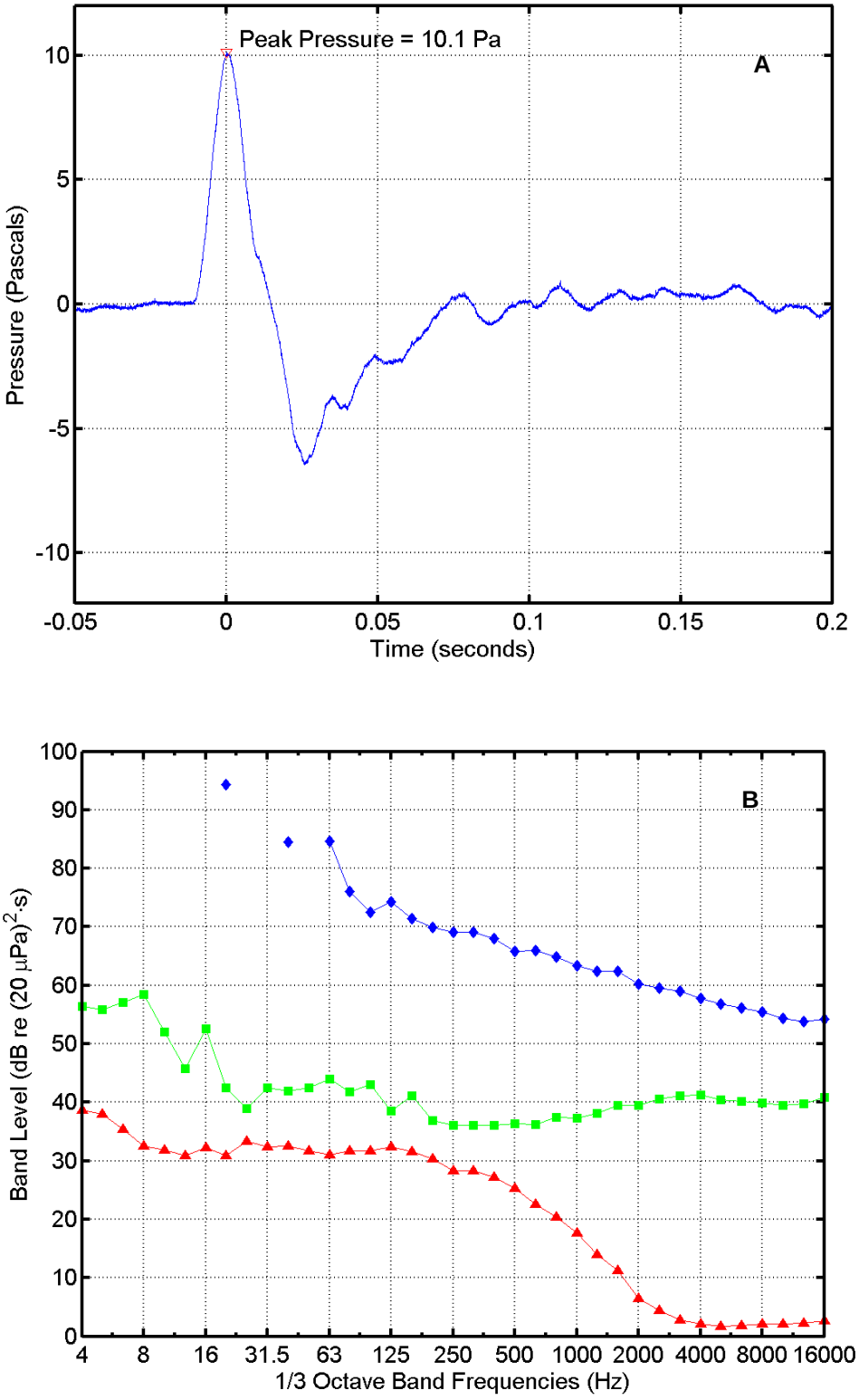


FIGURE B-10. (A) Pressure waveform and (B) one-third octave band levels for an AGS Missile flight at 13:16 on 24 February 2005 recorded at "Vizcaino Point". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

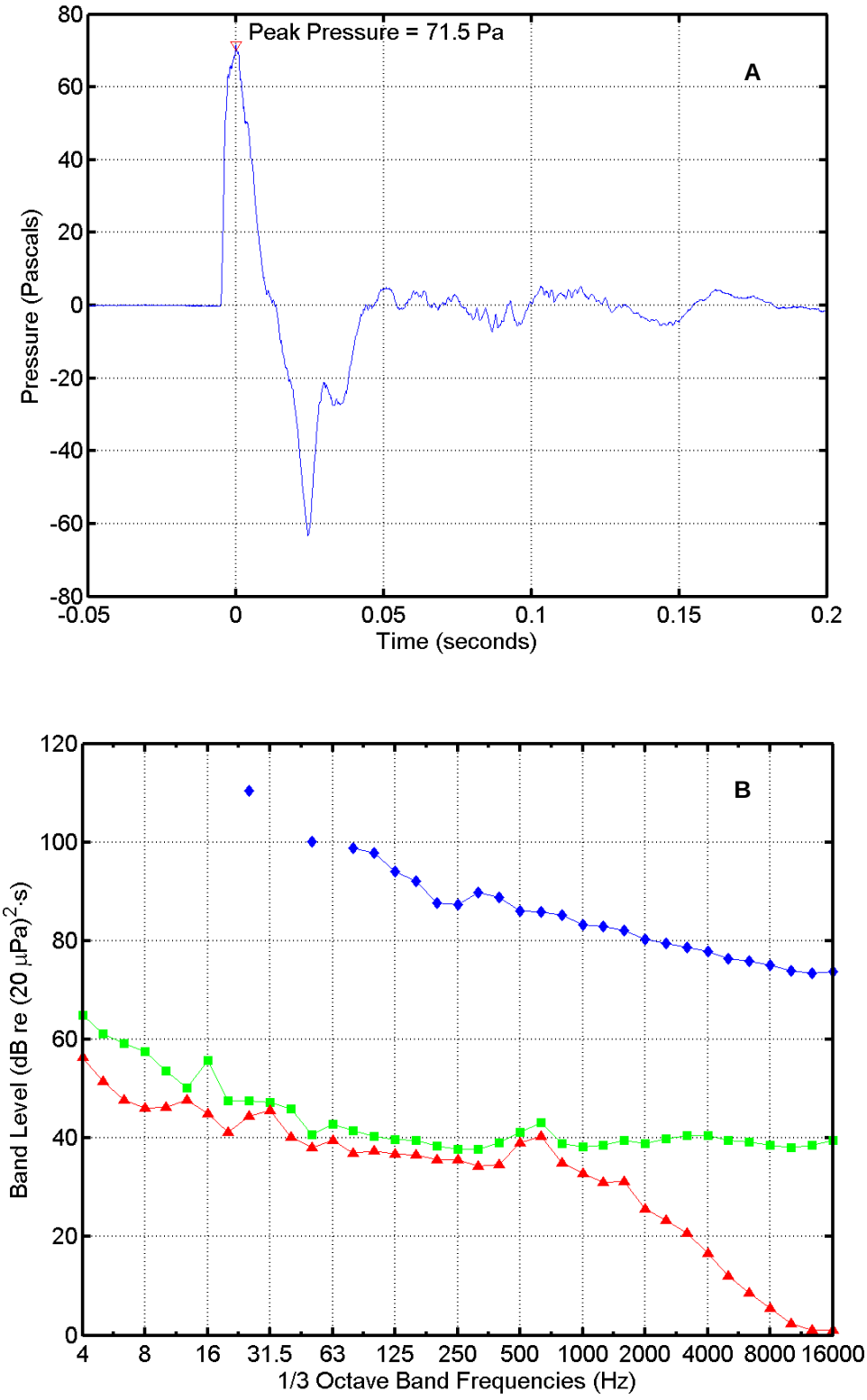


FIGURE B-11. (A) Pressure waveform and (B) one-third octave band levels for an AGS Missile flight at 13:16 on 24 February 2005 recorded at "Dos Coves South". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

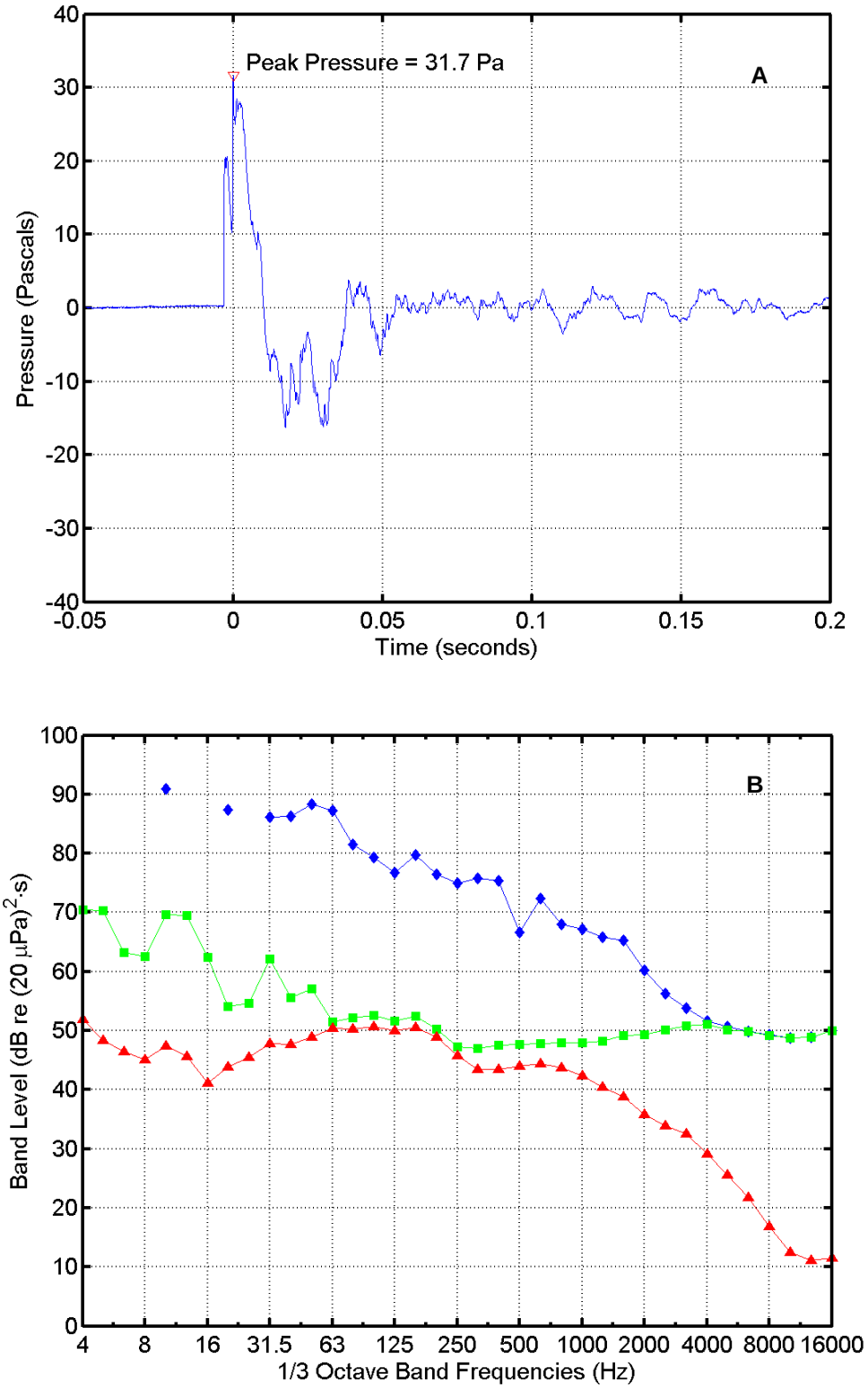


FIGURE B-12. (A) Pressure waveform and (B) one-third octave band levels for an AGS Missile flight at 13:16 on 24 February 2005 recorded at "Bachelor Beach South". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

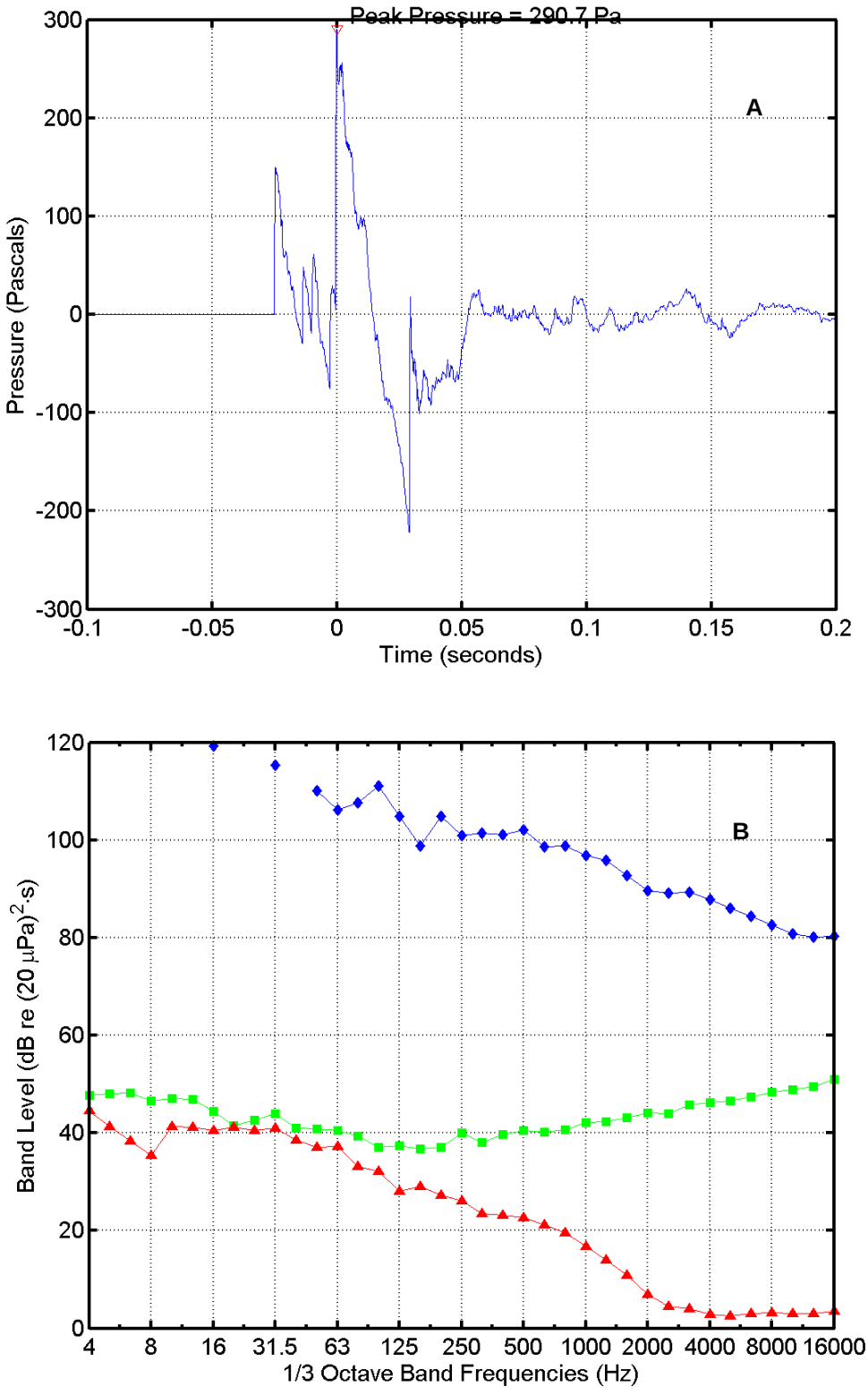


FIGURE B-13. (A) Pressure waveform and (B) one-third octave band levels for the first flight of a Dual Vandal launch at 09:30:00 on 11 March 2005 recorded at "809 Camera". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

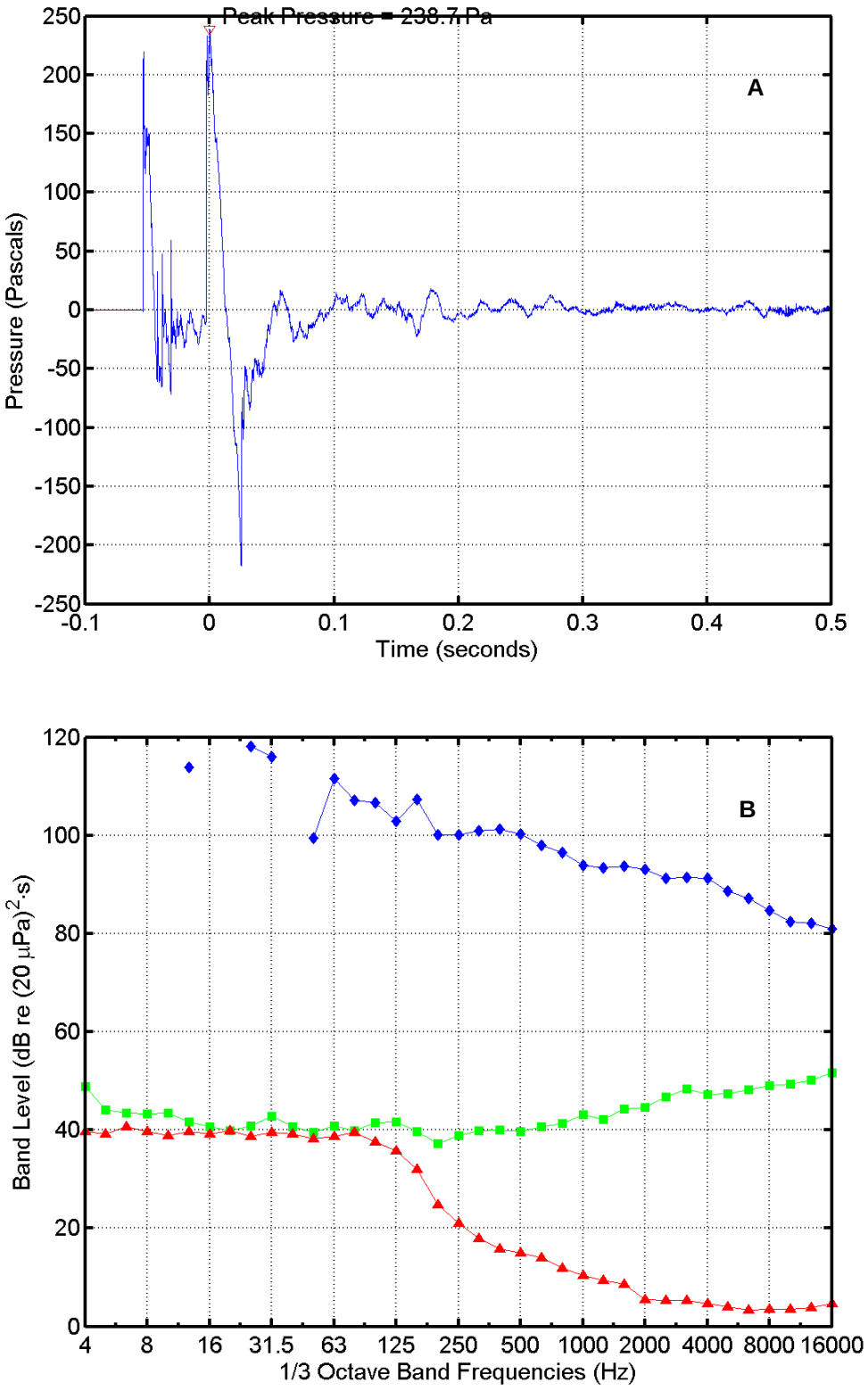


FIGURE B-14. (A) Pressure waveform and (B) one-third octave band levels for the first flight of a Dual Vandal launch at 09:30:00 on 11 March 2005 recorded at "The Y". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

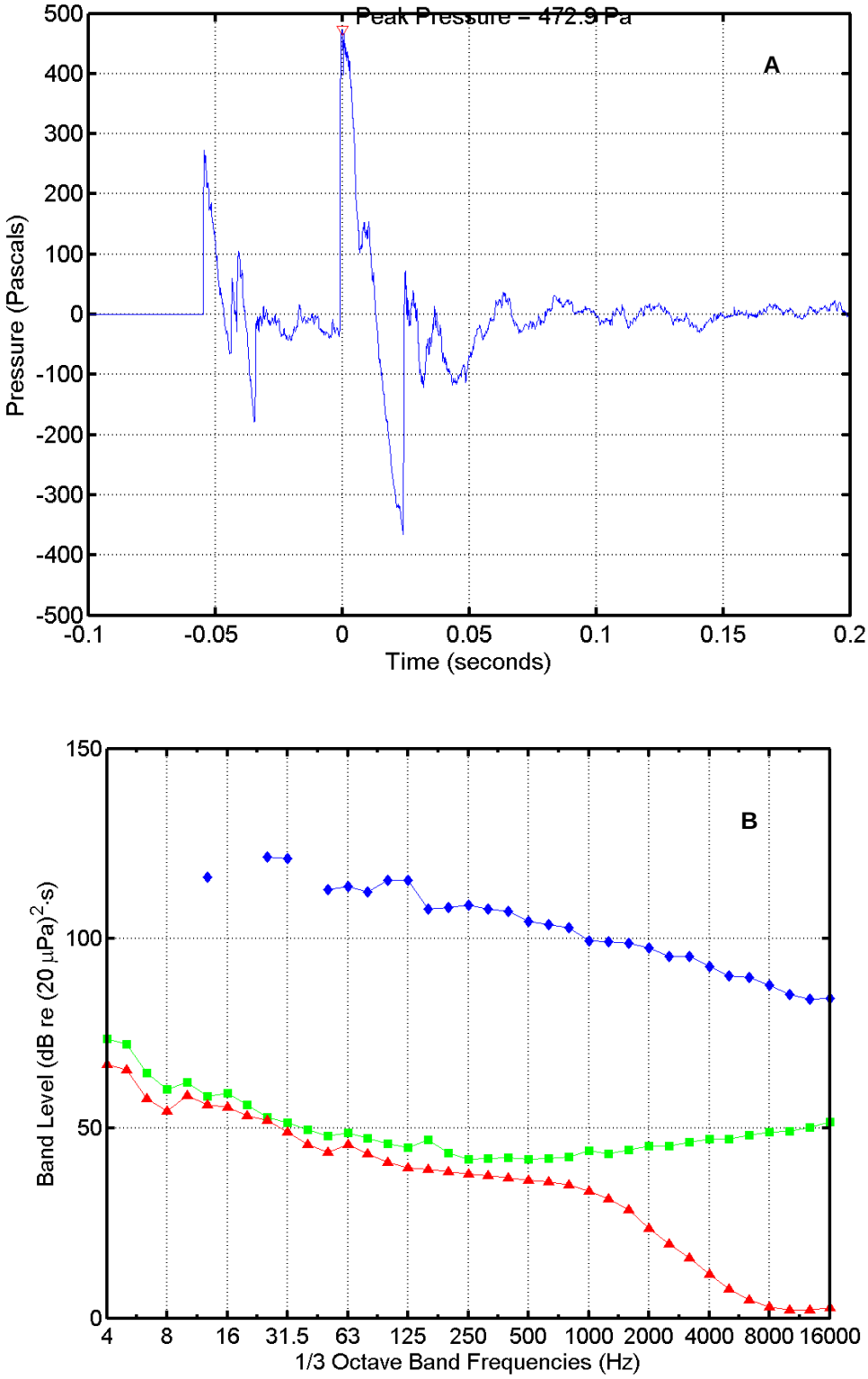


FIGURE B-15. (A) Pressure waveform and (B) one-third octave band levels for the first flight of a Dual Vandal launch at 09:30:00 on 11 March 2005 recorded at "Dos Coves South". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

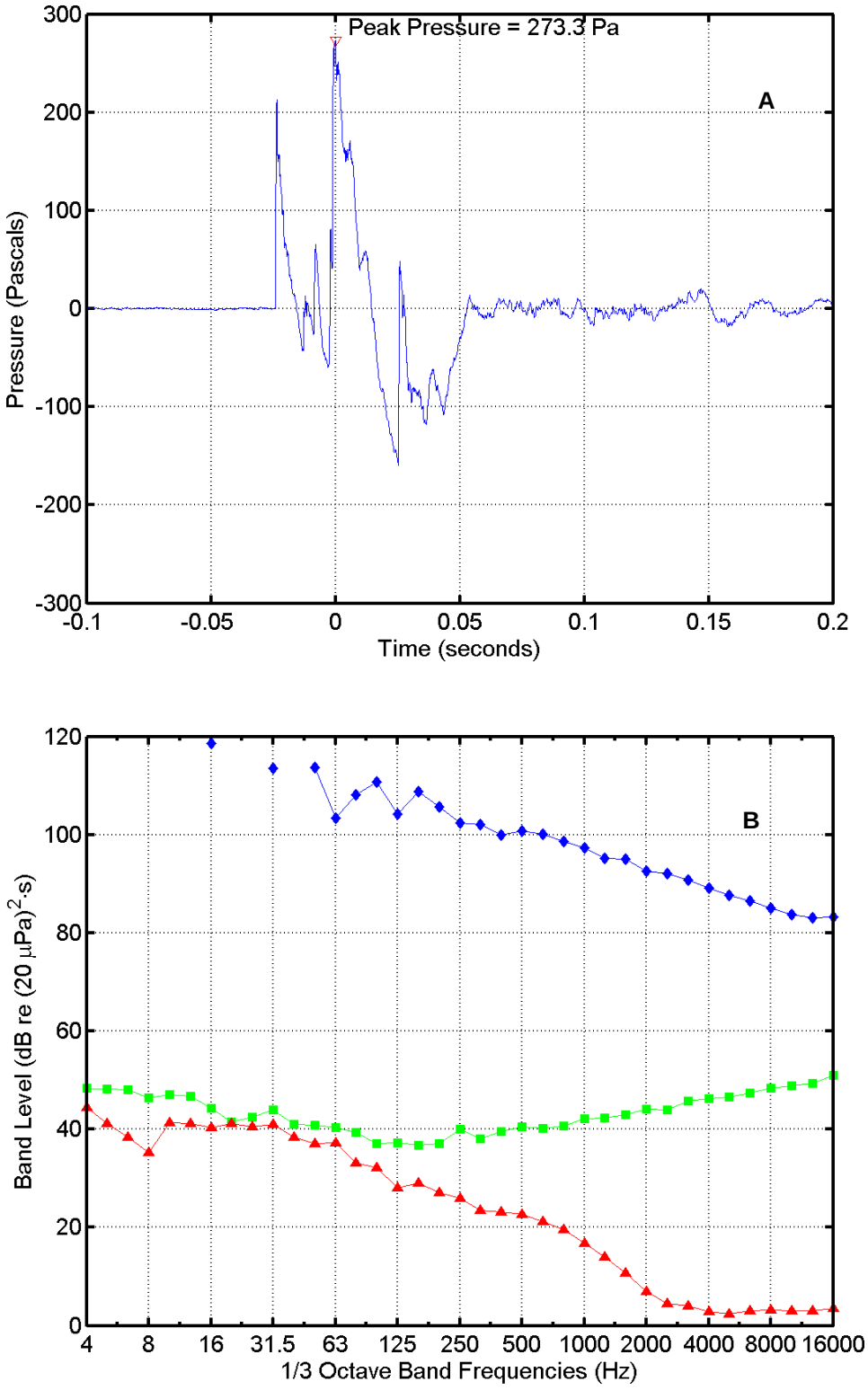


FIGURE B-16. (A) Pressure waveform and (B) one-third octave band levels for the second flight of a Dual Vandal launch at 09:30:04 on 11 March 2005 recorded at "809 Camera". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

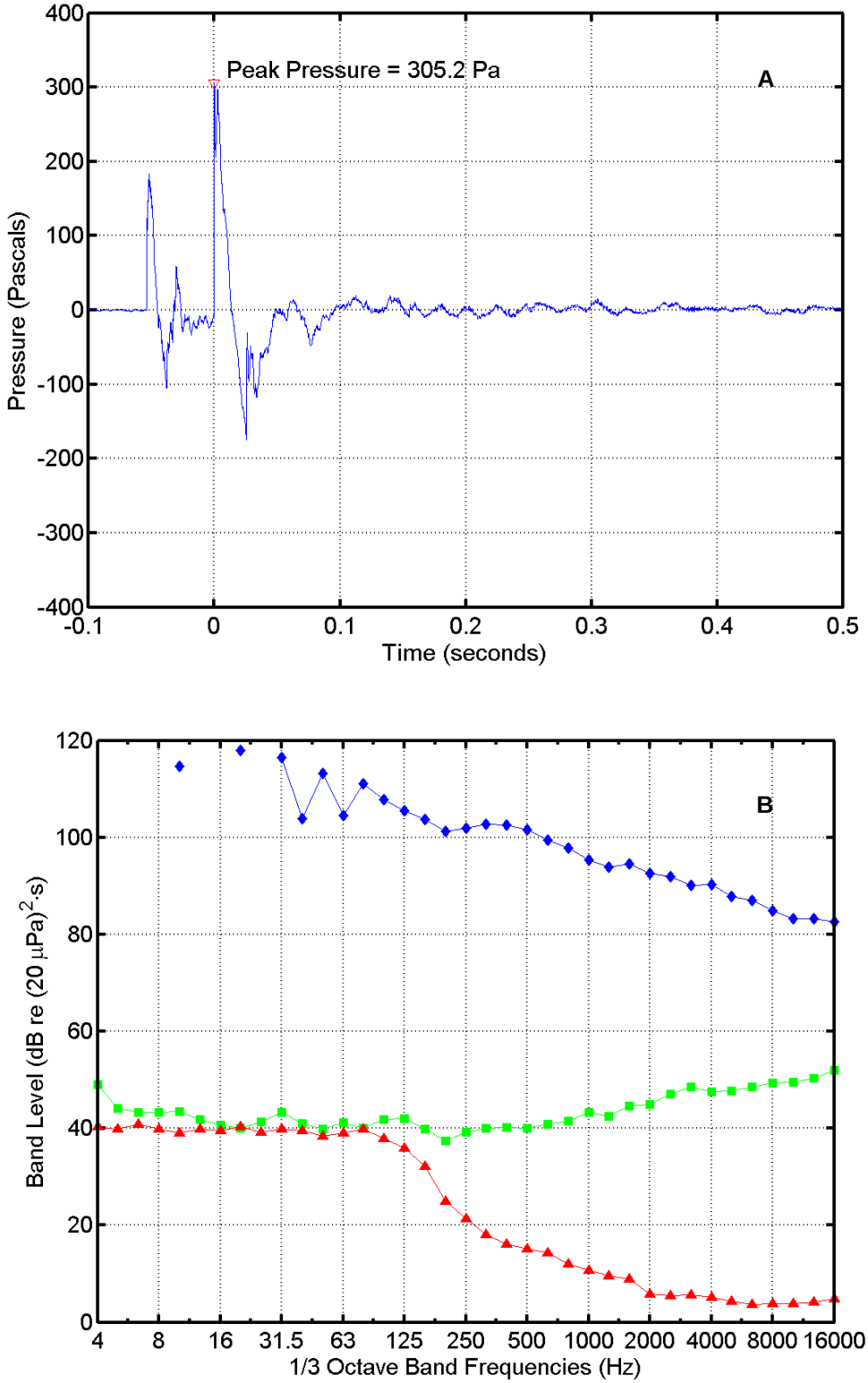


FIGURE B-17. (A) Pressure waveform and (B) one-third octave band levels for the second flight of a Dual Vandal launch at 09:30:04 on 11 March 2005 recorded at "The Y". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

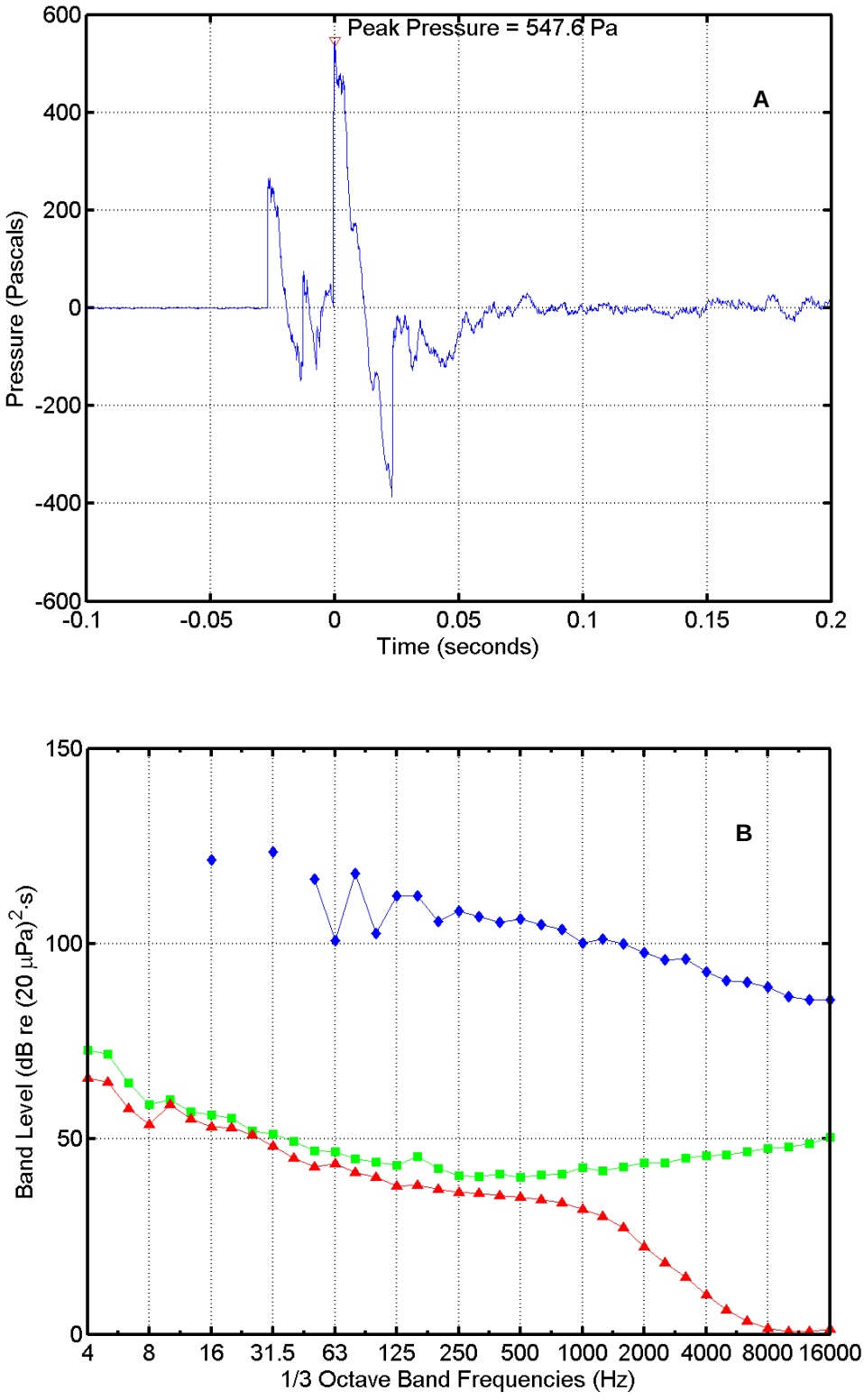


FIGURE B-18. (A) Pressure waveform and (B) one-third octave band levels for the second flight of a Dual Vandal launch at 09:30:04 on 11 March 2005 recorded at "Dos Coves South". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

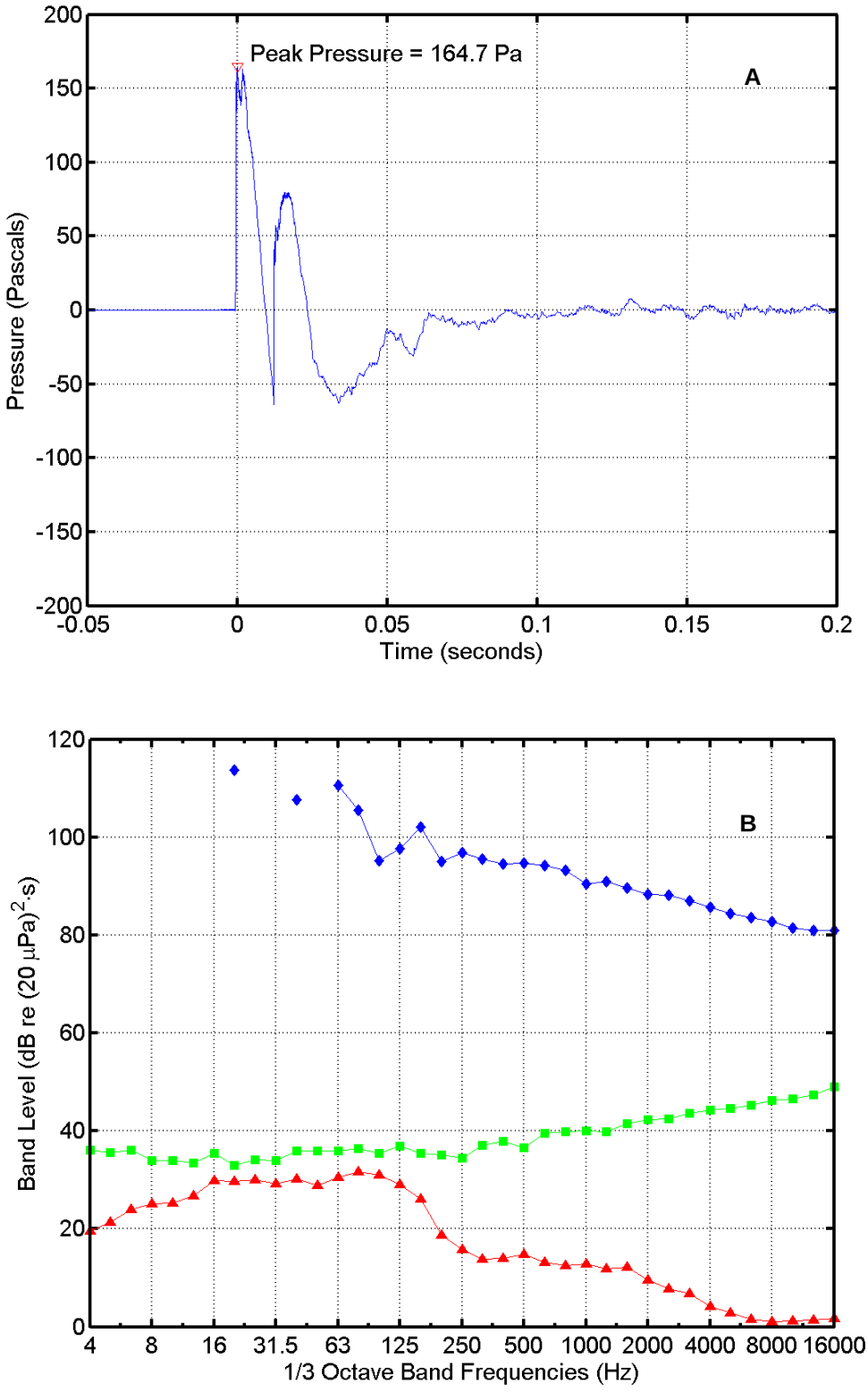


FIGURE B-19. (A) Pressure waveform and (B) one-third octave band levels for an SSST flight at 08:36 on 24 March 2005 recorded at "The Y". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

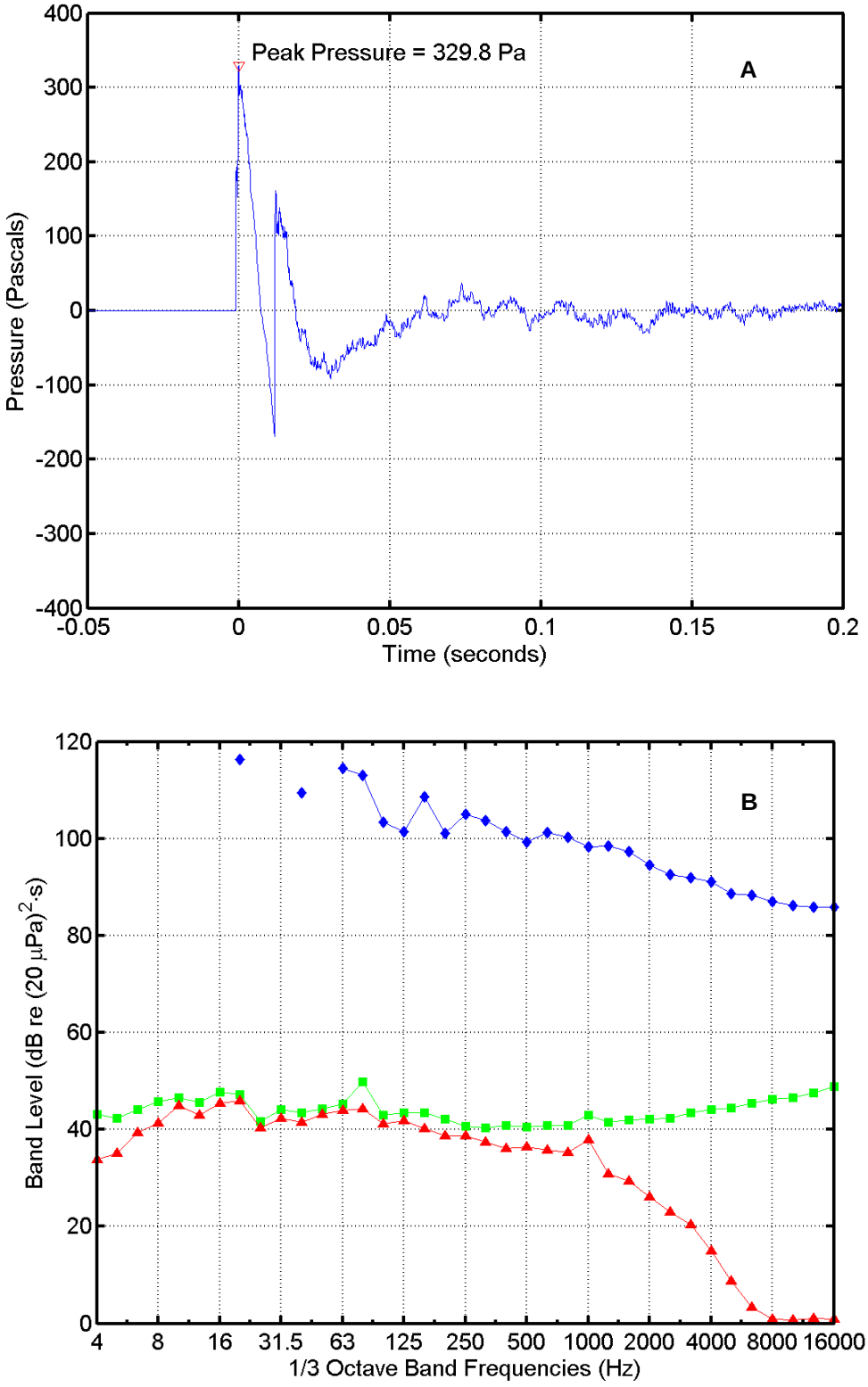


FIGURE B-20. (A) Pressure waveform and (B) one-third octave band levels for an SSST flight at 08:36 on 24 March 2005 recorded at "Dos Coves South". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

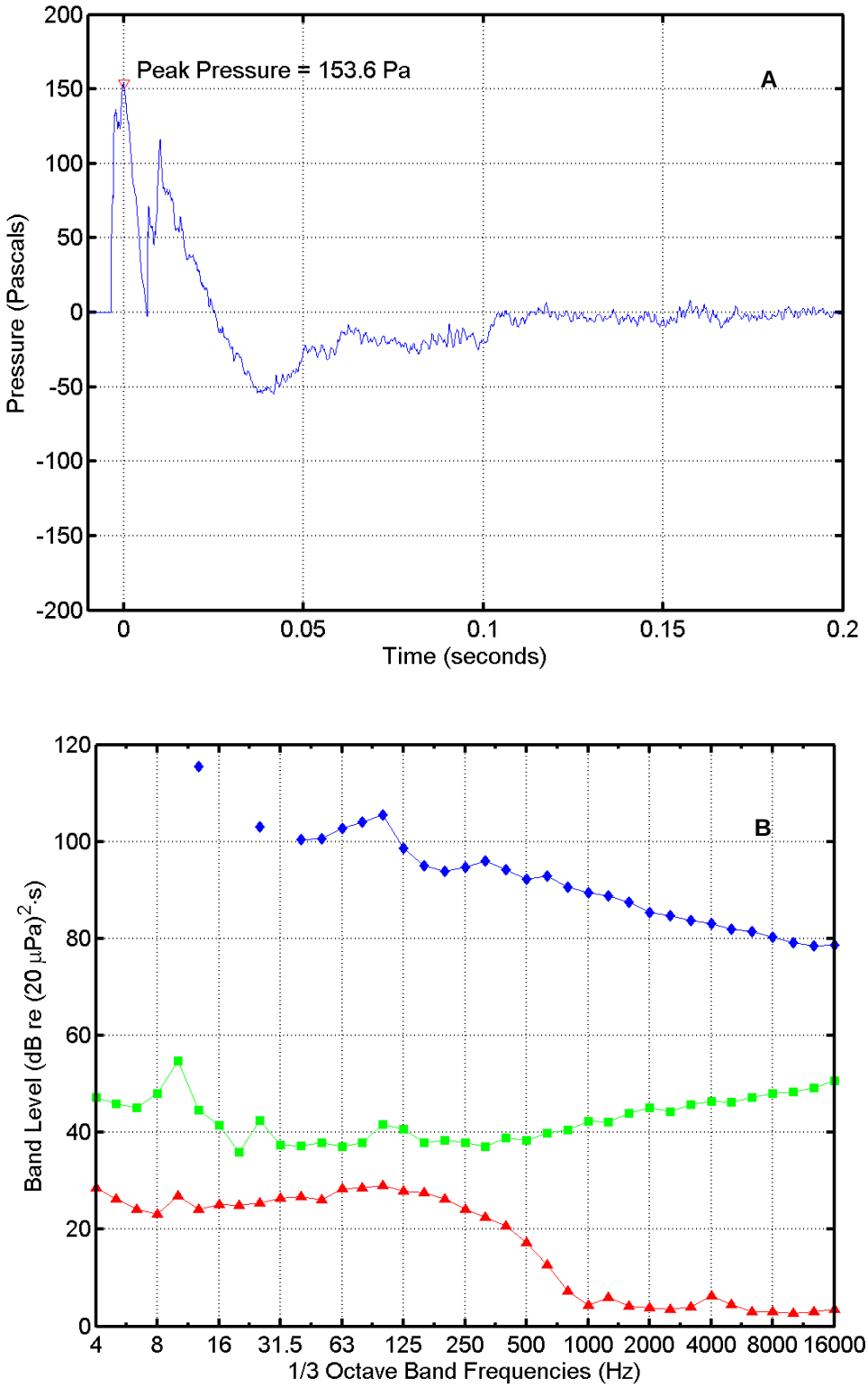


FIGURE B-21. (A) Pressure waveform and (B) one-third octave band levels for an SSST flight at 16:43 on 22 April 2005 recorded at "Redeye I". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

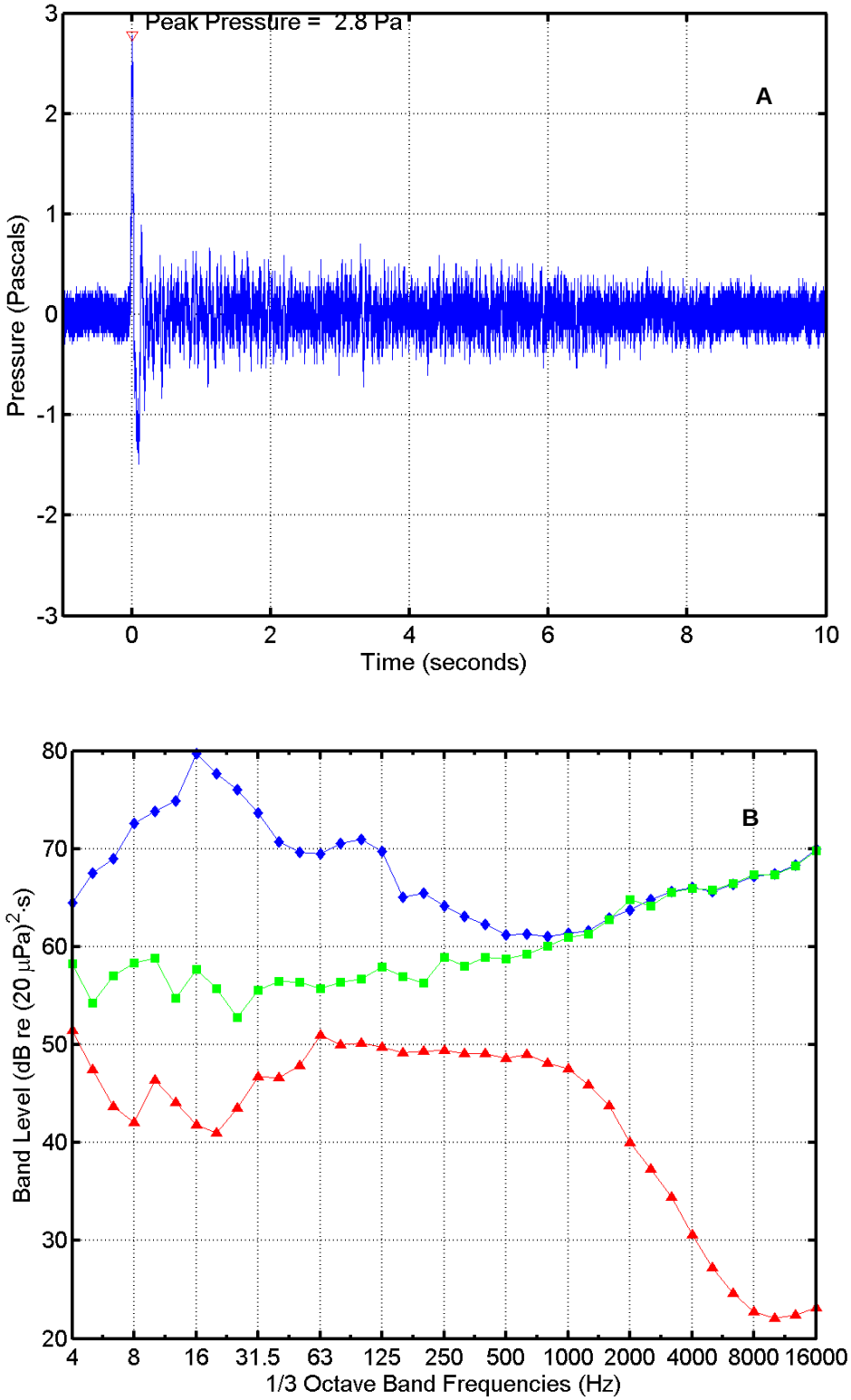


FIGURE B-22. (A) Pressure waveform and (B) one-third octave band levels for an SSST flight at 16:43 on 22 April 2005 recorded at "Phoca Reef". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

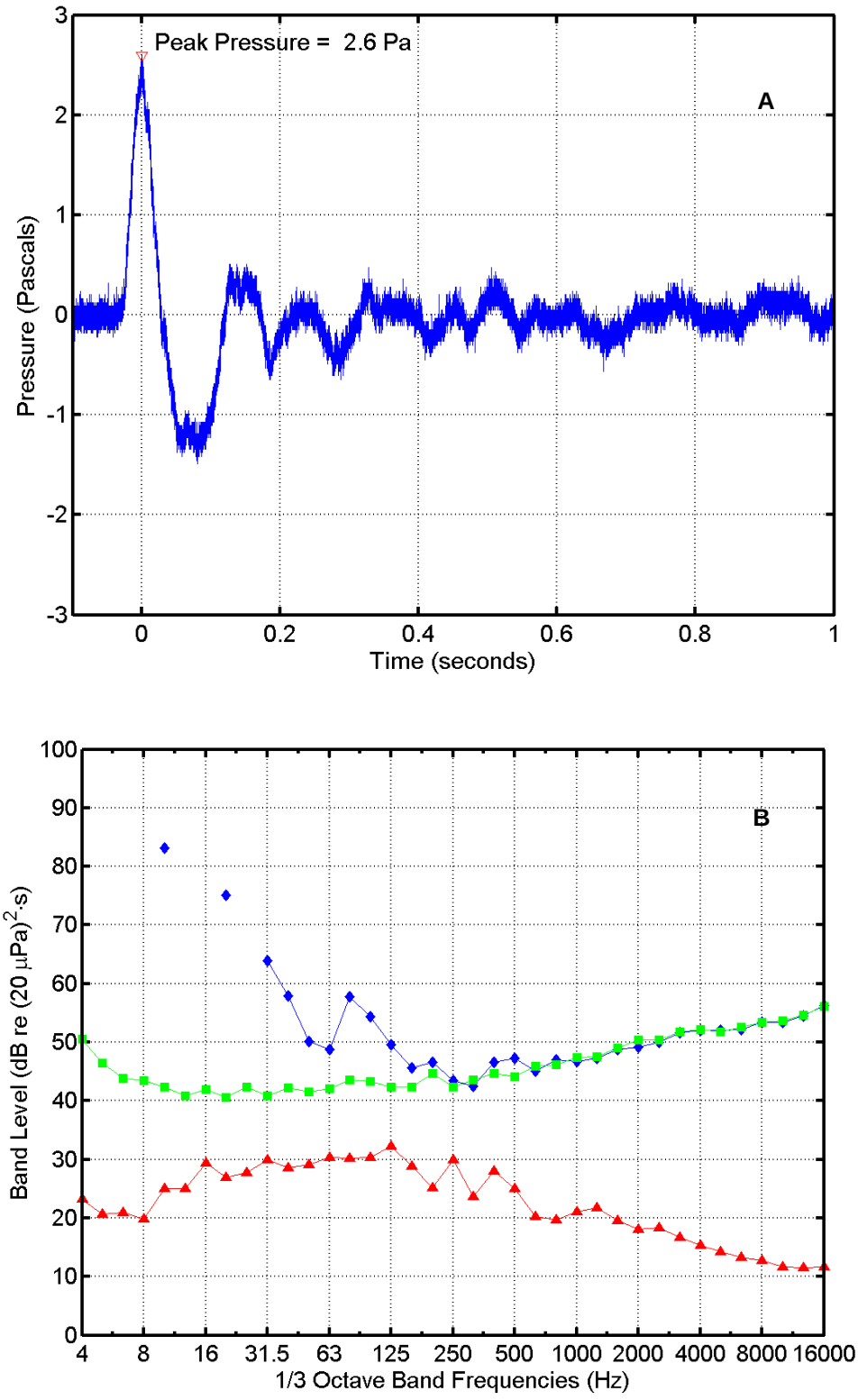


FIGURE B-23. (A) Pressure waveform and (B) one-third octave band levels for an SSST flight at 16:43 on 22 April 2005 recorded at "Phoca Point". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

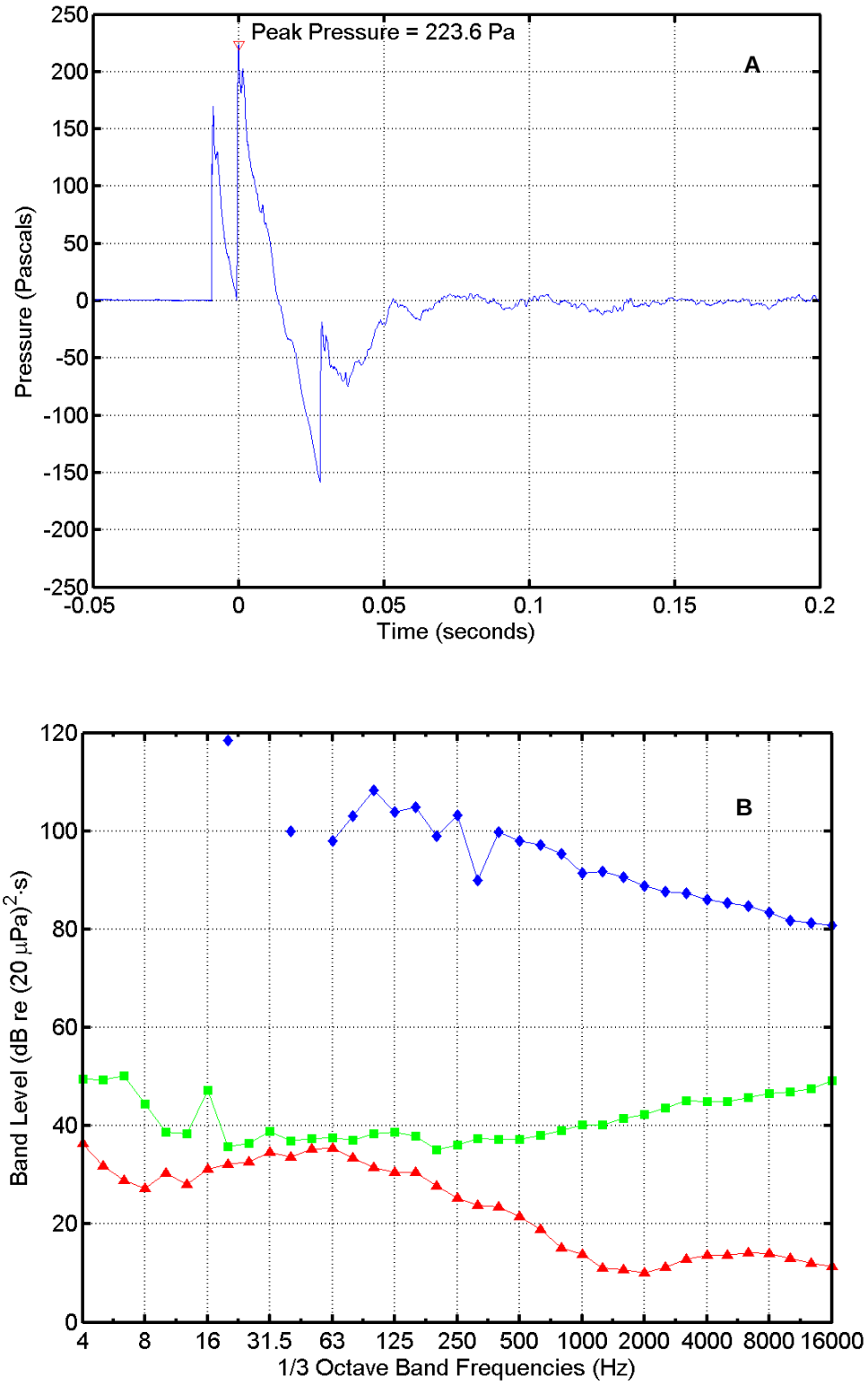


FIGURE B-24. (A) Pressure waveform and (B) one-third octave band levels for a Vandal flight at 07:29 on 2 June 2005 recorded at "Bomber Cove". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

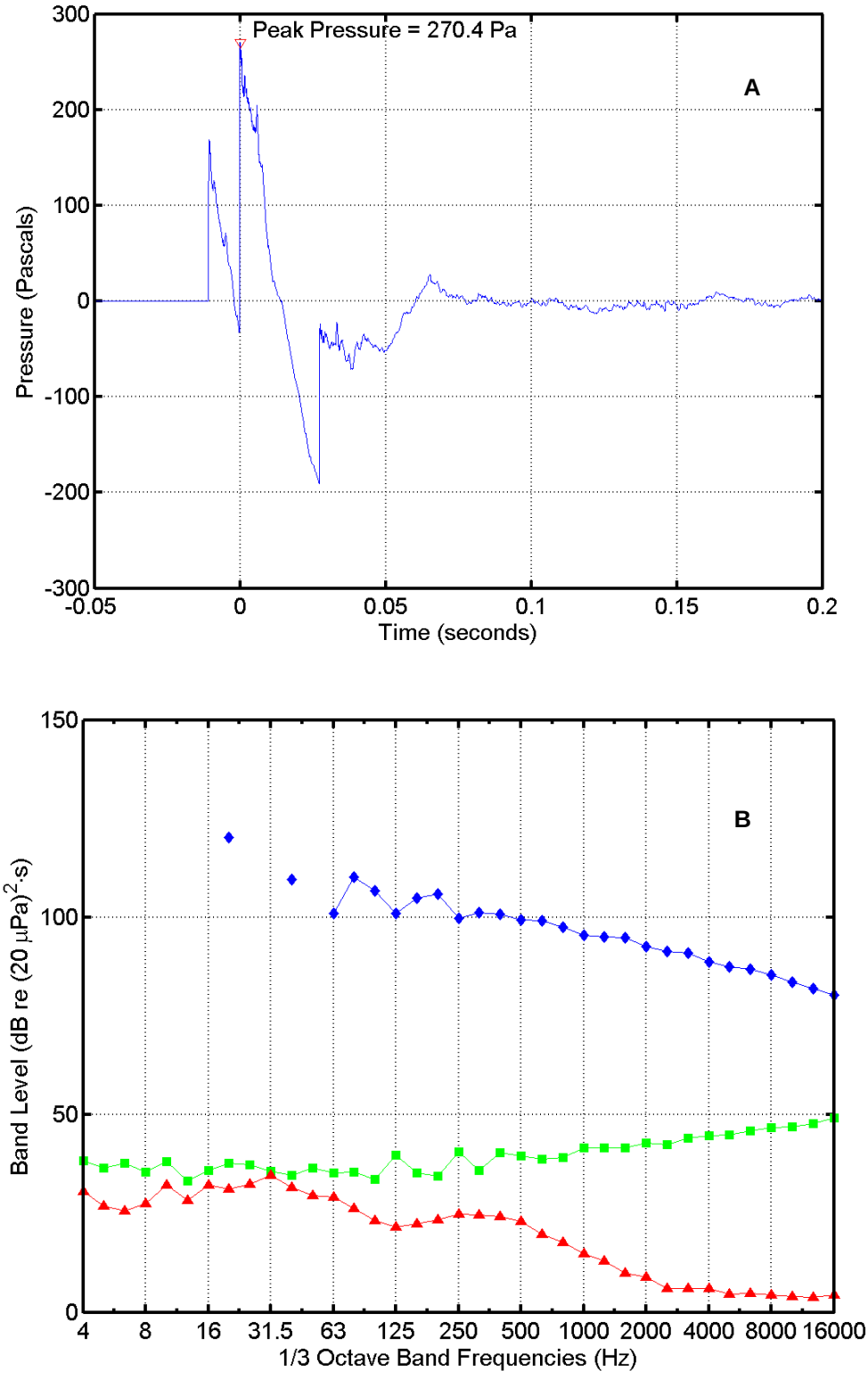
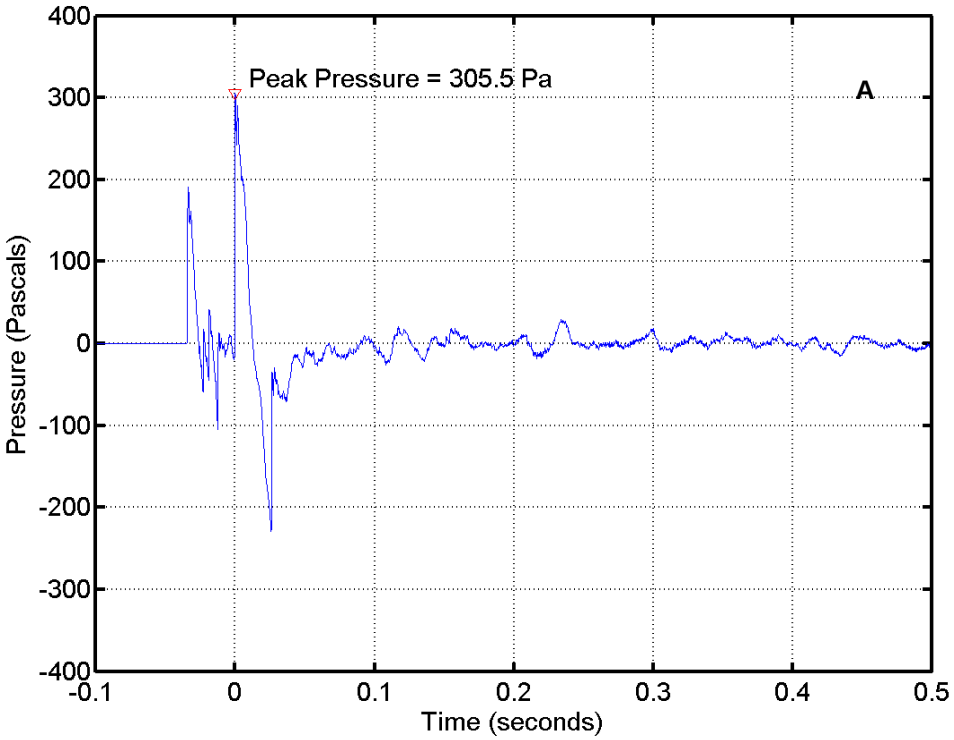


FIGURE B-25. (A) Pressure waveform and (B) one-third octave band levels for a Vandal flight at 07:29 on 2 June 2005 recorded at "809 Camera". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).



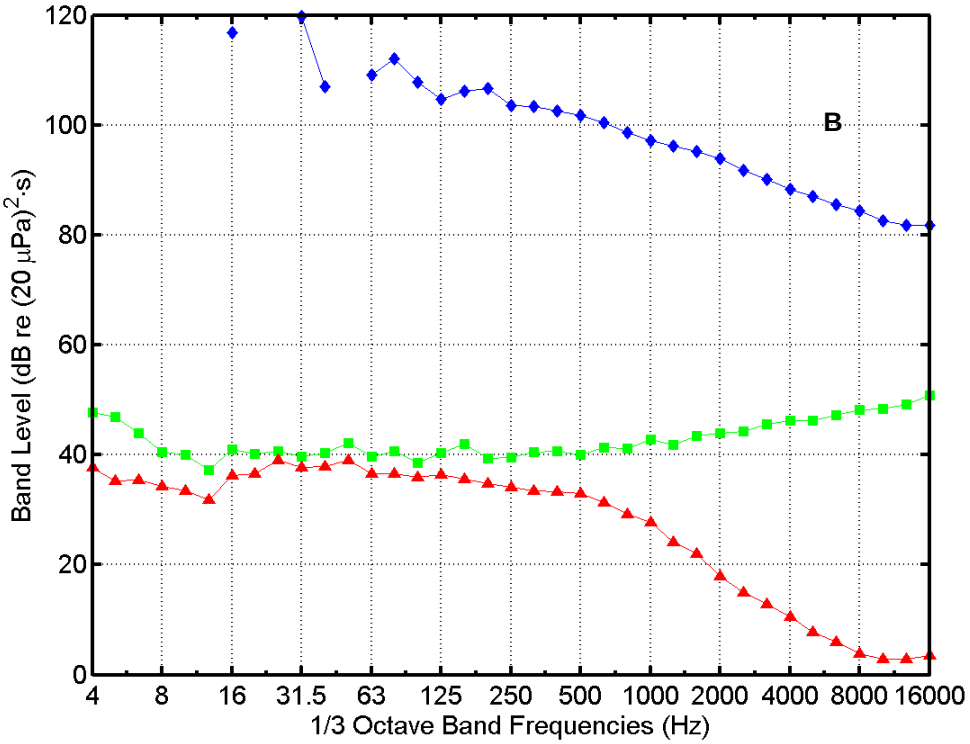


FIGURE B-26. (A) Pressure waveform and (B) one-third octave band levels for a Vandal flight at 07:29 on 2 June 2005 recorded at "The Y". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

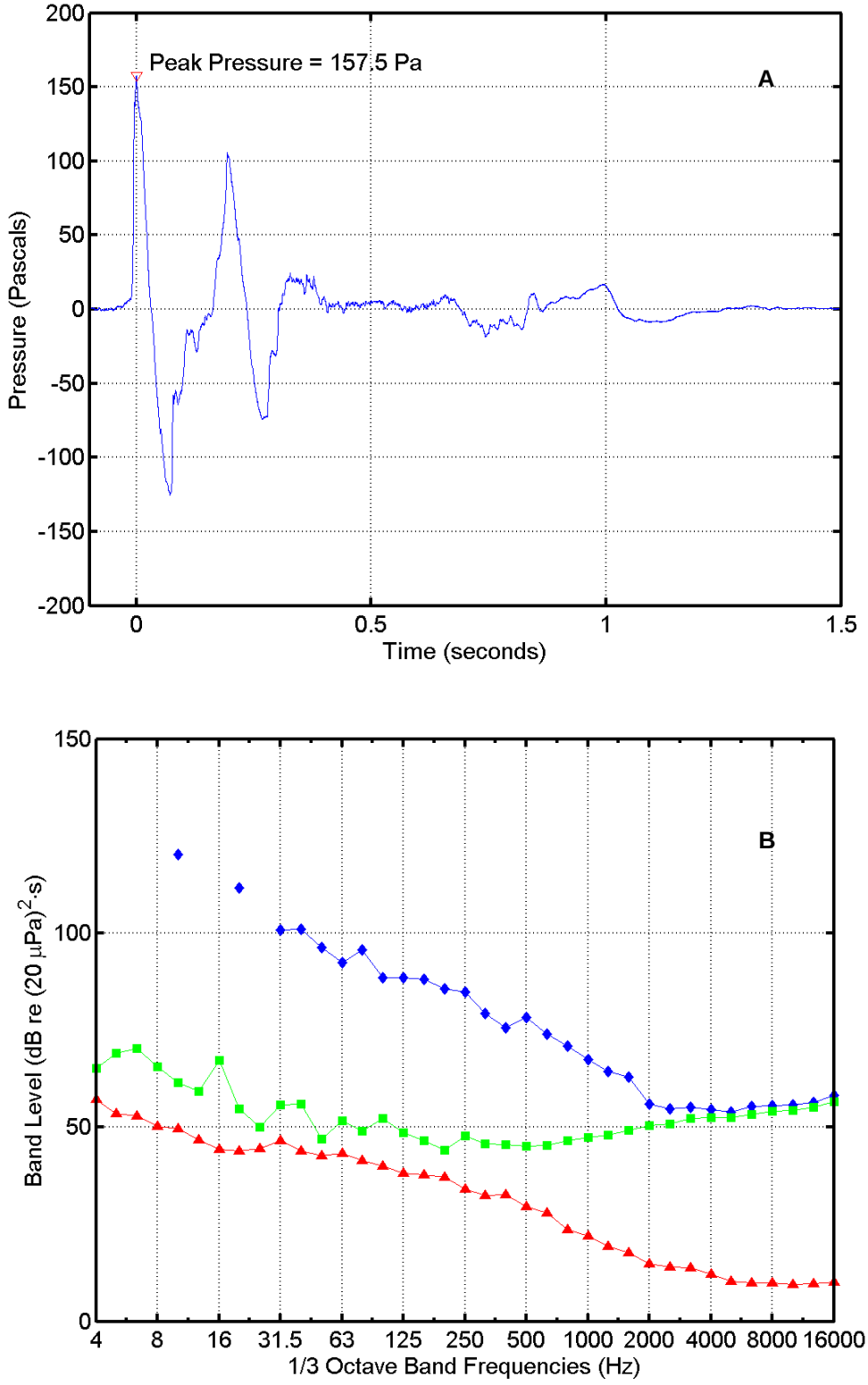


FIGURE B-27. (A) Pressure waveform and (B) one-third octave band levels for a Vandal flight at 09:49 on 2 June 2005 recorded at "Bomber Cove". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

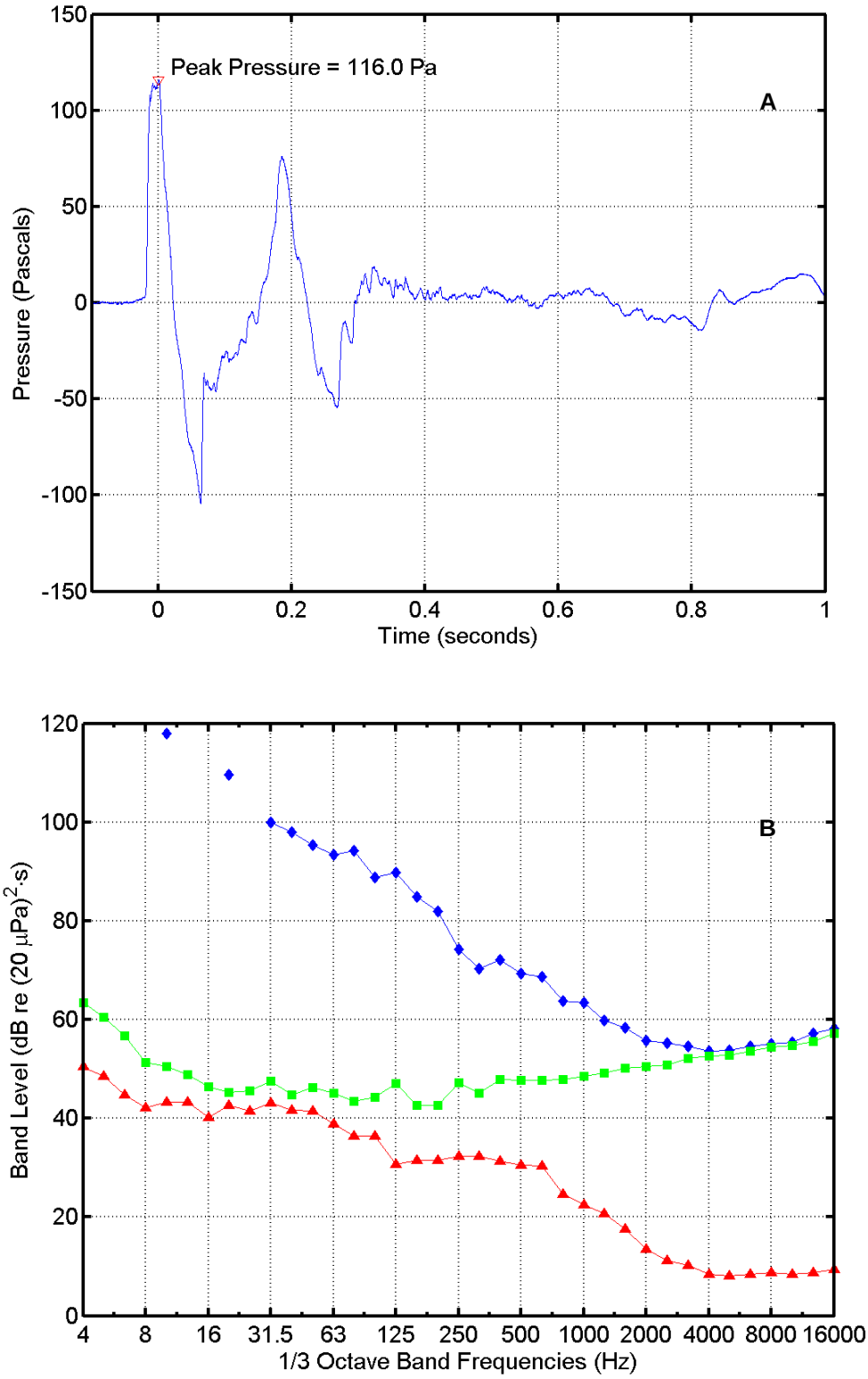


FIGURE B-28. (A) Pressure waveform and (B) one-third octave band levels for a Vandal flight at 09:49 on 2 June 2005 recorded at "809 Camera". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

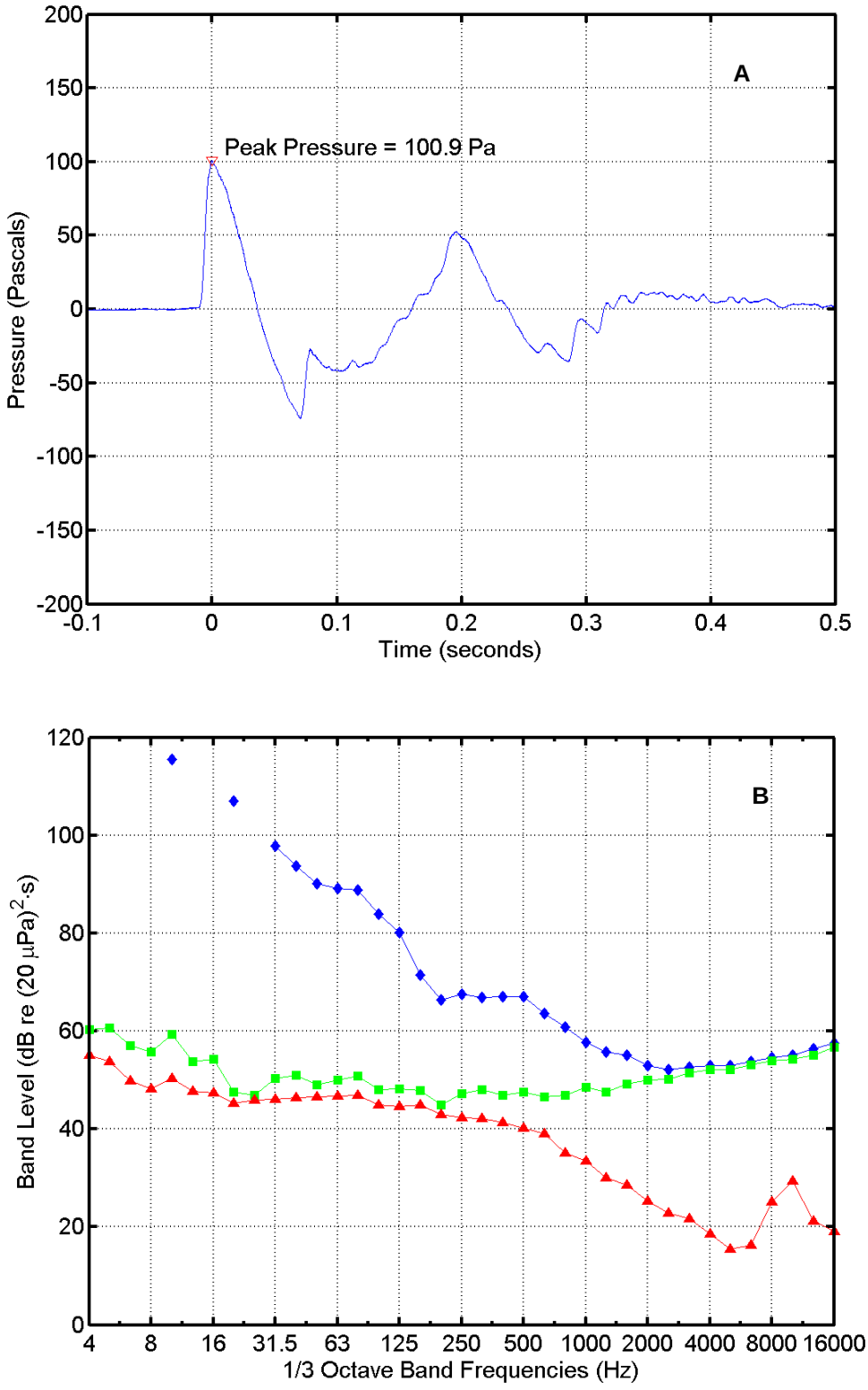


FIGURE B-29. (A) Pressure waveform and (B) one-third octave band levels for a Vandal flight at 09:49 on 2 June 2005 recorded at "The Y". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

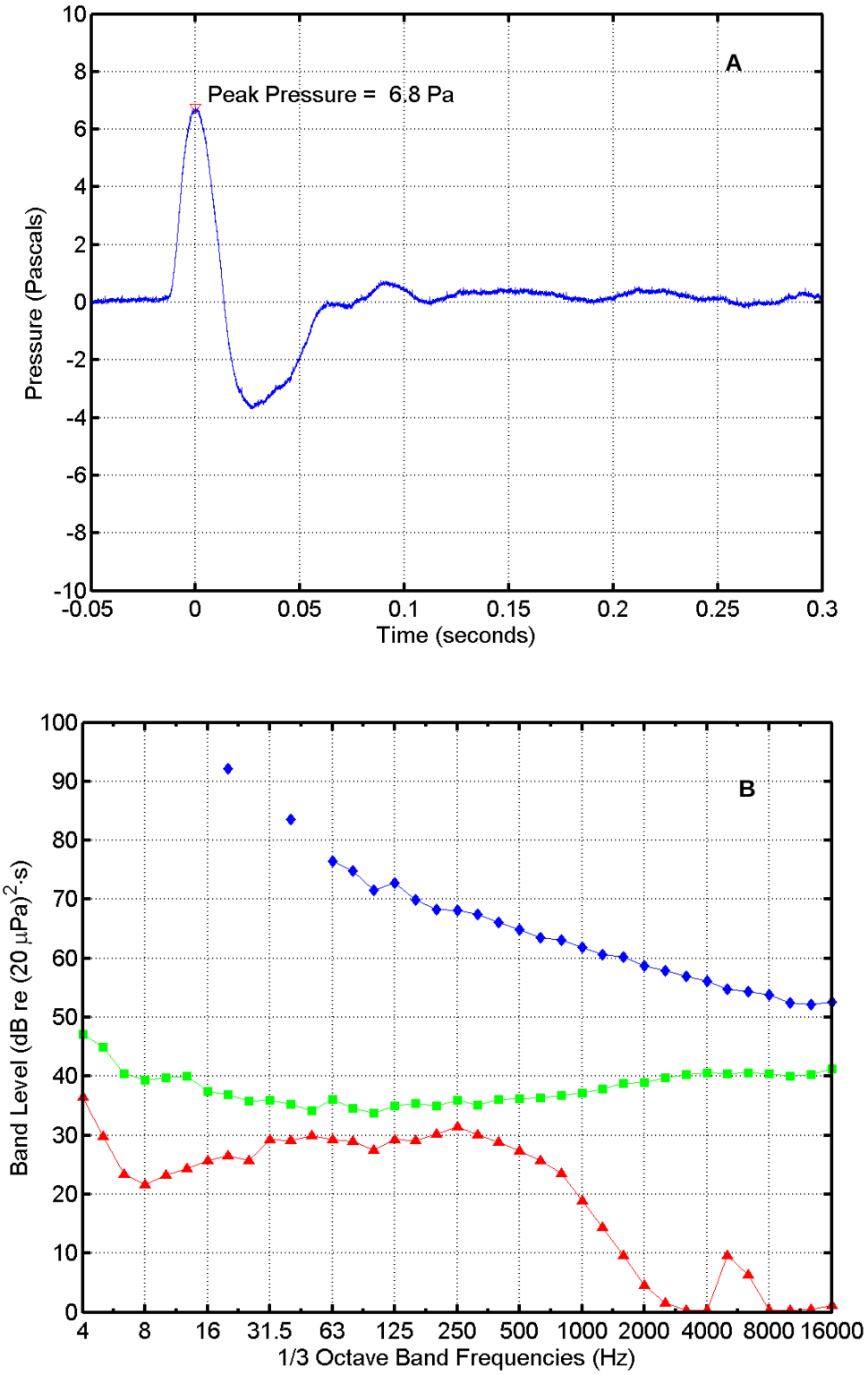


FIGURE B-30. (A) Pressure waveform and (B) one-third octave band levels for an AGS Slug flight at 10:08 on 16 June 2005 recorded at "Redeye I". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

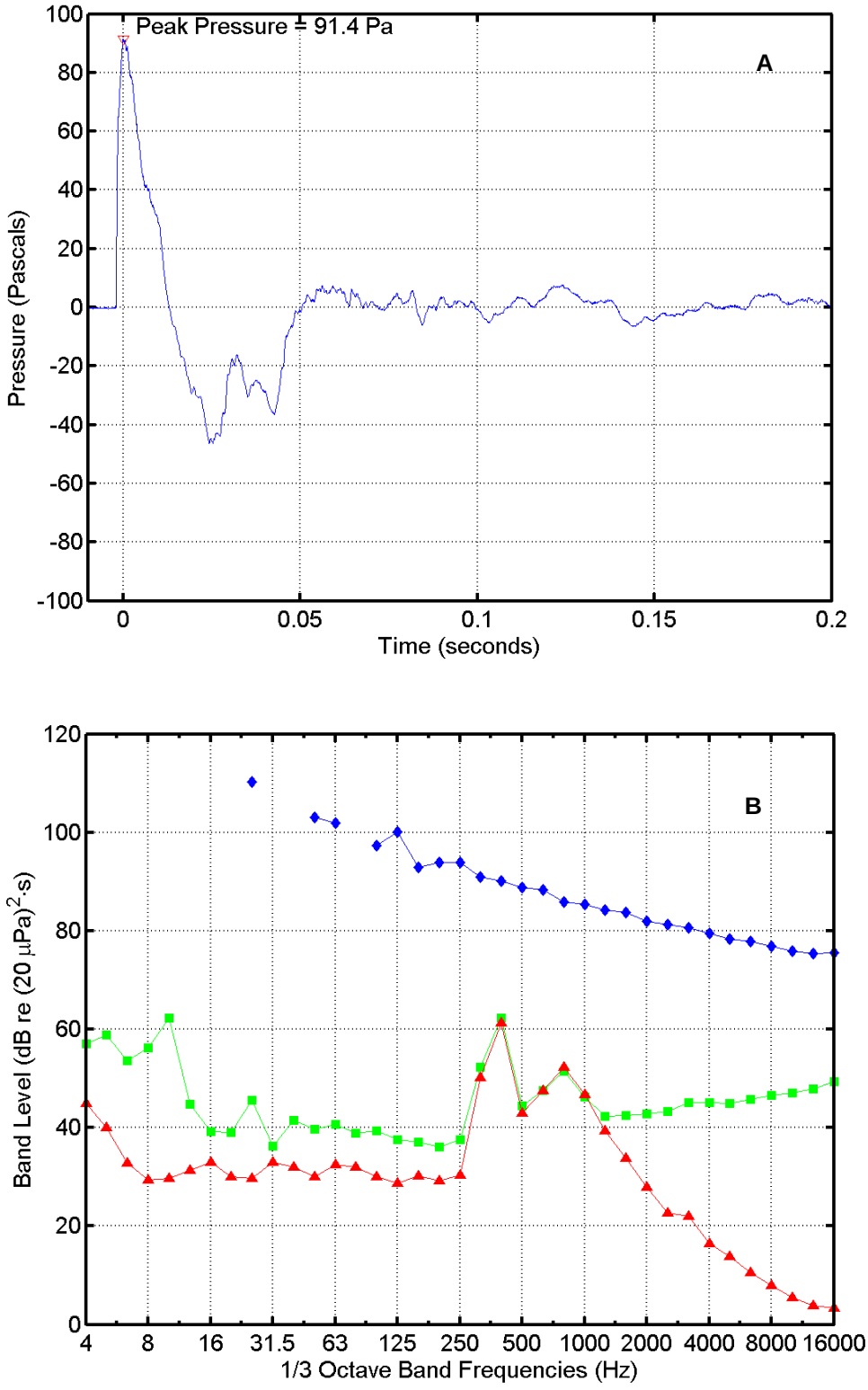


FIGURE B-31. (A) Pressure waveform and (B) one-third octave band levels for an AGS Slug flight at 10:08 on 16 June 2005 recorded at "Dos Coves South". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

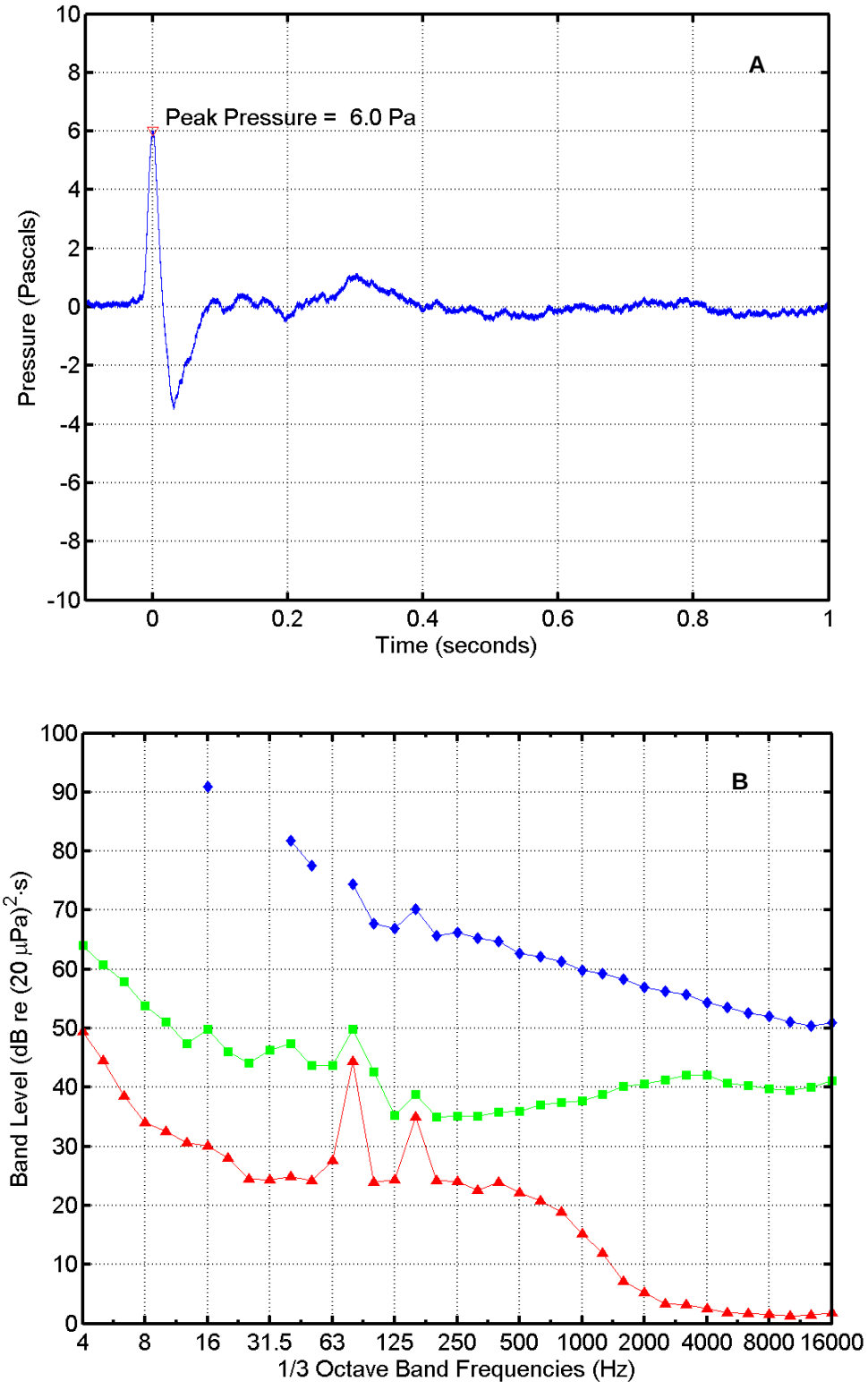


FIGURE B-32. (A) Pressure waveform and (B) one-third octave band levels for an AGS Missile flight at 14:00 on 16 June 2005 recorded at "Redeye I". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

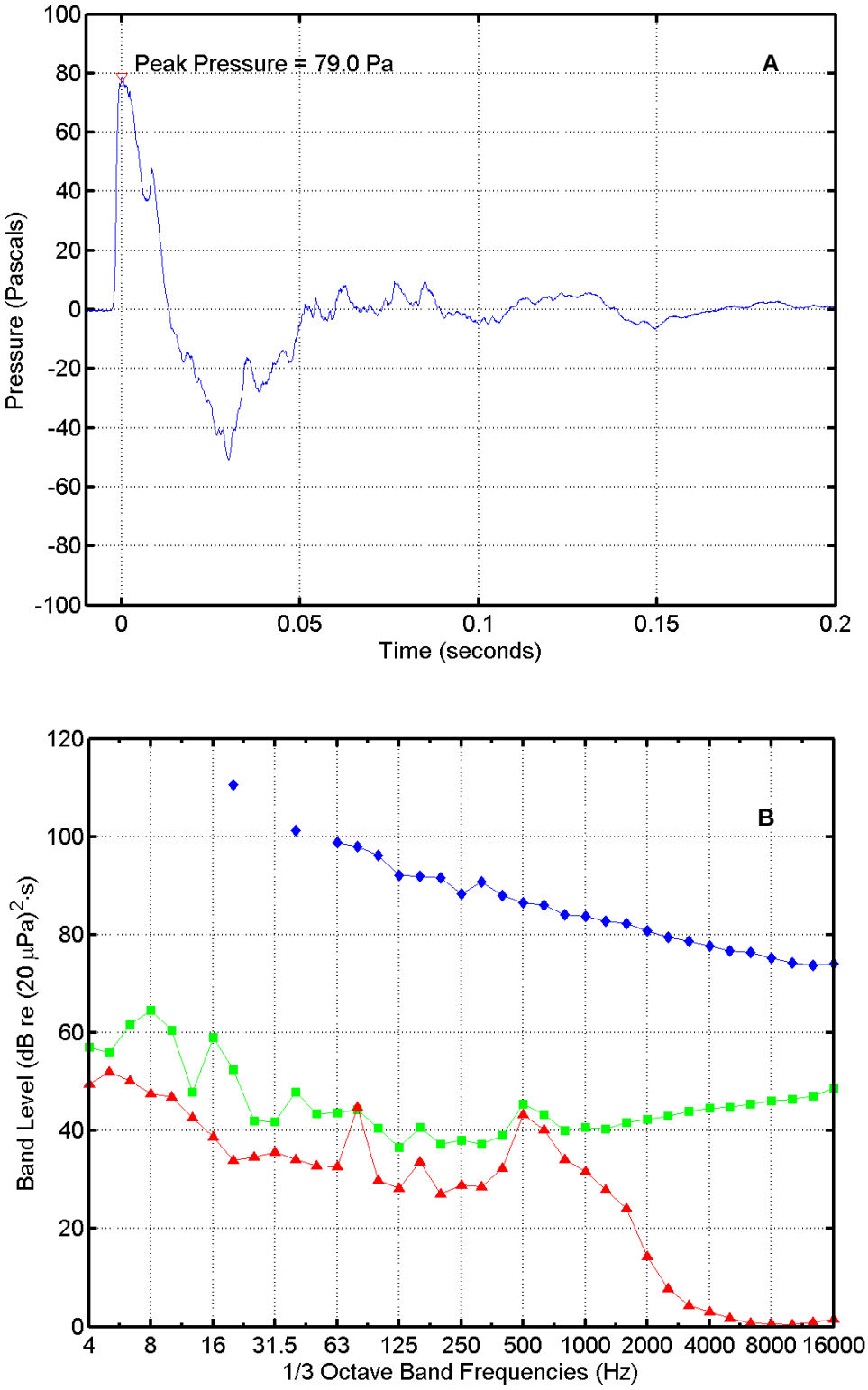


FIGURE B-33. (A) Pressure waveform and (B) one-third octave band levels for an AGS Missile flight at 14:00 on 16 June 2005 recorded at "Dos Coves South". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

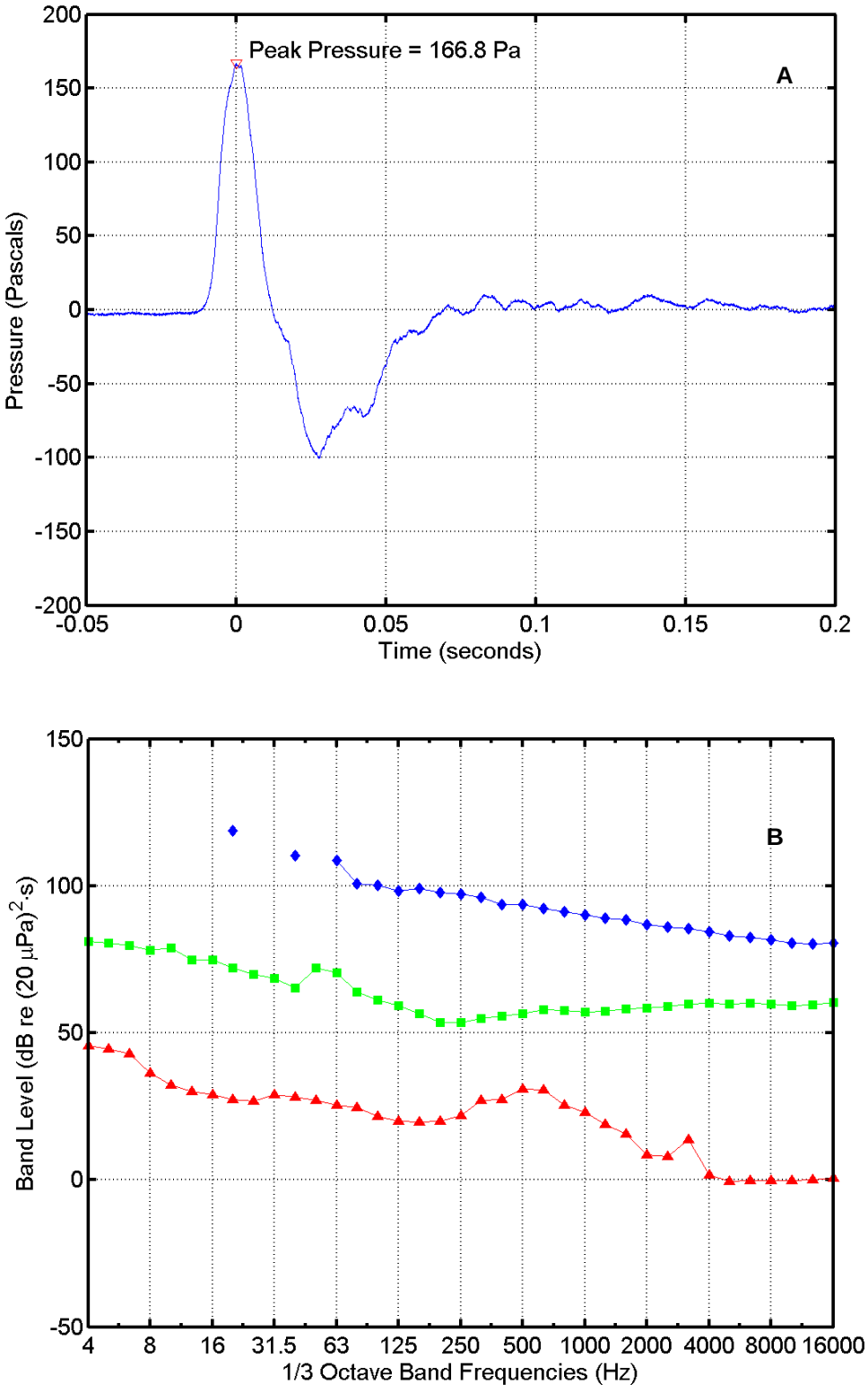


FIGURE B-34. (A) Pressure waveform and (B) one-third octave band levels for an AGS Slug flight at 08:56 on 29 June 2005 recorded at "The Y". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

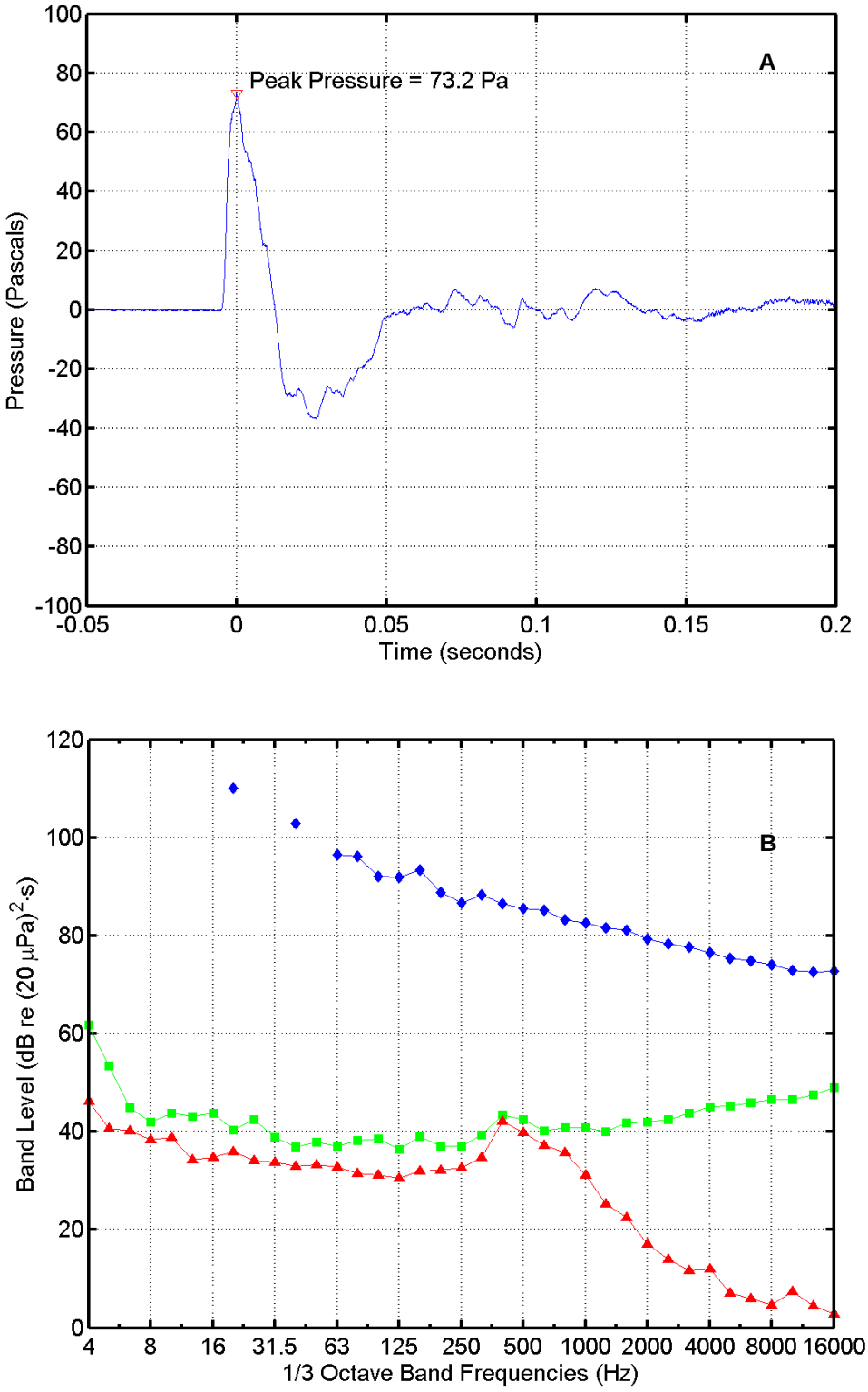


FIGURE B-35. (A) Pressure waveform and (B) one-third octave band levels for an AGS Slug flight at 08:56 on 29 June 2005 recorded at "Dos Coves Gate". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

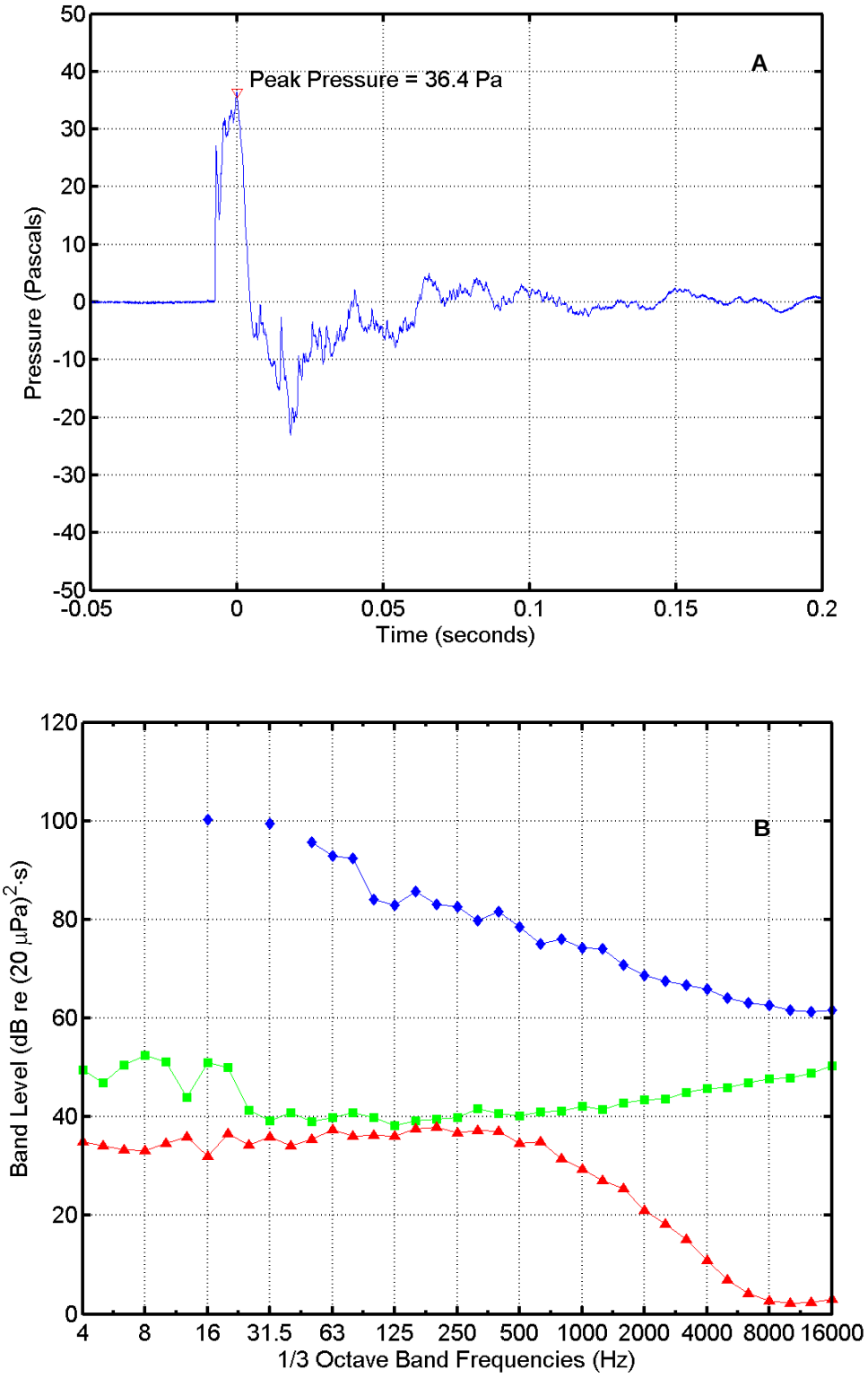


FIGURE B-36. (A) Pressure waveform and (B) one-third octave band levels for an AGS Slug flight at 08:56 on 29 June 2005 recorded at "Bachelor Beach". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

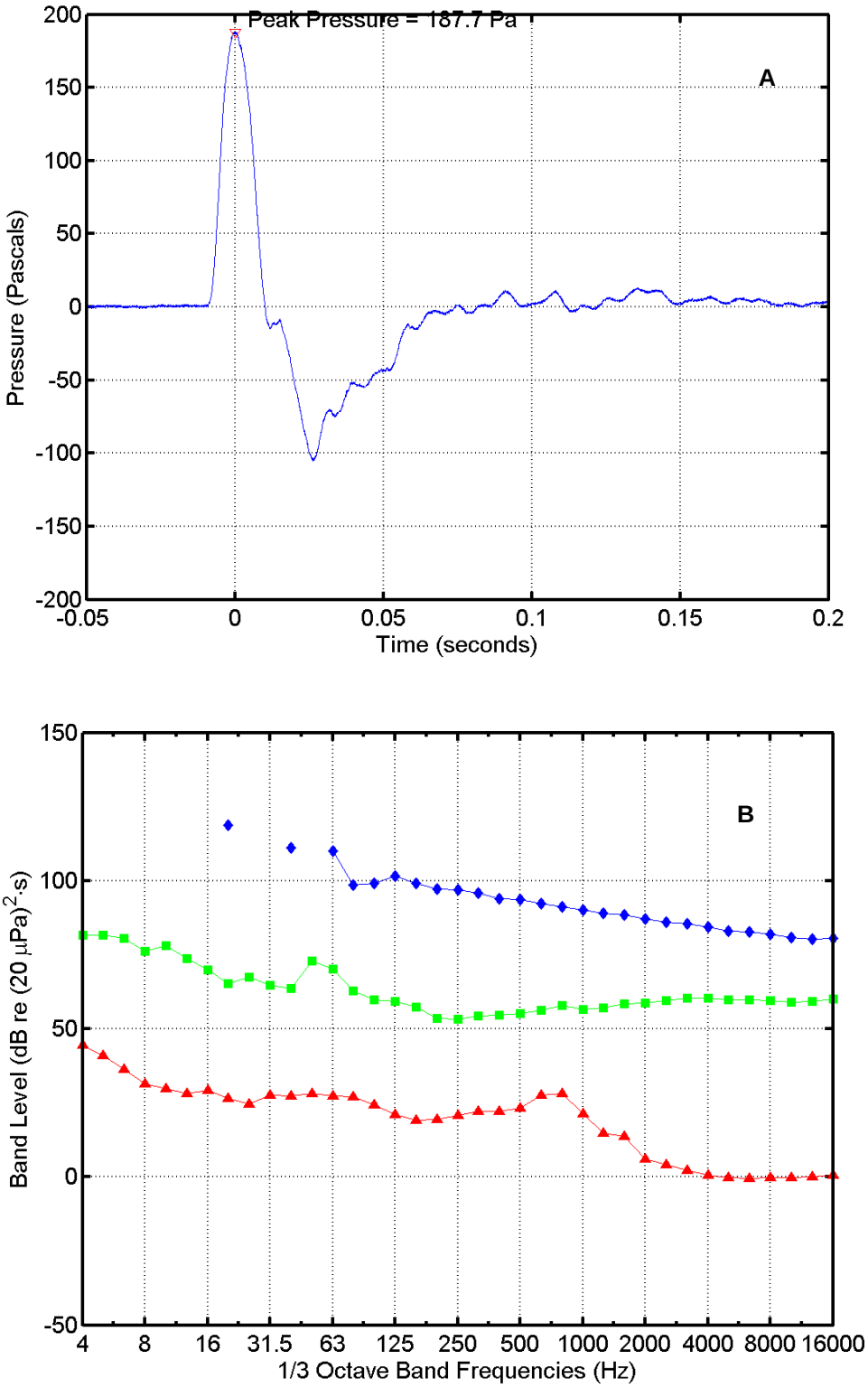


FIGURE B-37. (A) Pressure waveform and (B) one-third octave band levels for an AGS Slug flight at 11:04 on 29 June 2005 recorded at "The Y". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

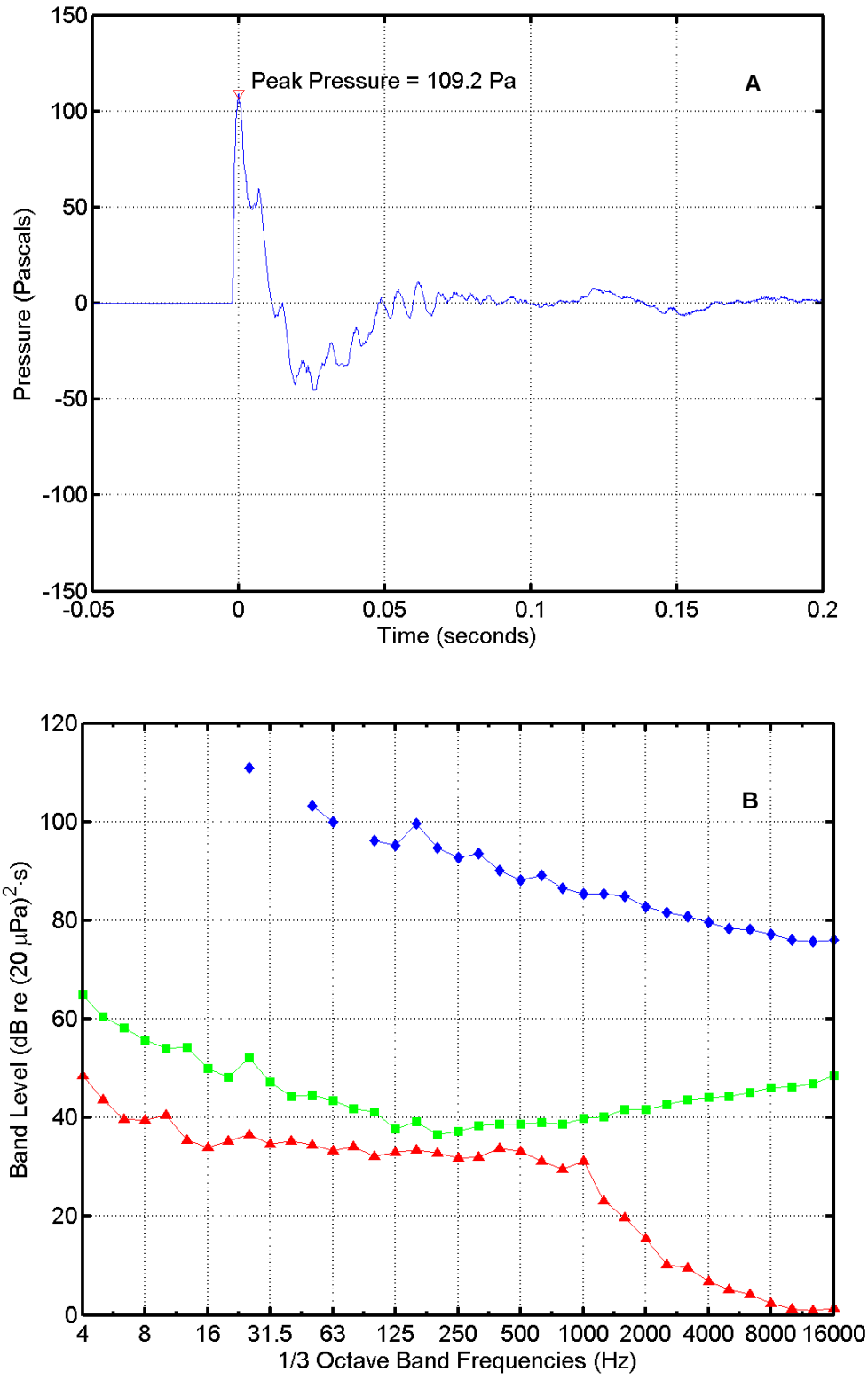


FIGURE B-38. (A) Pressure waveform and (B) one-third octave band levels for an AGS Slug flight at 11:04 on 29 June 2005 recorded at "Dos Coves Gate". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

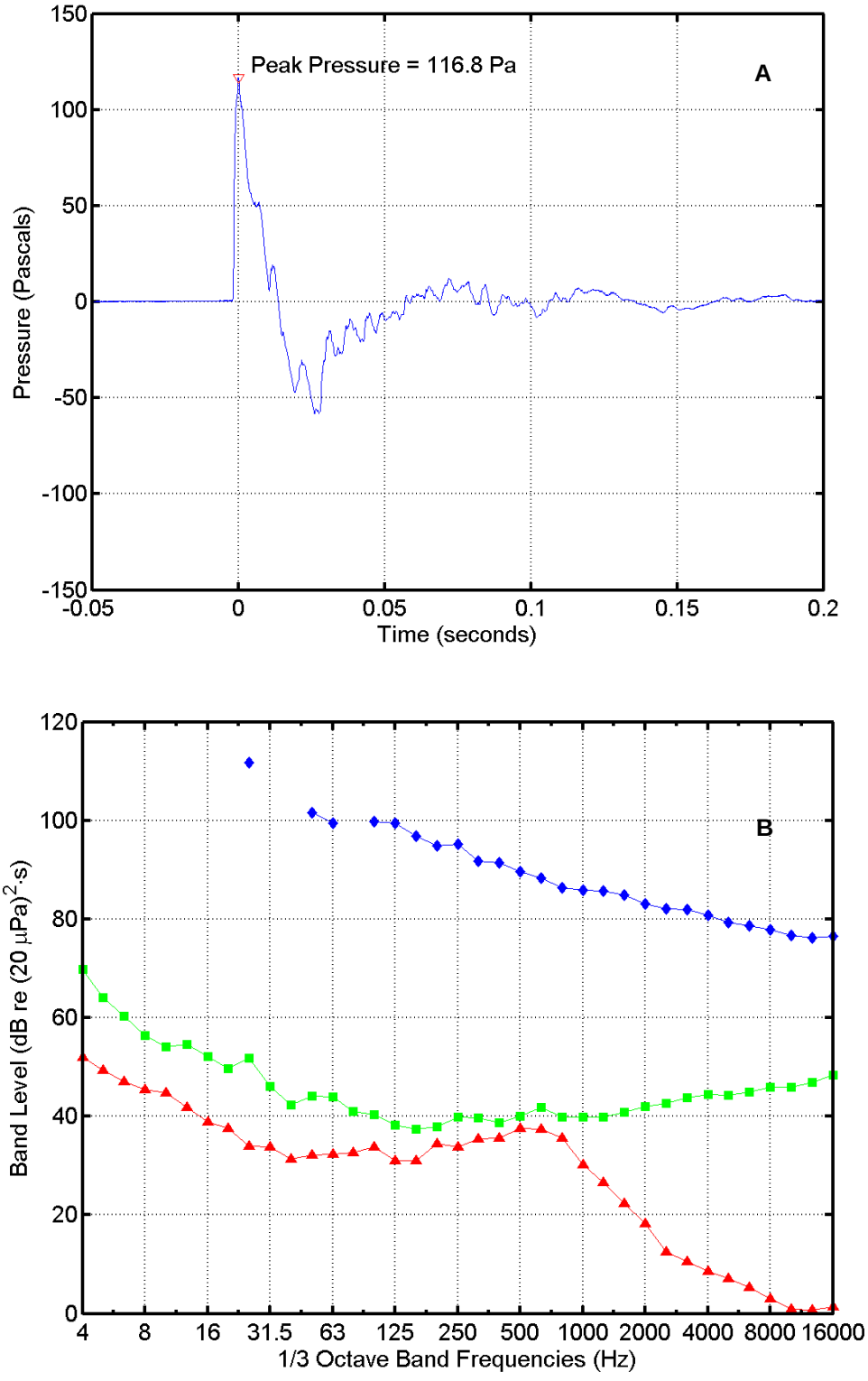


FIGURE B-39. (A) Pressure waveform and (B) one-third octave band levels for an AGS Slug flight at 14:35 on 29 June 2005 recorded at "Dos Coves Gate". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

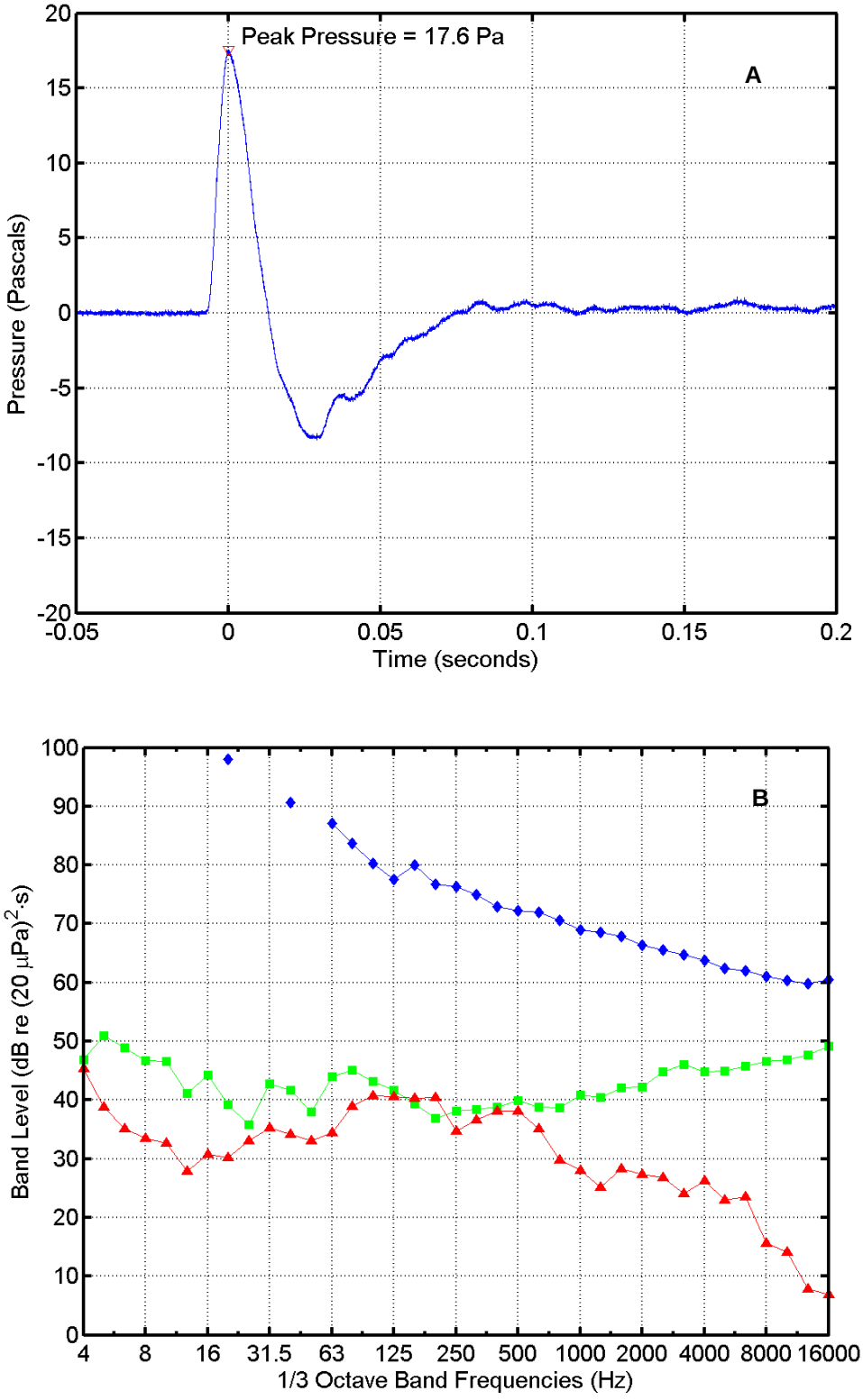


FIGURE B-40. (A) Pressure waveform and (B) one-third octave band levels for an AGS Slug flight at 12:56 on 26 July 2005 recorded at "Bomber Cove". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

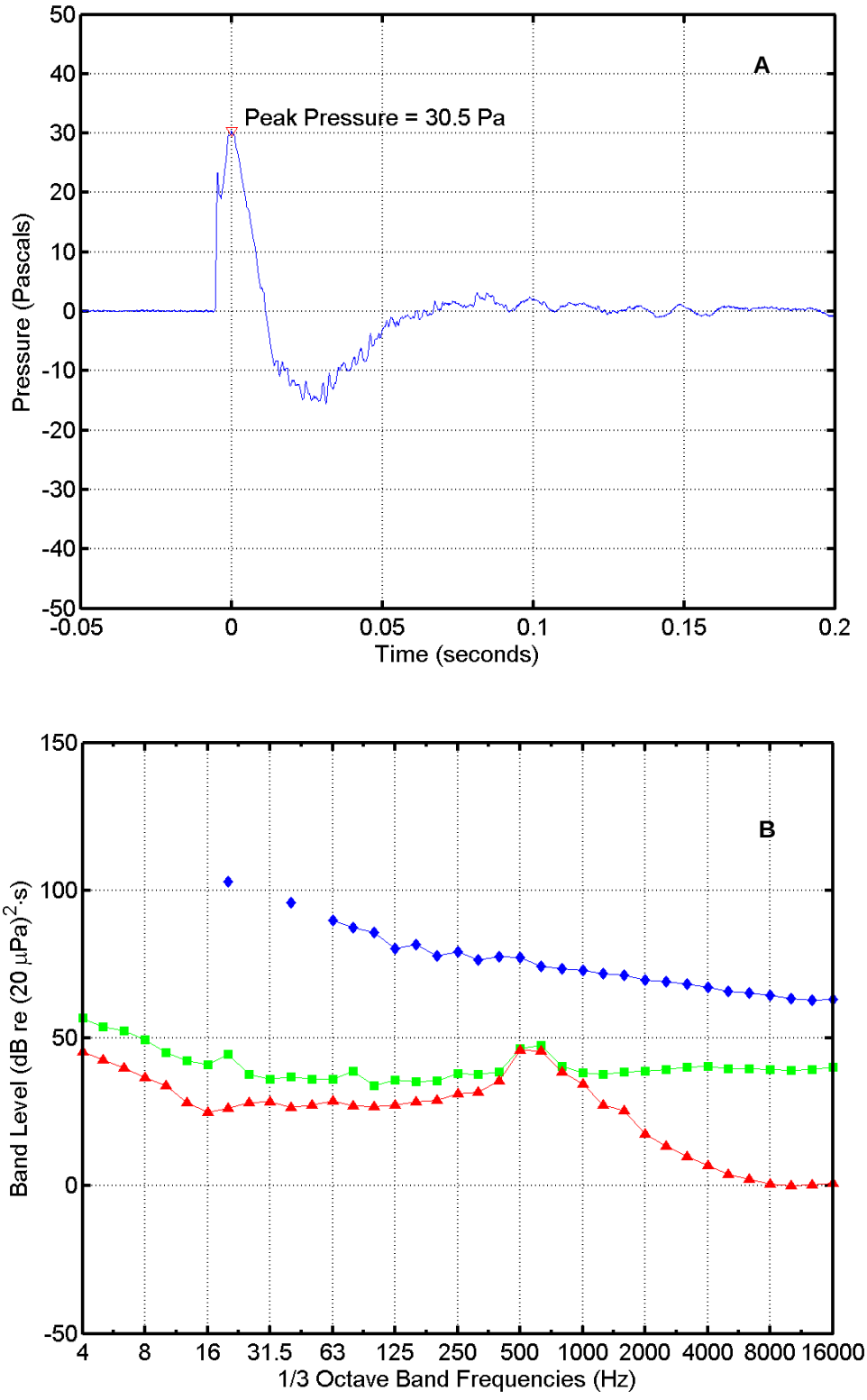


FIGURE B-41. (A) Pressure waveform and (B) one-third octave band levels for an AGS Slug flight at 12:56 on 26 July 2005 recorded at "The Y". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

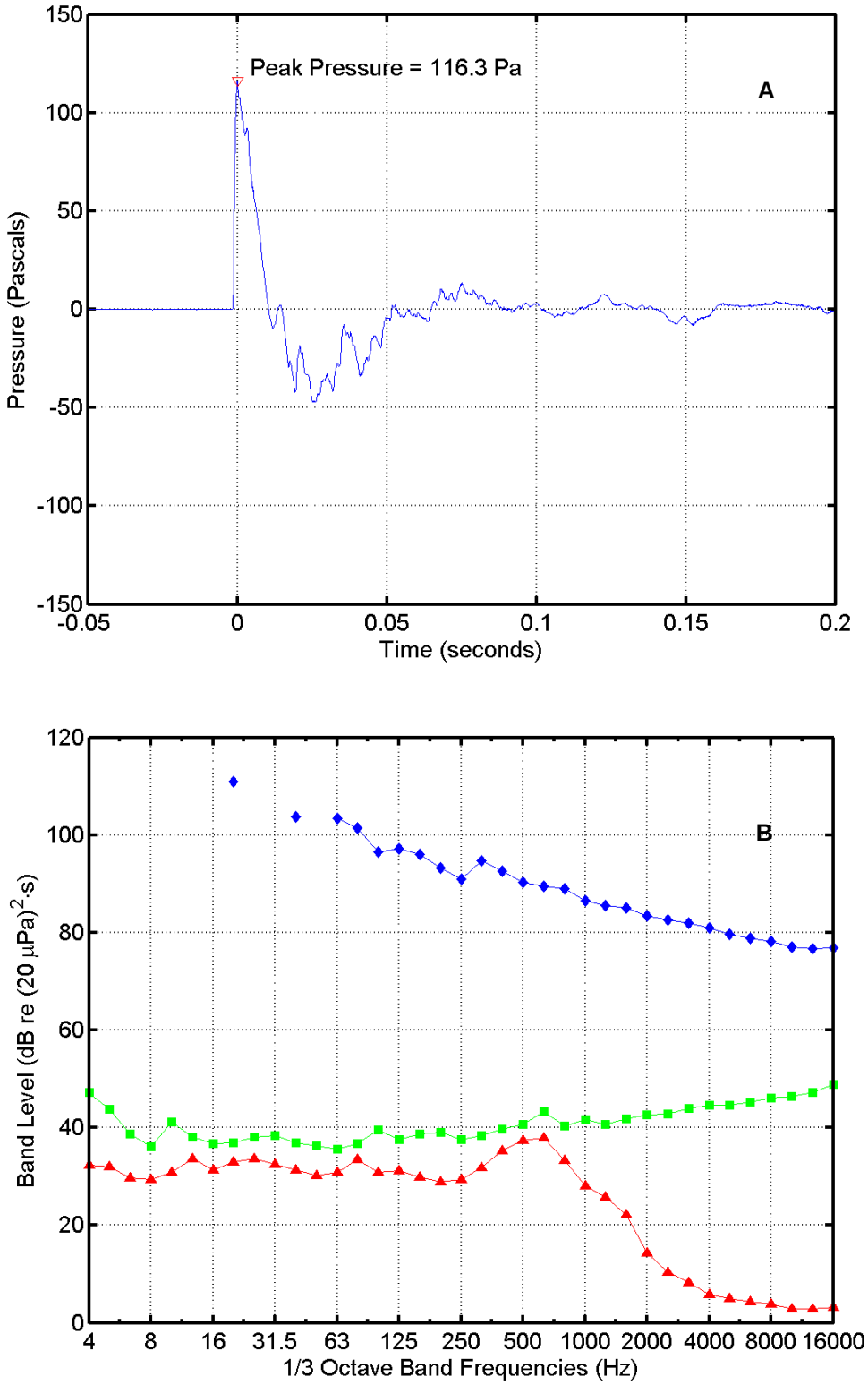


FIGURE B-42. (A) Pressure waveform and (B) one-third octave band levels for an AGS Slug flight at 12:56 on 26 July 2005 recorded at "Dos Coves South". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

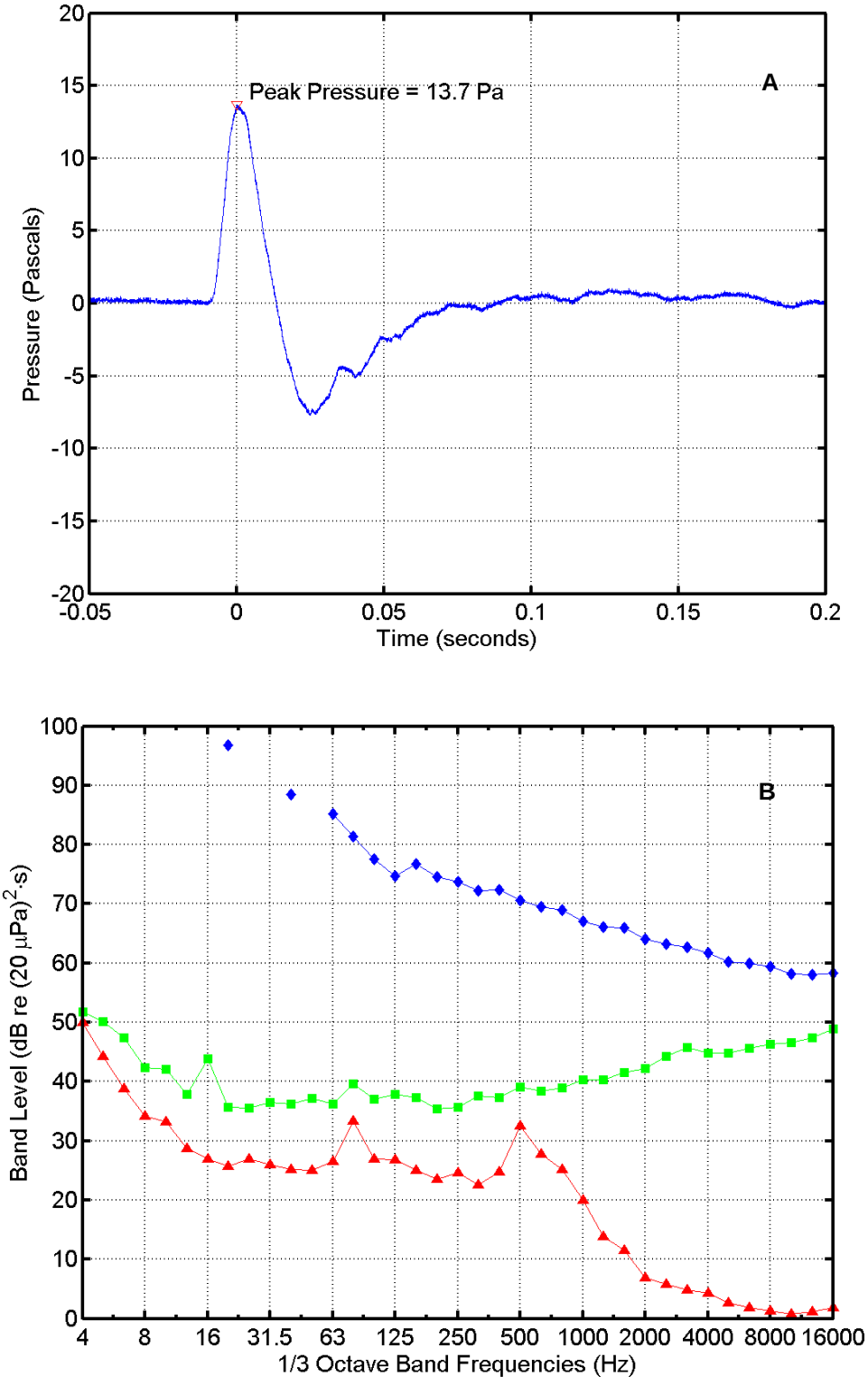


FIGURE B-43. (A) Pressure waveform and (B) one-third octave band levels for an AGS Missile flight at 14:53 on 26 July 2005 recorded at "Bomber Cove". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

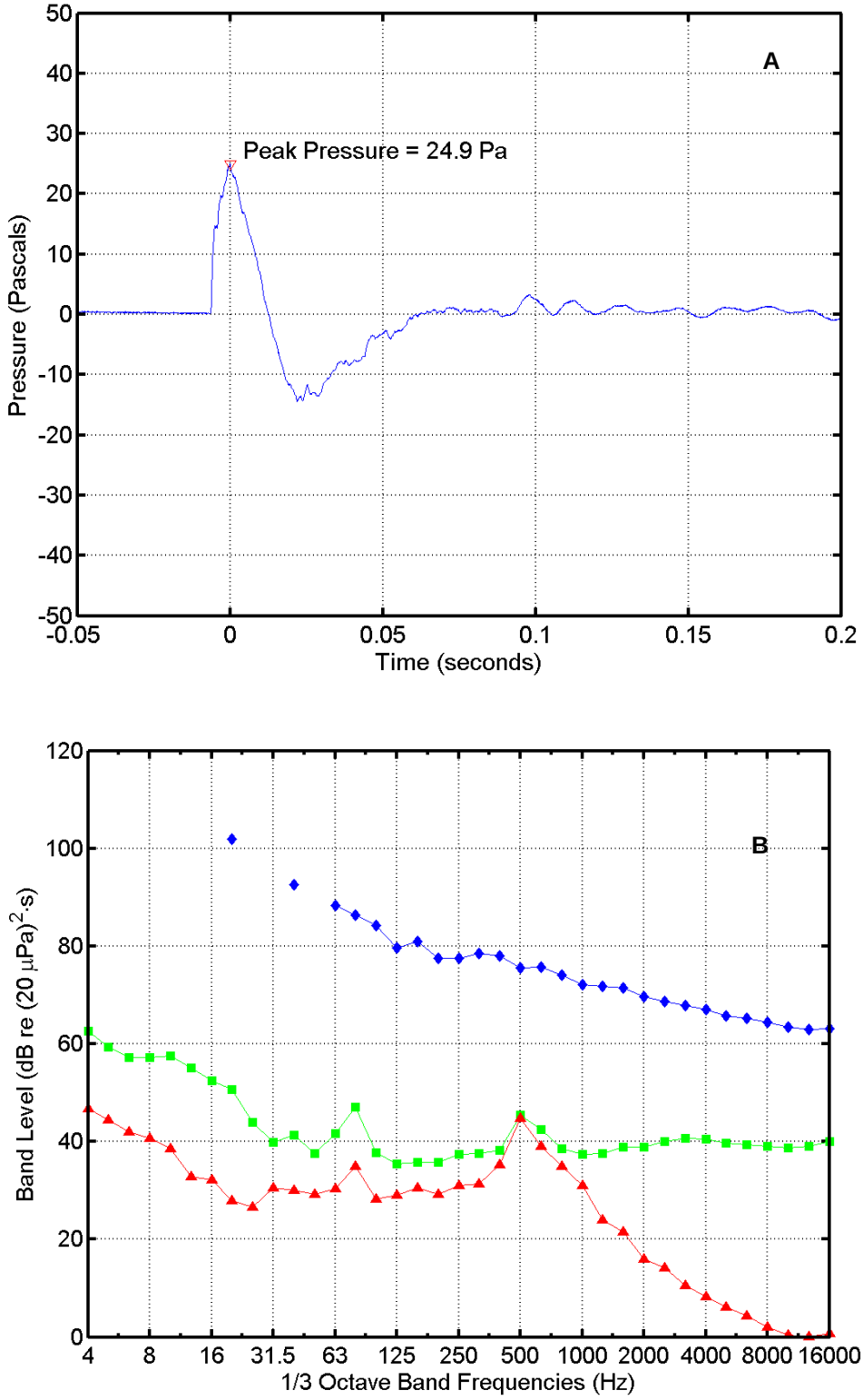


FIGURE B-44. (A) Pressure waveform and (B) one-third octave band levels for an AGS Missile flight at 14:53 on 26 July 2005 recorded at "The Y". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

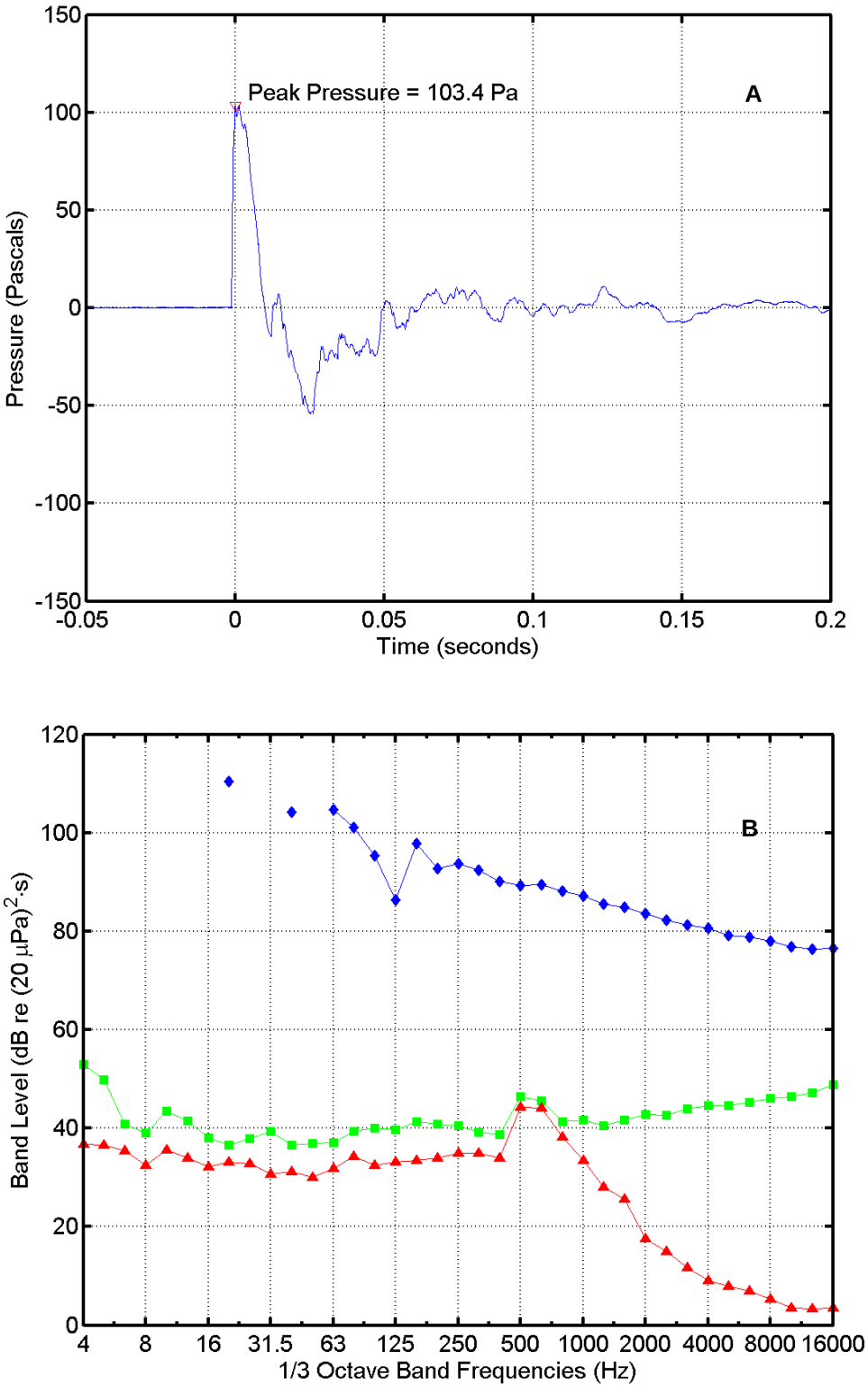


FIGURE B-45. (A) Pressure waveform and (B) one-third octave band levels for an AGS Missile flight at 14:53 on 26 July 2005 recorded at "Dos Coves South". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

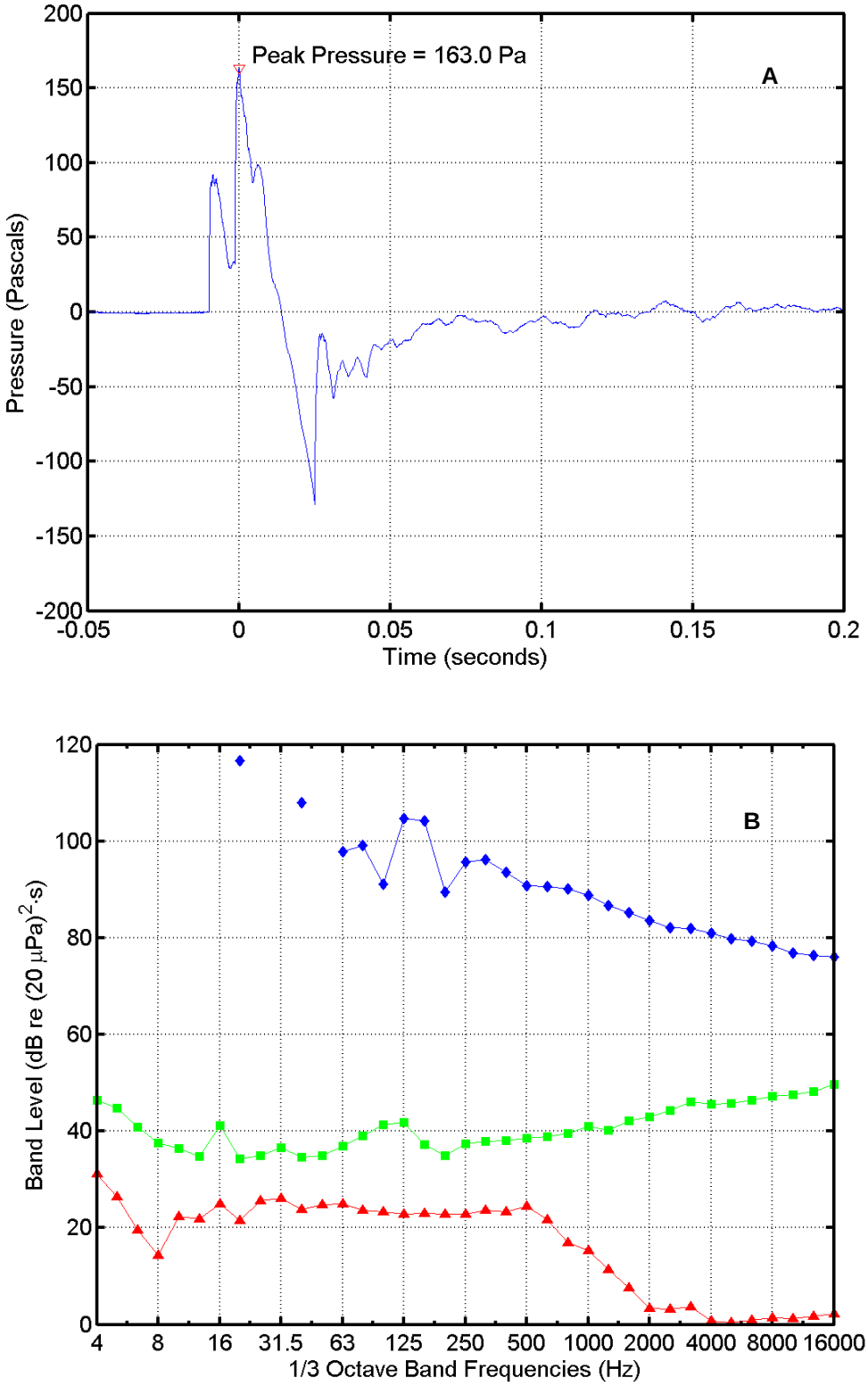


FIGURE B-46. (A) Pressure waveform and (B) one-third octave band levels for a Vandal flight at 10:04 on 27 July 2005 recorded at "Bomber Cove". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

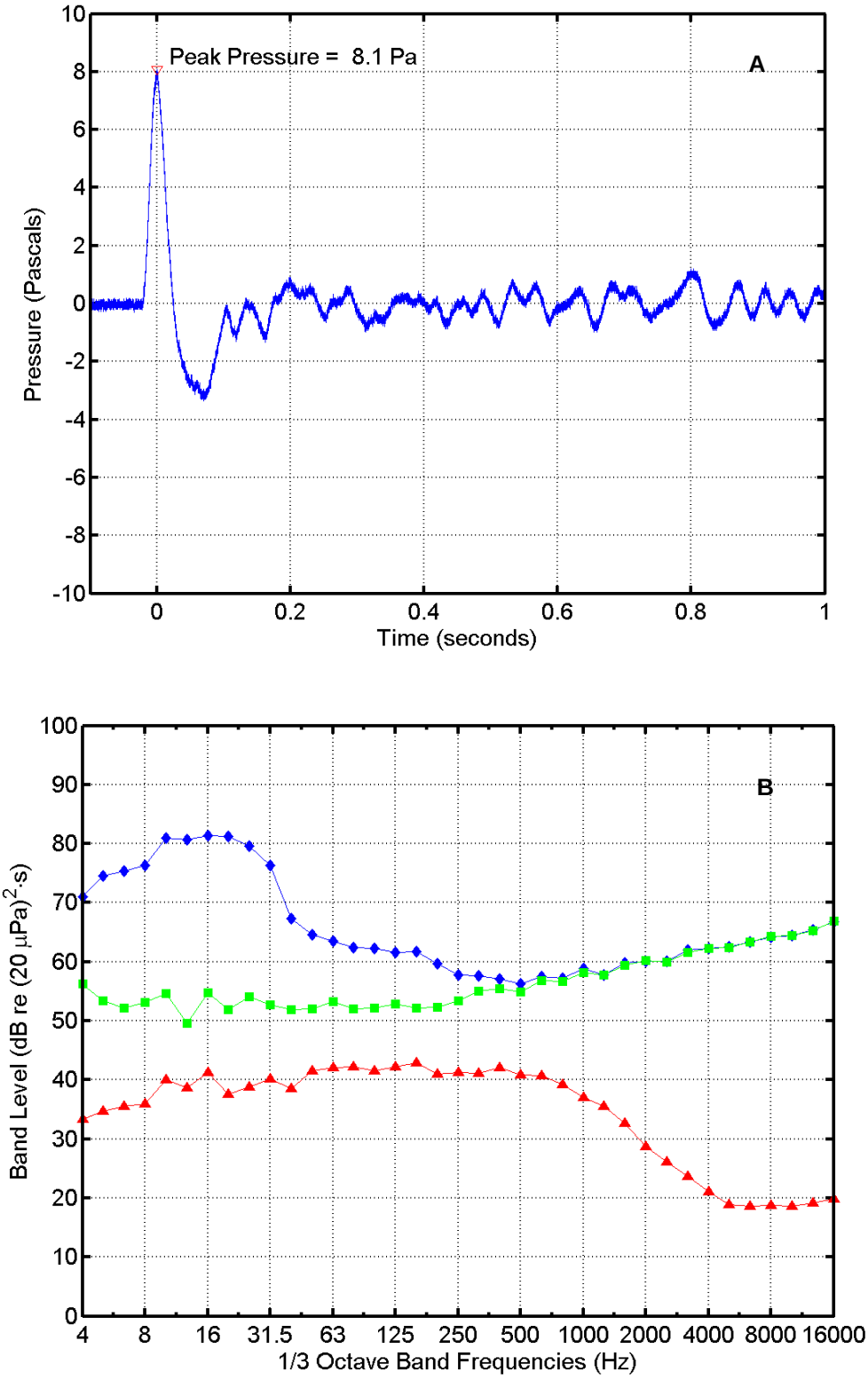


FIGURE B-47. (A) Pressure waveform and (B) one-third octave band levels for a Vandal flight at 10:04 on 27 July 2005 recorded at "Phoca Reef". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

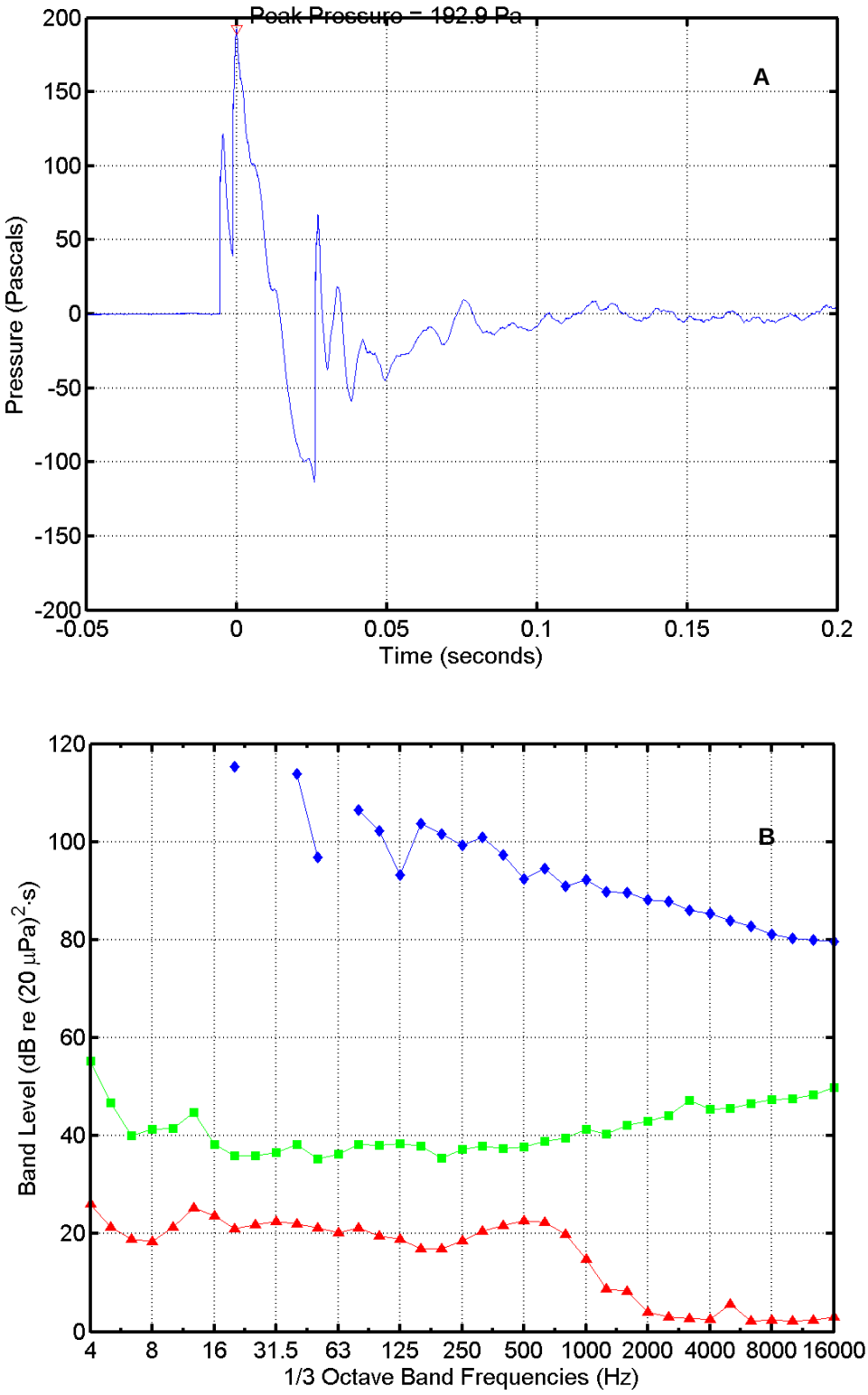


FIGURE B-48. (A) Pressure waveform and (B) one-third octave band levels for a Vandal flight at 08:04 on 28 July 2005 recorded at "Bomber Cove". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

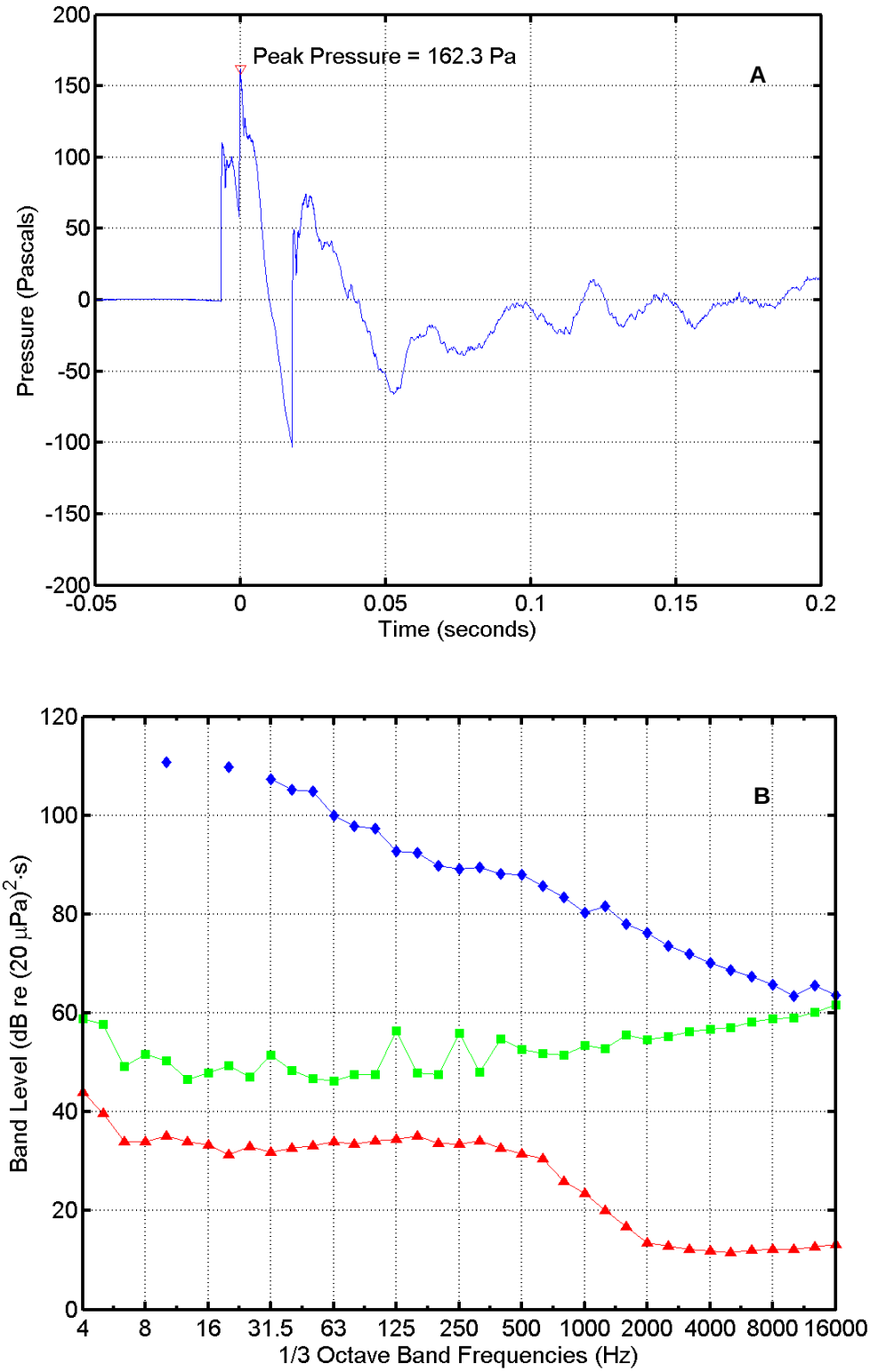


FIGURE B-49. (A) Pressure waveform and (B) one-third octave band levels for a Vandal flight at 08:04 on 28 July 2005 recorded at "Harbor Seal Overlook". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

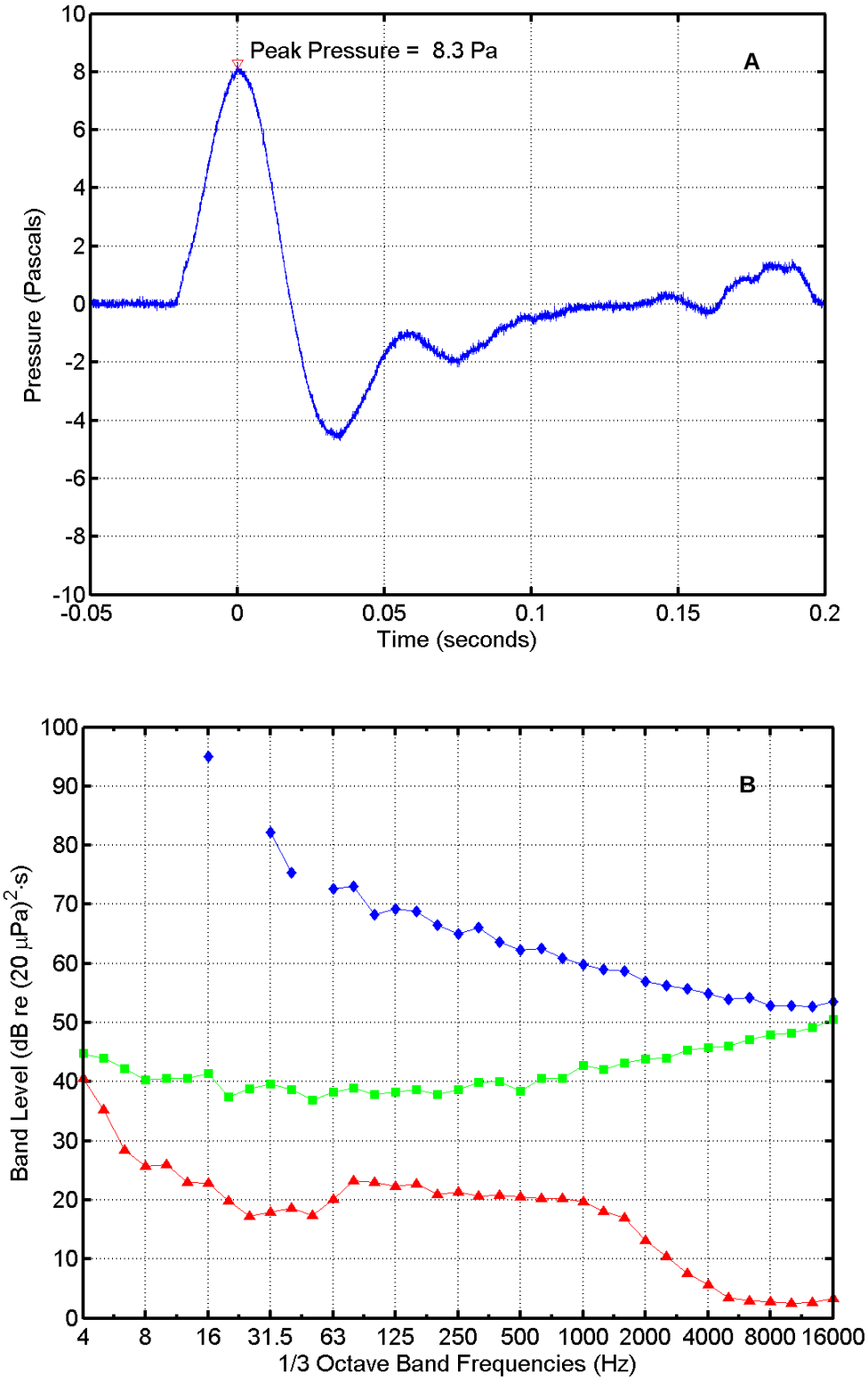


FIGURE B-50. (A) Pressure waveform and (B) one-third octave band levels for a Vandal flight at 08:04 on 28 July 2005 recorded at "Phoca Reef". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

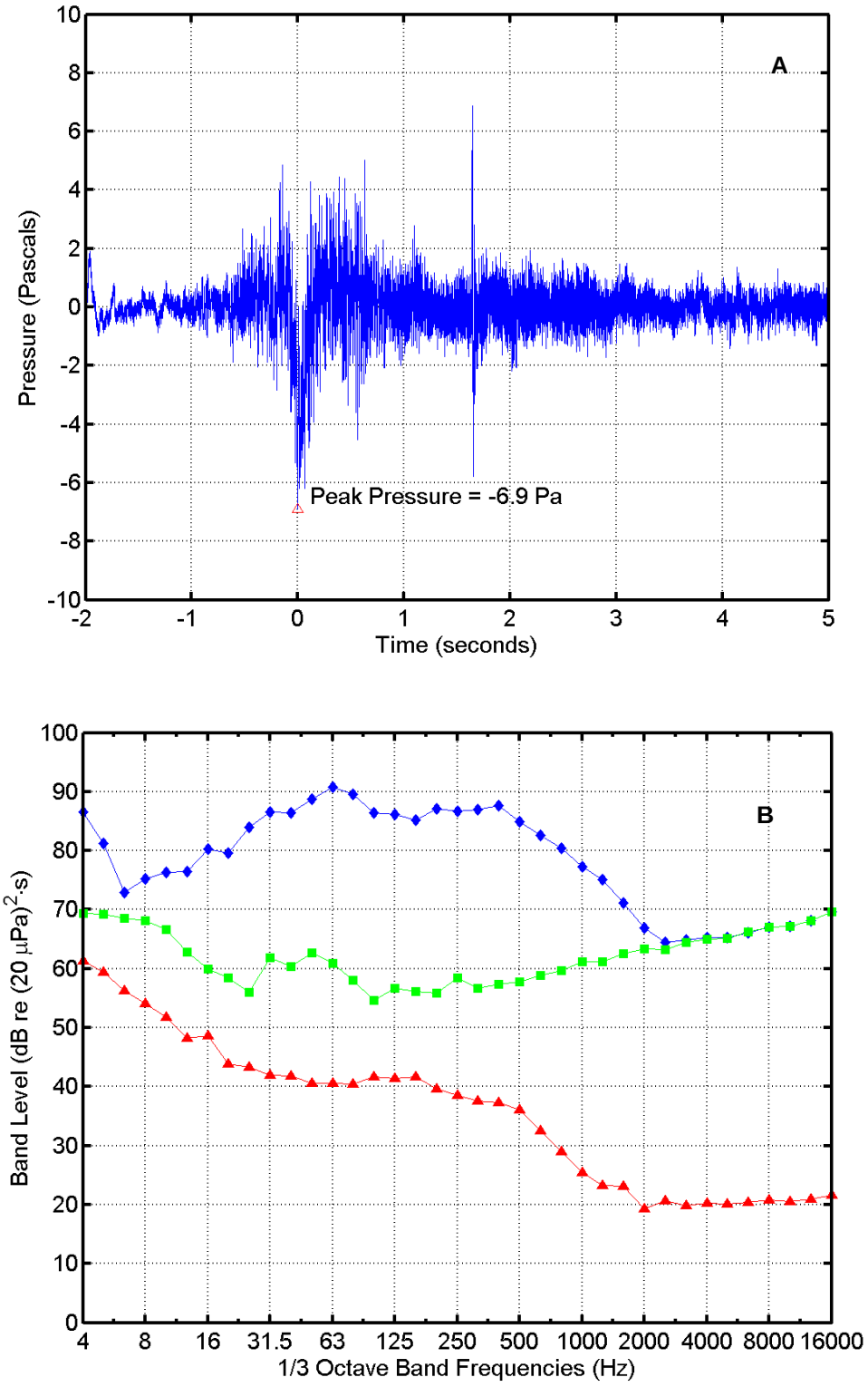


FIGURE B-51. (A) Pressure waveform and (B) one-third octave band levels for a Vandal flight at 11:20 on 28 July 2005 recorded at "Harbor Seal Overlook". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

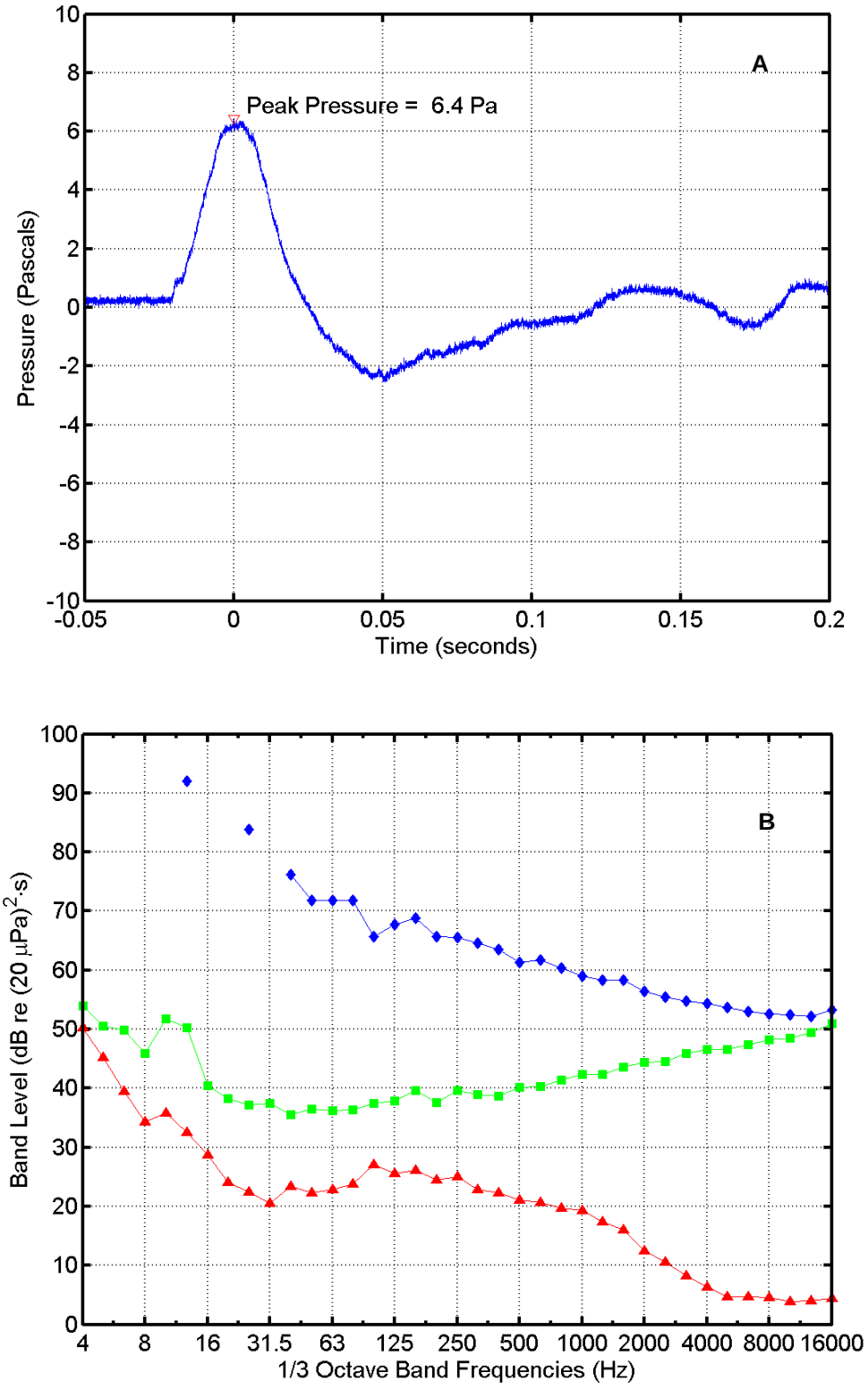


FIGURE B-52. (A) Pressure waveform and (B) one-third octave band levels for a Vandal flight at 11:20 on 28 July 2005 recorded at "Phoca Reef". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

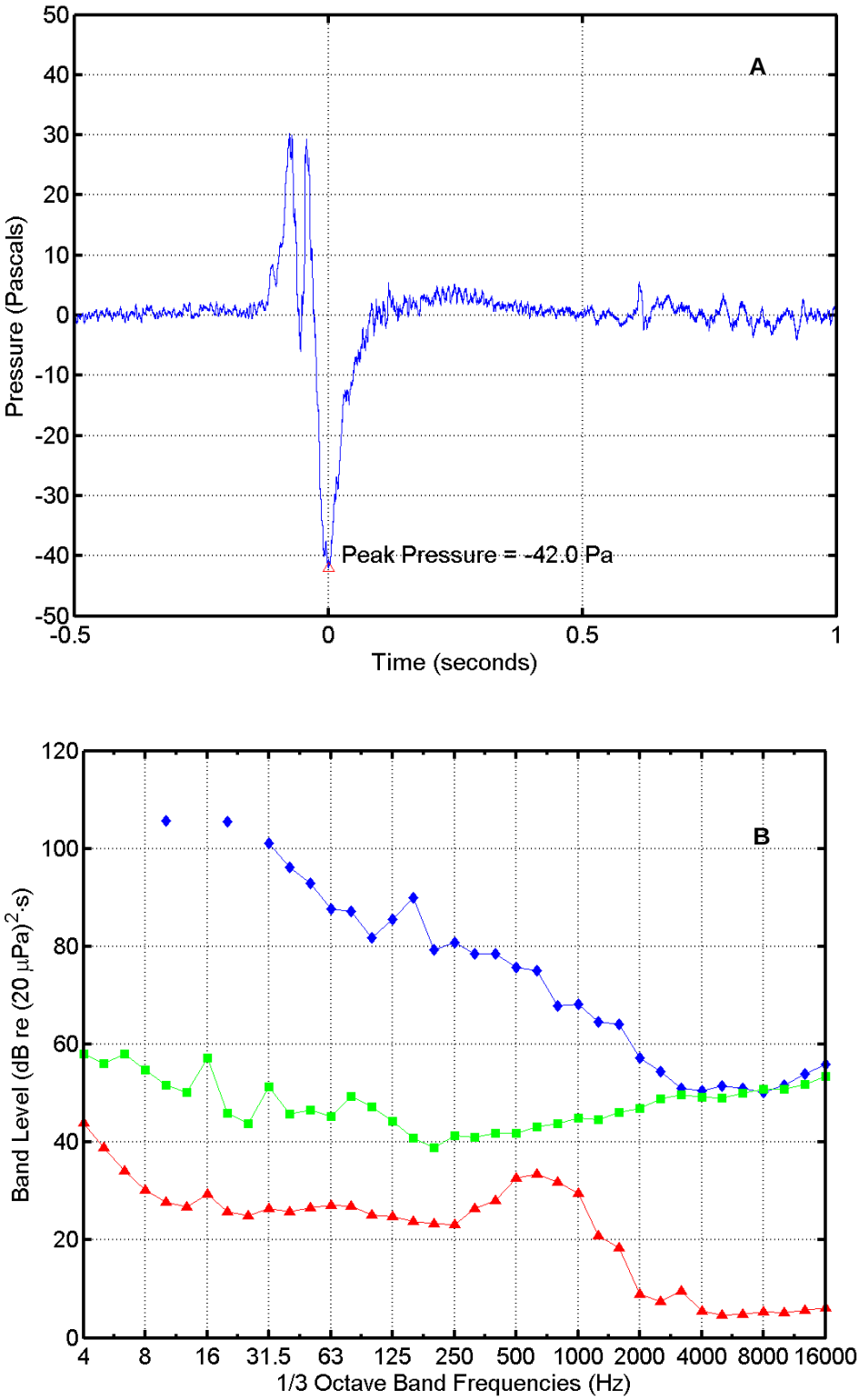


FIGURE B-53. (A) Pressure waveform and (B) one-third octave band levels for a Vandal flight at 11:30 on 28 July 2005 recorded at "Bomber Cove". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

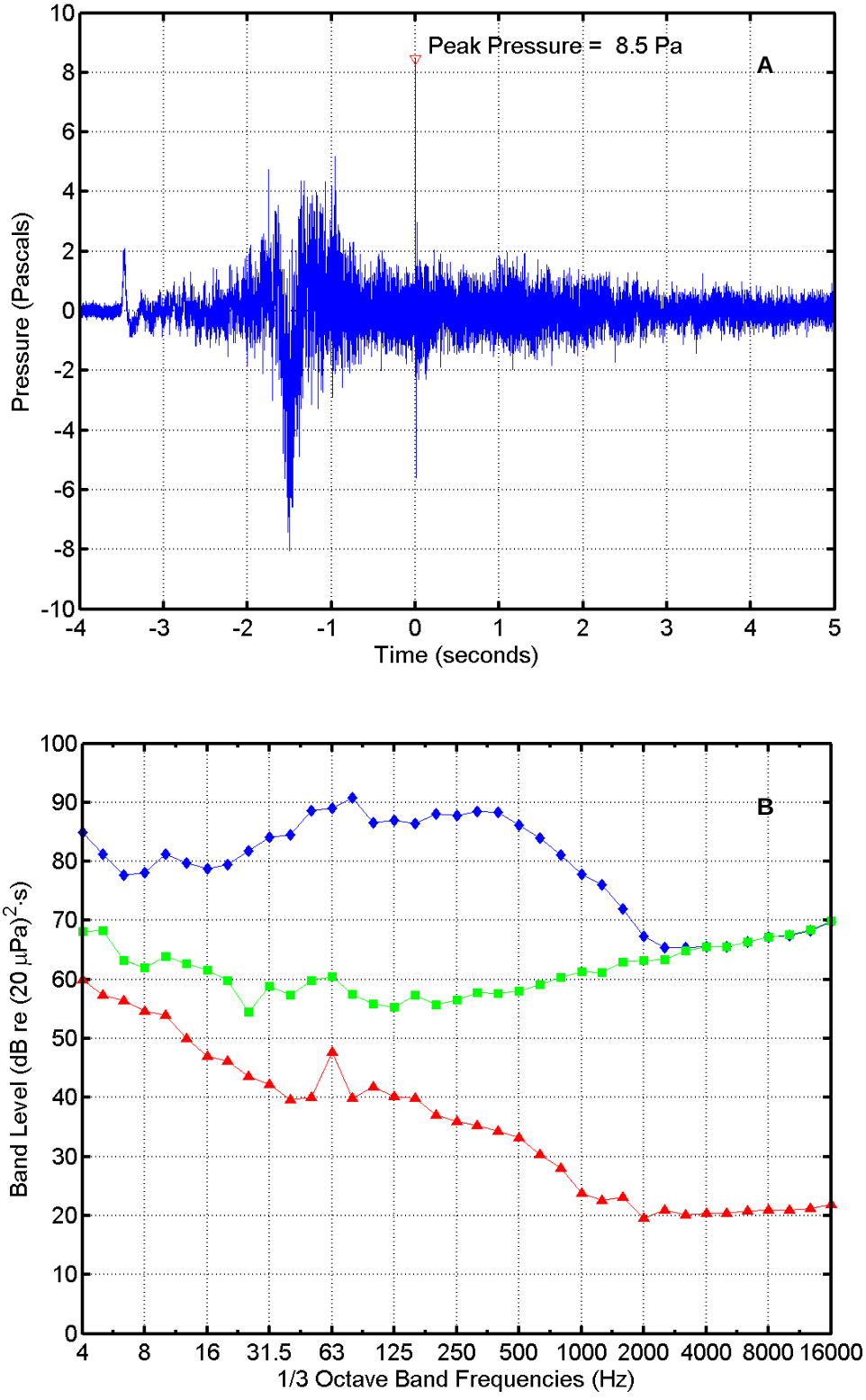


FIGURE B-54. (A) Pressure waveform and (B) one-third octave band levels for a Vandal flight at 11:30 on 28 July 2005 recorded at "Harbor Seal Overlook". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

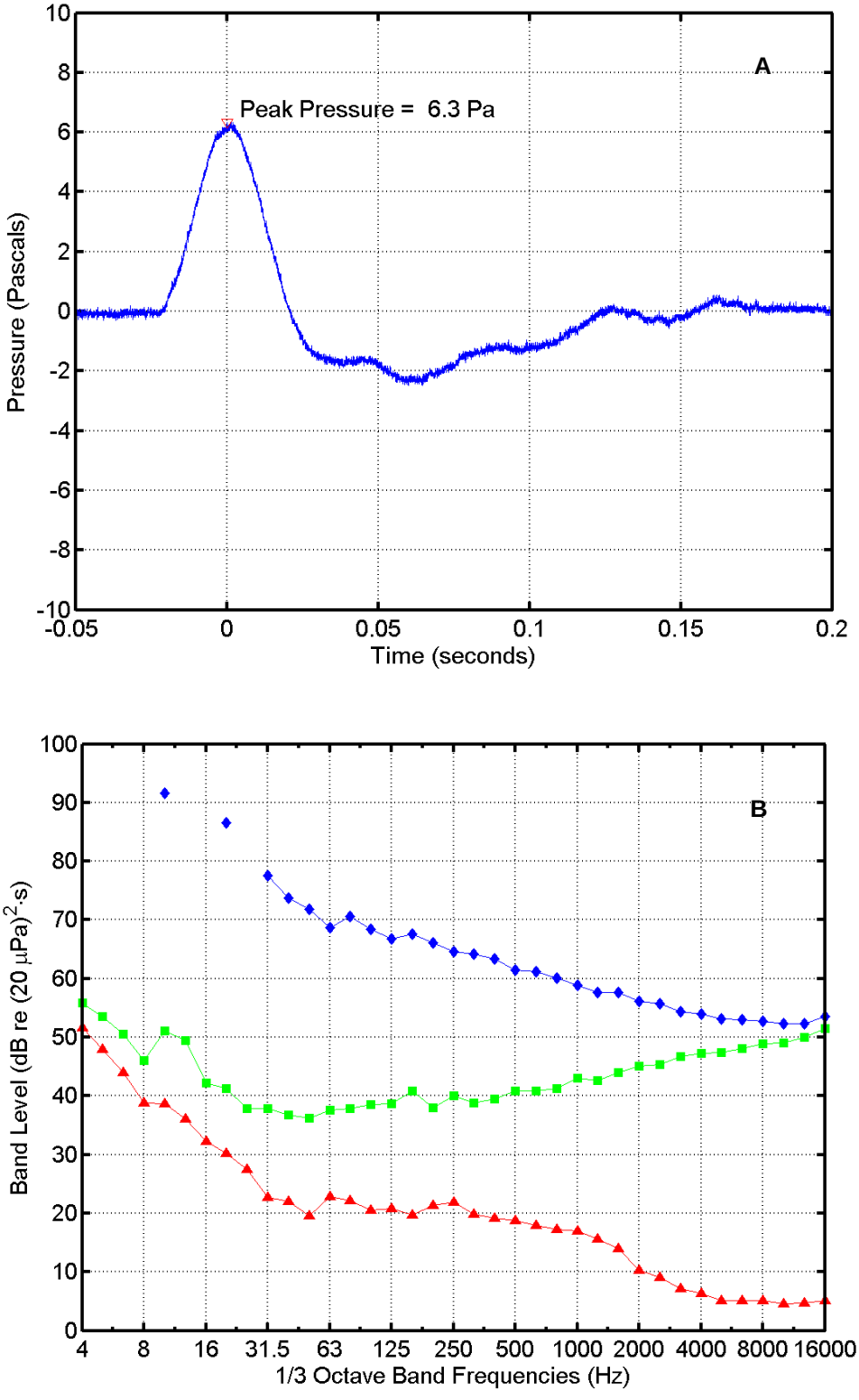


FIGURE B-55. (A) Pressure waveform and (B) one-third octave band levels for a Vandal flight at 11:30 on 28 July 2005 recorded at "Phoca Reef". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

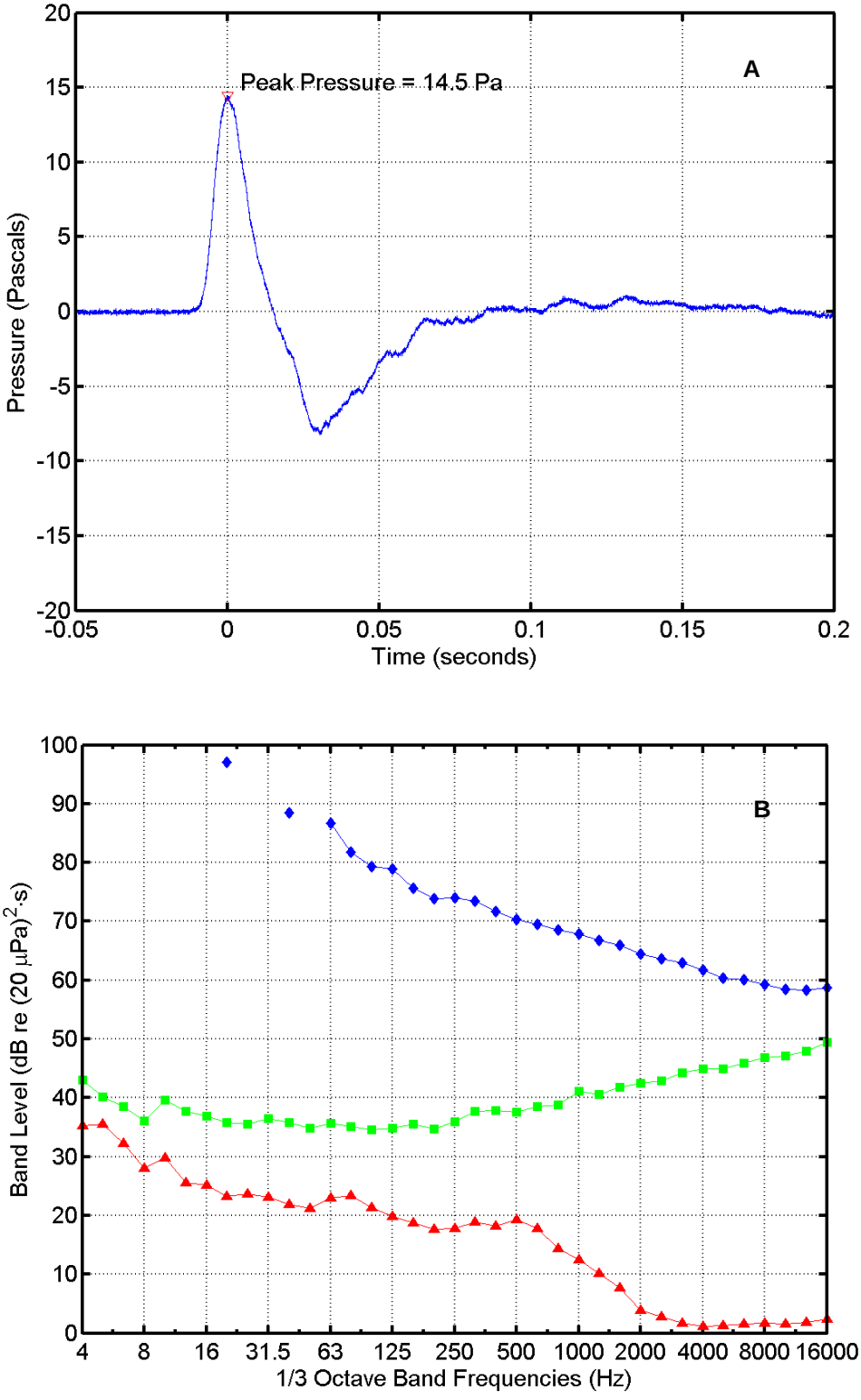


FIGURE B-56. (A) Pressure waveform and (B) one-third octave band levels for an AGS Slug flight at 09:03 on 25 August 2005 recorded at "Bomber Cove". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

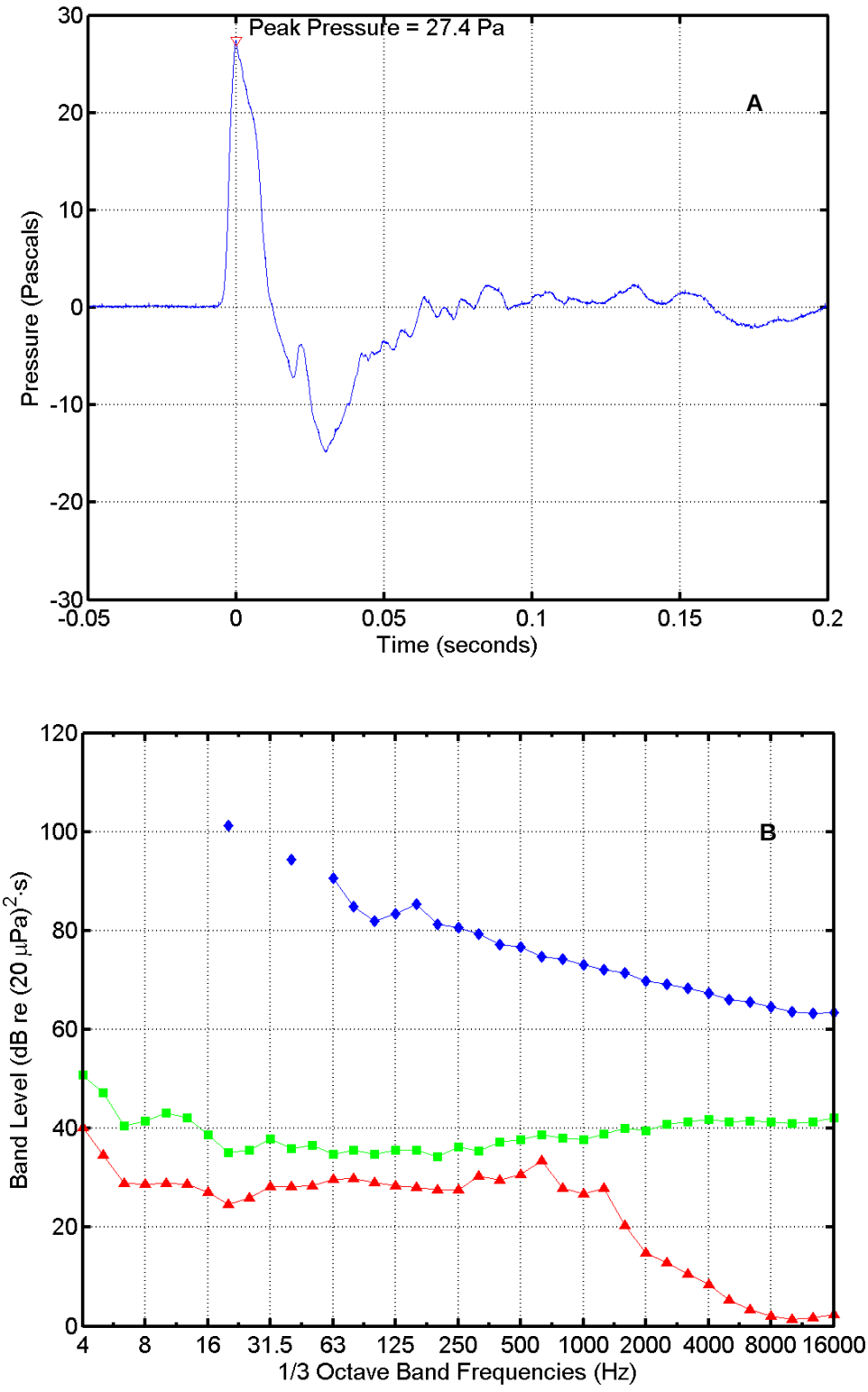


FIGURE B-57. (A) Pressure waveform and (B) one-third octave band levels for an AGS Slug flight at 09:03 on 25 August 2005 recorded at "The Y". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

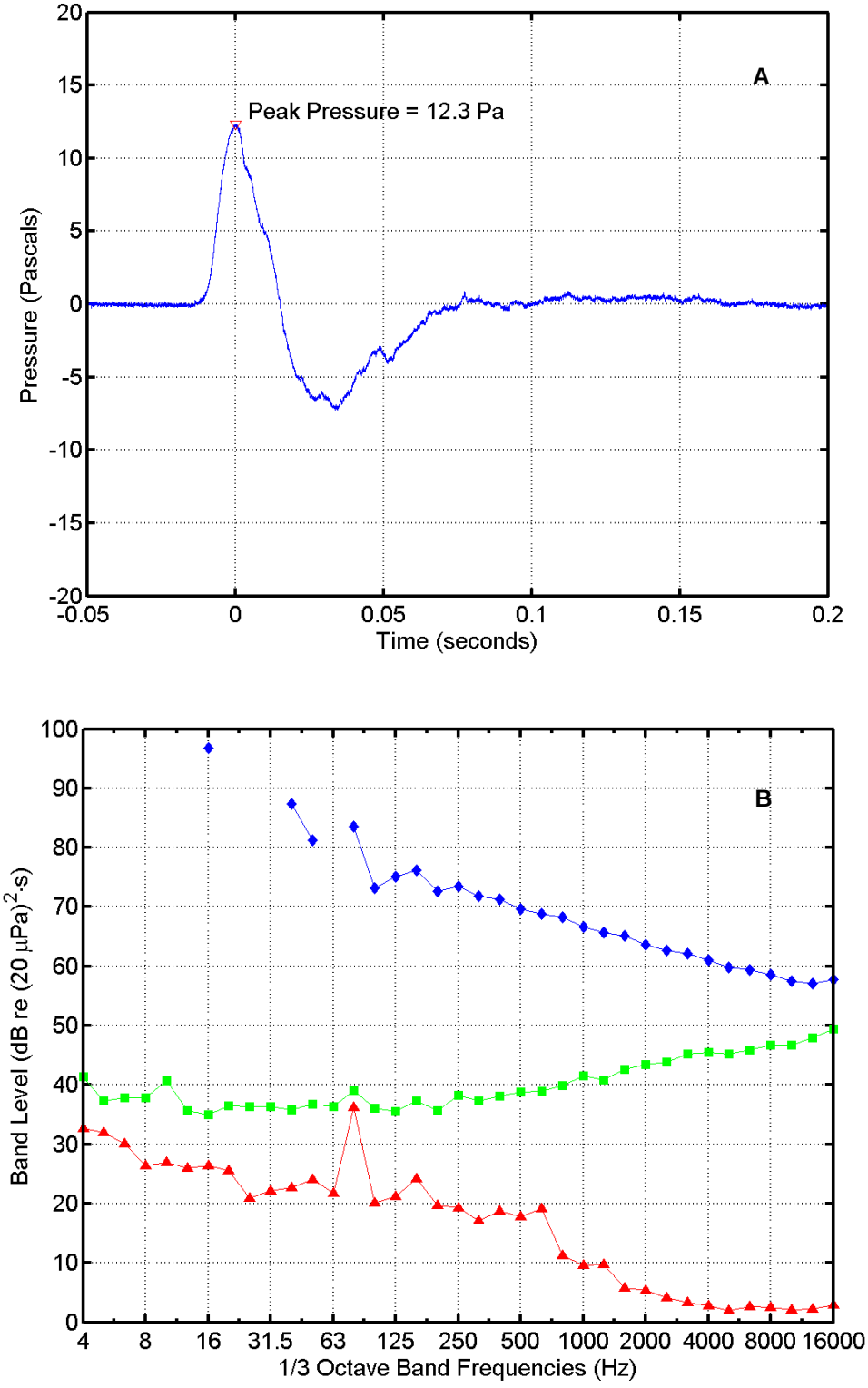


FIGURE B-58. (A) Pressure waveform and (B) one-third octave band levels for an AGS Missile flight at 11:30 on 25 August 2005 recorded at "Bomber Cove". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

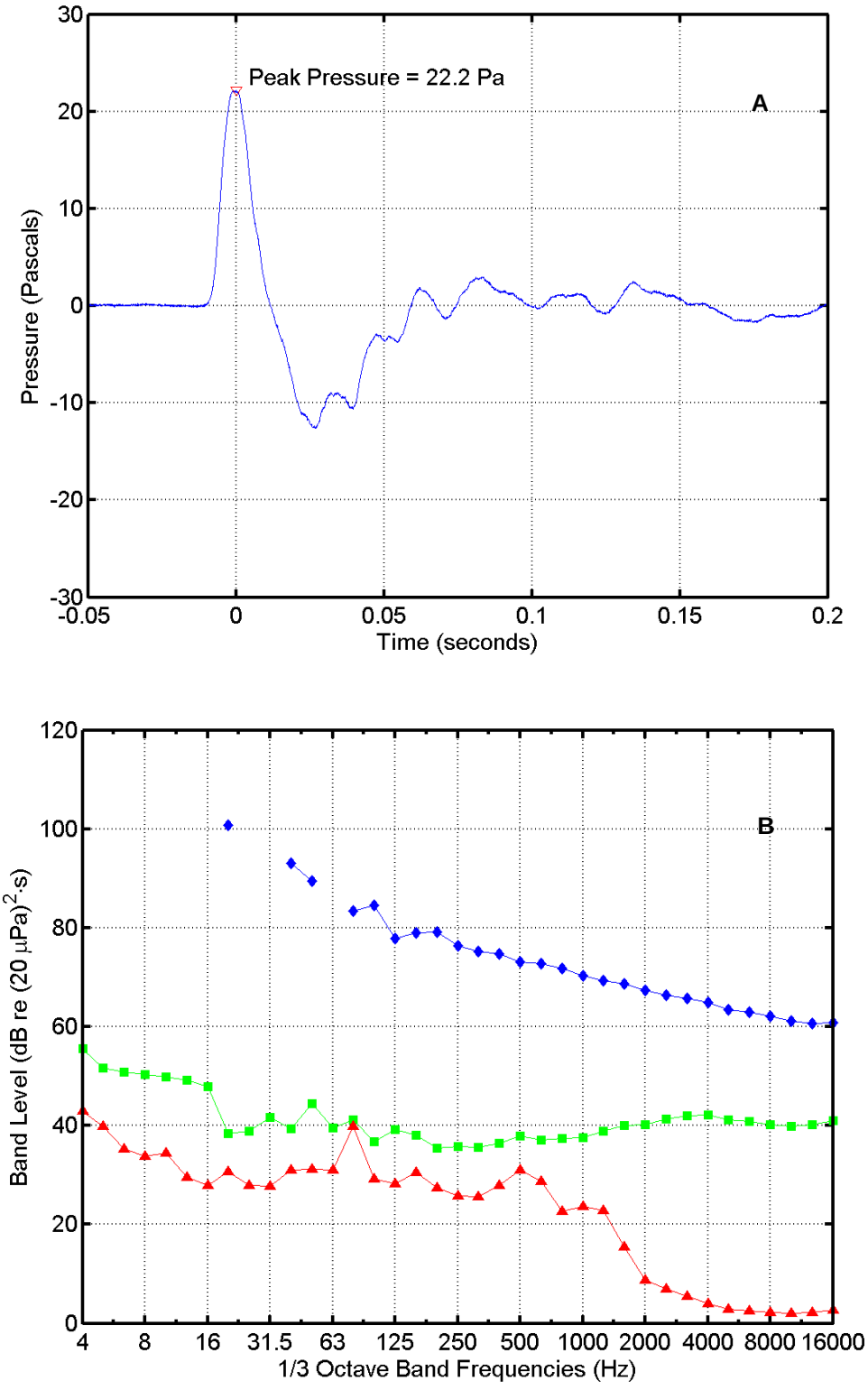


FIGURE B-59. (A) Pressure waveform and (B) one-third octave band levels for an AGS Missile flight at 11:30 on 25 August 2005 recorded at "The Y". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

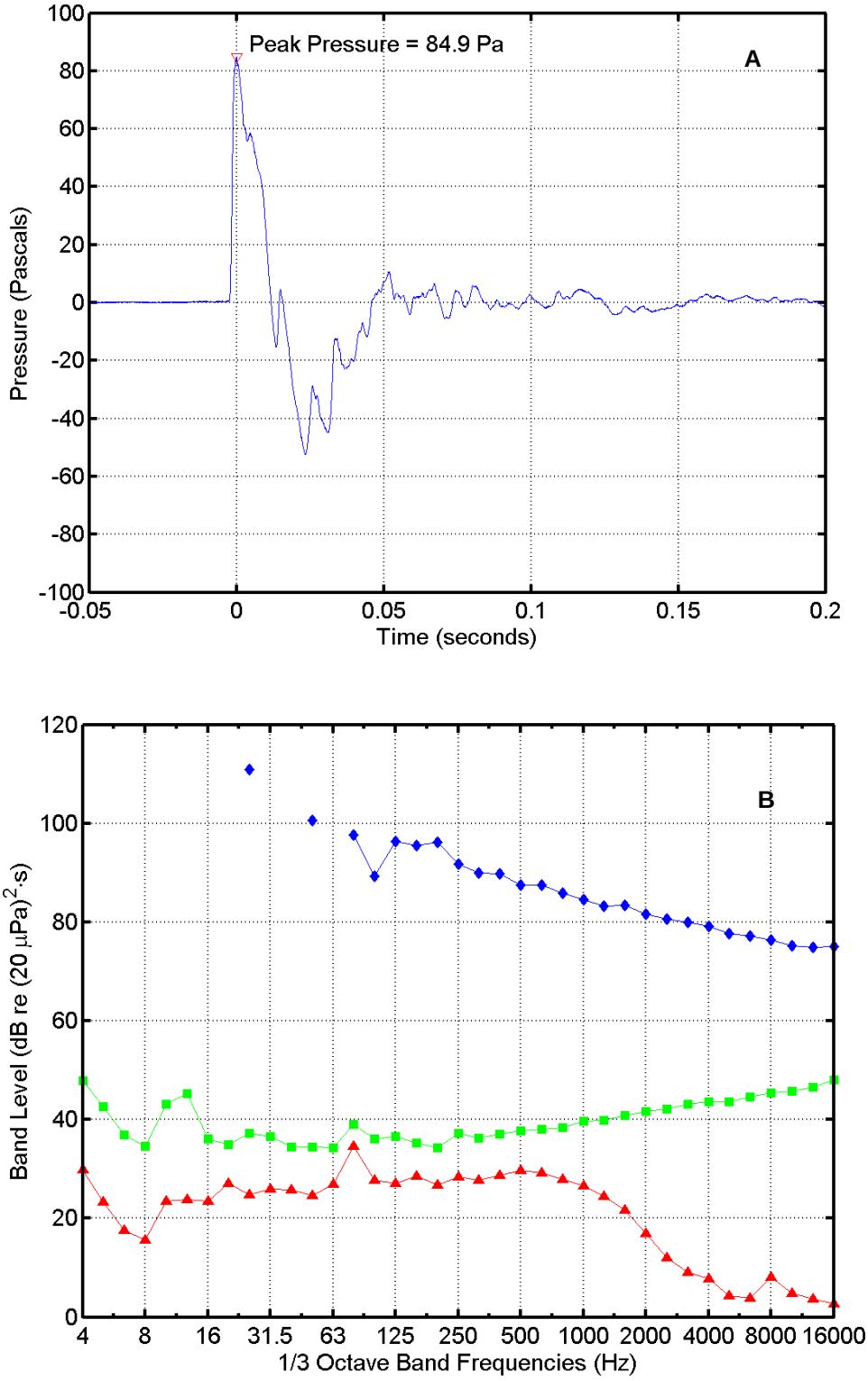


FIGURE B-60. (A) Pressure waveform and (B) one-third octave band levels for an AGS Missile flight at 11:30 on 25 August 2005 recorded at "Dos Coves South". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

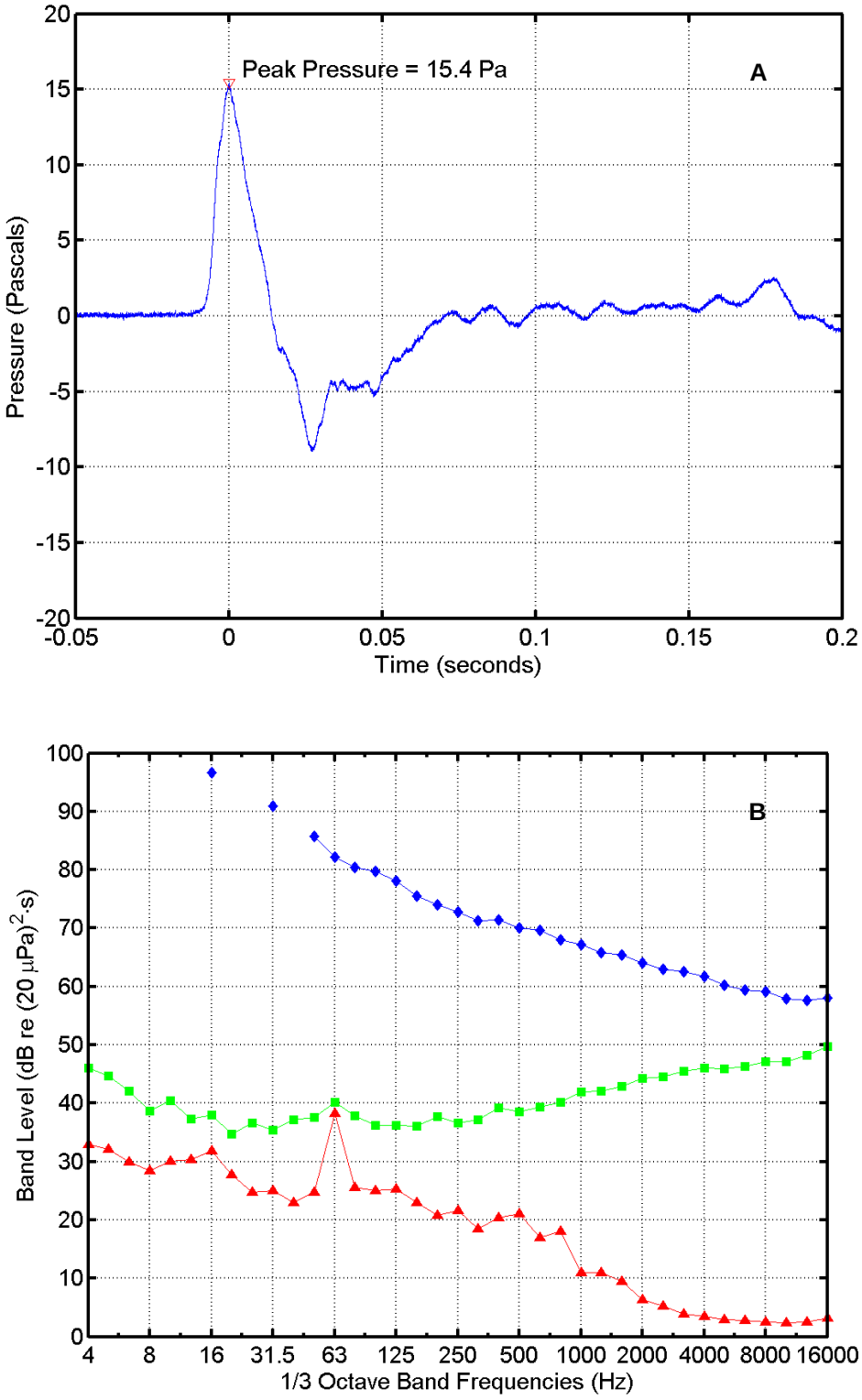


FIGURE B-61. (A) Pressure waveform and (B) one-third octave band levels for an AGS Missile flight at 13:30 on 25 August 2005 recorded at "Bomber Cove". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

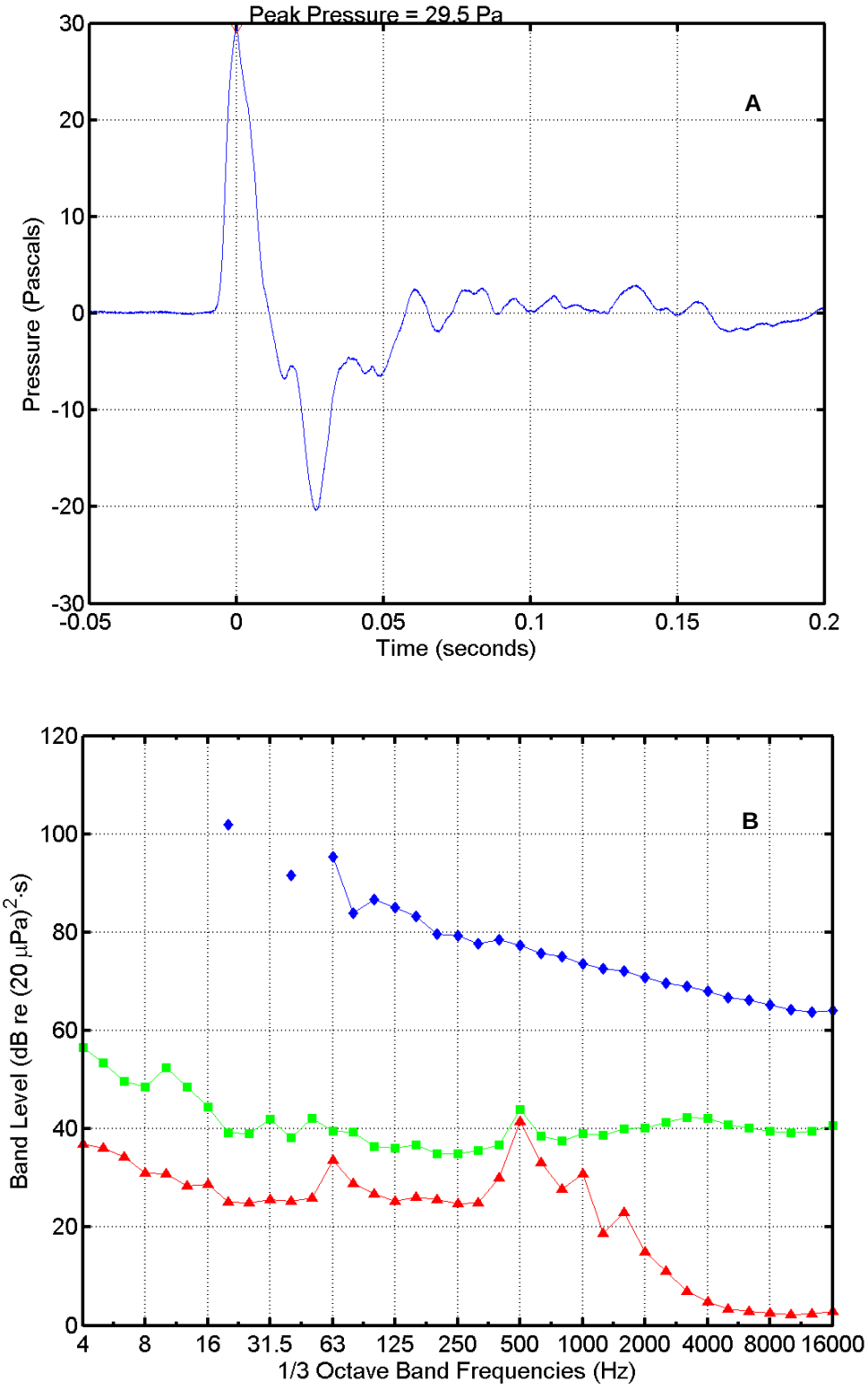


FIGURE B-62. (A) Pressure waveform and (B) one-third octave band levels for an AGS Missile flight at 13:30 on 25 August 2005 recorded at "The Y". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

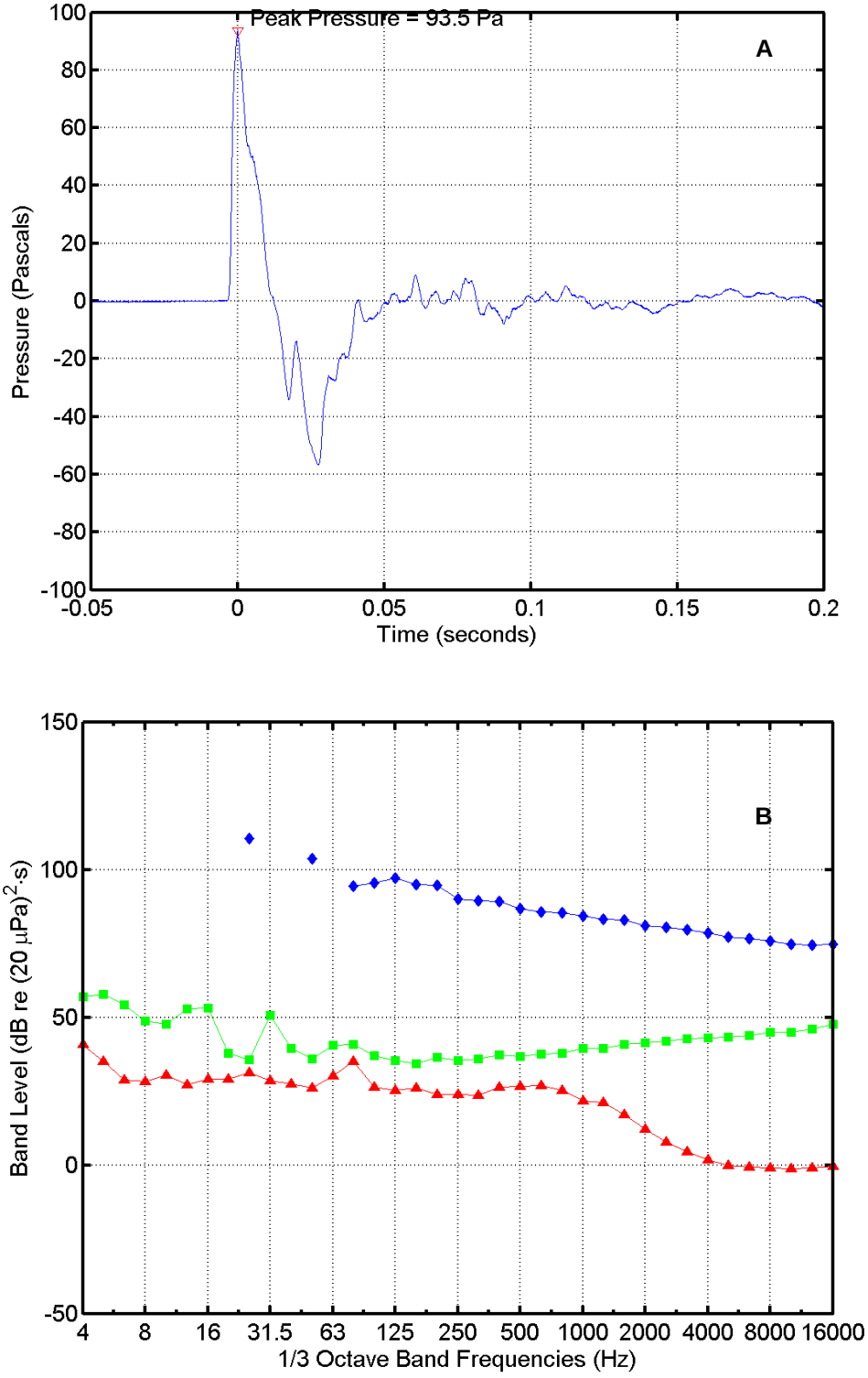


FIGURE B-63. (A) Pressure waveform and (B) one-third octave band levels for an AGS Missile flight at 13:30 on 25 August 2005 recorded at "Dos Coves South". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

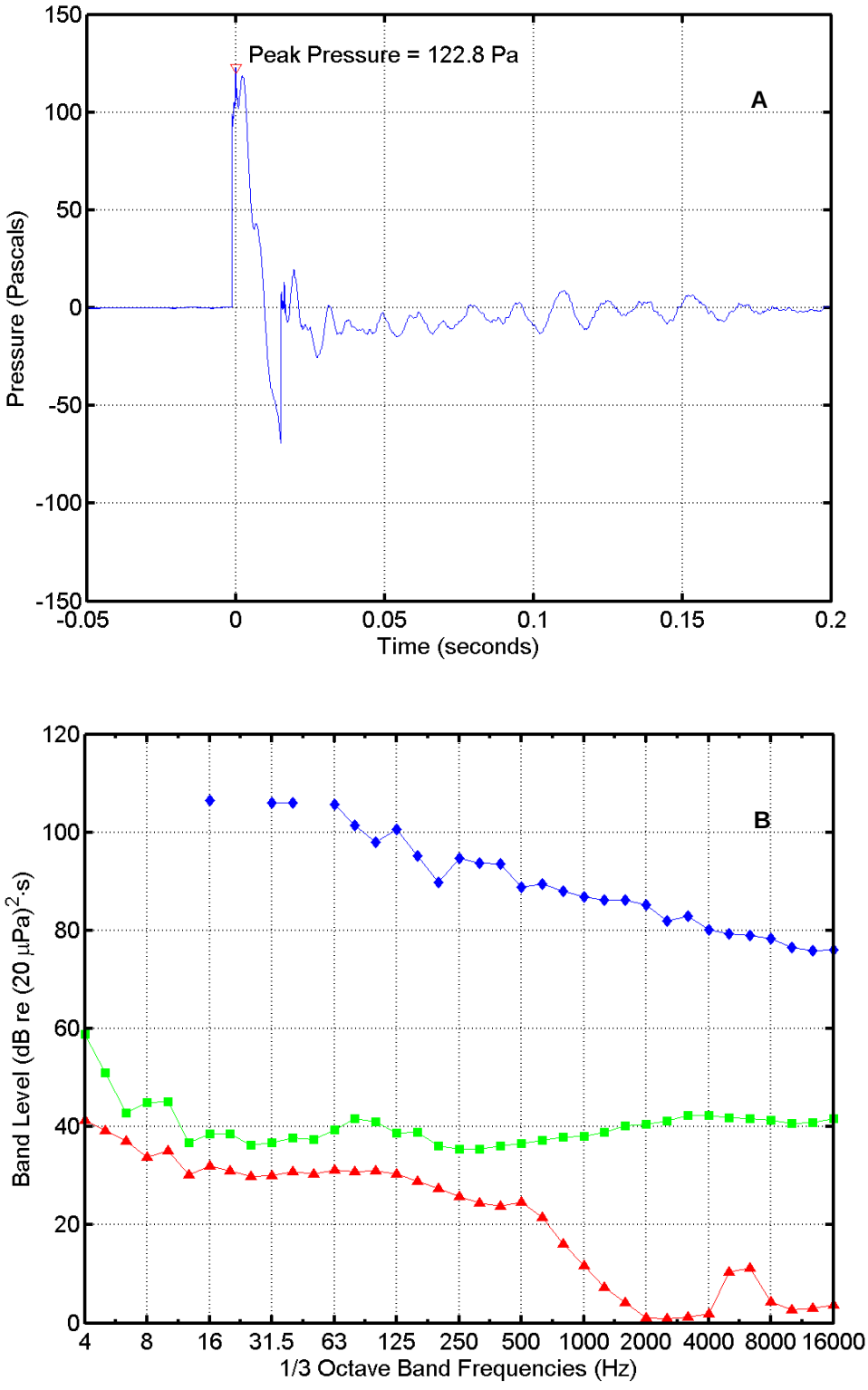


FIGURE B-64. (A) Pressure waveform and (B) one-third octave band levels for an SSST flight at 09:30 on 6 October 2005 recorded at "Bomber Cove". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).

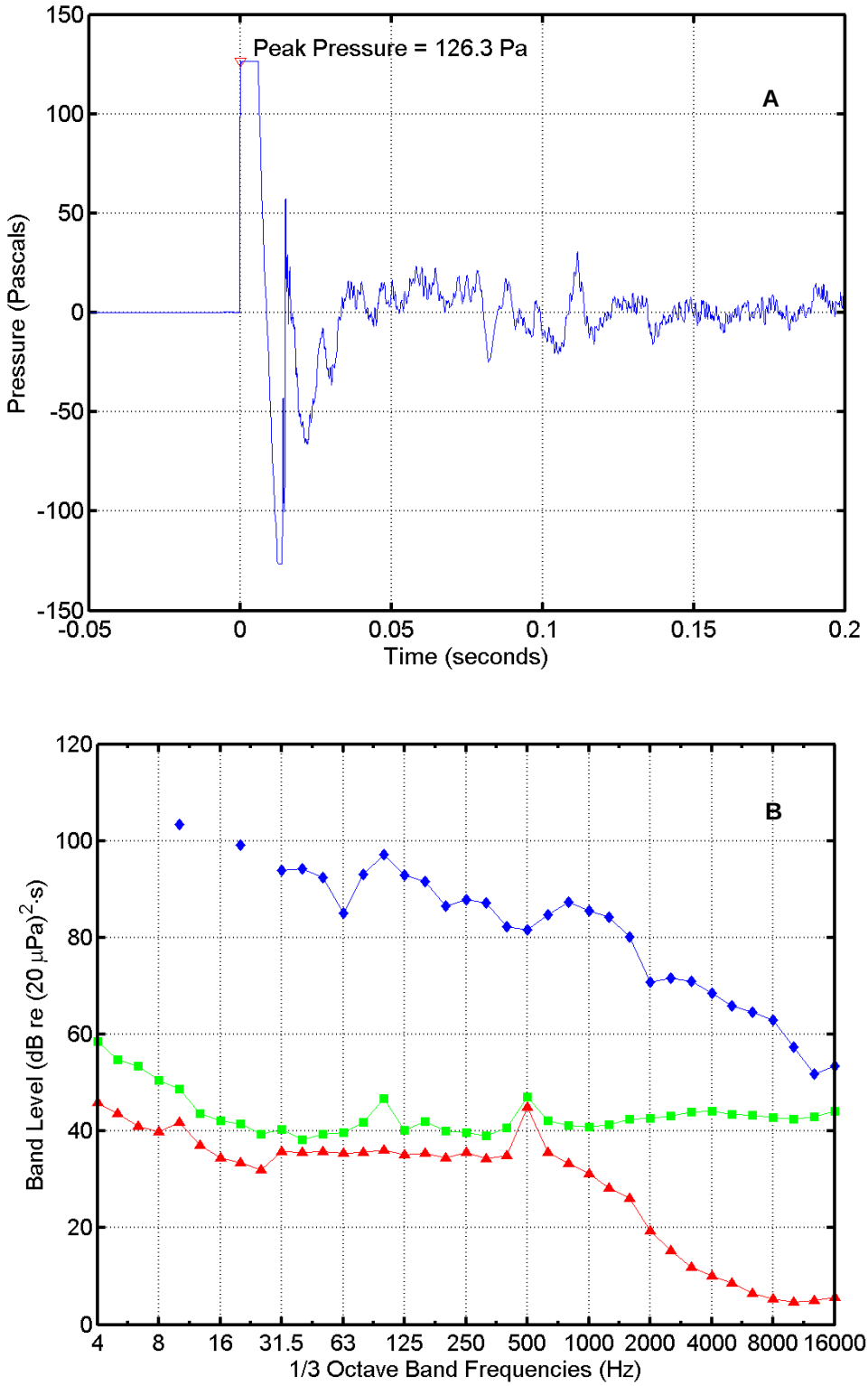


FIGURE B-65. (A) Pressure waveform and (B) one-third octave band levels for an SSST flight at 09:30 on 6 October 2005 recorded at "Dos Coves South". In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).