Pinniped Monitoring during Missile Launches on San Nicolas Island, California, December 2016 - November 2017

Naval Air Warfare Center Weapons Division
Point Mugu, California

For Submittal To

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

30 December 2017

This Page Intentionally Blank

Pinniped Monitoring During Missile Launches on San Nicolas Island, California, December 2016 - November 2017

John H. Burke

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

For

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

30 December 2017

Suggested format for citation:

Burke, J. H. 2017. Pinniped Monitoring During Missile Launches on San Nicolas Island, California, December 2016 - November 2017. Naval Air Warfare Center Weapons Division, Point Mugu, CA. 55 pp.

This Page Intentionally Blank

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACRONYMS AND ABBREVIATIONS

3-D	3-dimensional
ASL	above sea level
ATAR	Autonomous Terrestrial Acoustic Recorder
B807	Building 807
B809	Building 809
CFR	Code of Federal Regulations
cm	centimeter
CPA	Closest Point of Approach
dB	decibel
dBA	decibel, A-weighted, to emphasize mid-frequencies and to de-emphasize low and high frequencies to which human (and pinniped) ears are less sensitive
F	Fahrenheit
FOV	field of view
ft	feet
FLIR	Forward Looking Infrared
hr	hour
Hz	Hertz
IHA	Incidental Harassment Authorization
in	inches
kg	kilogram
kHz	kilohertz
km	kilometer (1 km = 3281 ft, 0.62 mi, or 0.54 n.mi)
kts	knots or nautical miles per hour
lb	pounds
LOA	Letter of Authorization
m	meter
mi	mile
min	minute
mm	millimeter
MMPA	Marine Mammal Protection Act
M_{pa}	Frequency weighting appropriate for pinnipeds in air (see Gentry et al. 2004; Southall et al. 2007)
NAWCWD	Naval Air Warfare Center Weapons Division
nm	nautical miles
NMFS	National Marine Fisheries Service
PTS	Permanent Threshold Shift
rms	root mean square (a type of average)
s	second
SEL	sound exposure level
SEL-A	A-weighted sound exposure level
SEL-M	M_{pa}-weighted sound exposure level
SNI	San Nicolas Island
SPL	sound pressure level
SPL-f	flat-weighted sound pressure level
TTS	Temporary Threshold Shift
µPa	micropascal

This Page Intentionally Blank

EXECUTIVE SUMMARY

The Naval Air Warfare Center Weapons Division (NAWCWD) holds a Letter of Authorization (LOA) issued by the National Marine Fisheries Service (NMFS) allowing non-lethal takes of pinnipeds incidental to the Navy's missile launch operations on San Nicolas Island (SNI), California. Past LOAs span the periods of June 2009 through June 2014. New small take regulations and an associated LOA for the period of 3 June 2014 through 3 June 2019 were issued pursuant to 50 Code of Federal Regulations (CFR) 216.151–158 and §101(a)(5)(A) of the Marine Mammal Protection Act (MMPA), 16 United States Code (USC) §1371(a)(5)(A). Those regulations were initially issued for the period 2 October 2003 through 2 October 2008, and were reissued for the period of 2 June 2009 through 2 June 2014. The regulations and associated LOA allows for the 'take by harassment' of small numbers of northern elephant seals (*Mirounga angustirostris*), Pacific harbor seals (*Phoca vitulina*), and California sea lions (*Zalophus californianus*) during routine launches on Navy-owned SNI.

In the Navy's original Petition for Regulations that led to promulgation of 50 CFR 216.151–158 a Pinniped Monitoring Plan and subsequent report was proposed to NMFS. The Plan includes provisions to monitor any effects of missile launch activities on pinnipeds hauled out at SNI in a manner similar to preliminary pinniped monitoring that took place during Navy activities from 2001–2008. Pinniped species monitored on SNI during that period included the Pacific harbor seal, northern elephant seal, and California sea lion. In June 2010, a revised Monitoring Plan was submitted to NMFS proposing discontinuation of monitoring for northern elephant seals, as this species had shown little or no reaction to most missile launches. NMFS accepted the proposed change to the Monitoring Plan (NMFS 2010) and issued the new LOA to acknowledge the change. Thus, elephant seal responses are not discussed in detail in this report.

Missiles Launched

This report describes the results of the visual and acoustic monitoring for missile launches from SNI between December 2016 and mid-November 2017. Three launches occurred after November 21, 2017; the results of these launches will be included in next year's report as the sound analysis could not be completed in time this year. The 2016-2017 rerport includes results from five missile launches on three separate days. During this monitoring period two dual launches – consisting of two missiles launched in rapid succession (e.g., less than 1 minute apart) – and one single launch occurred. Missiles launched were the GQM 163A "coyote" (GQM). All missiles were launched during daytime hours.

The launch azimuths resulted in missiles crossing SNI's shoreline on the island's western end and passing over and/or near various pinniped haul-outs. Up to three video monitoring sites were established for each launch overlooking beaches occupied by pinnipeds. Autonomous Terrestrial Acoustic Recorders (ATARs) and video systems were deployed at observation points nearby. An additional audio recording site was also established at the missile launch site for each launch. Audio recordings document launch sound at several distances from the launch trajectory of the missile. Audio, video and direct visual monitoring provided data on the behavioral reactions of pinnipeds hauled out during launches.

Pinniped Behavior during Missile Launches

Behavior of pinnipeds (California sea lions and Pacific harbor seals) hauled out on SNI beaches during missile launches is monitored by unattended video cameras set up before each launch. Video data are supplemented by direct visual scans of the haul-out groups several hours prior to the launches and the hour following the launches. Monitoring is attempted at up to three sites during each launch, with launch-to-launch variation in the locations monitored and number of locations depending upon presence of

hauled out pinnipeds. For each launch, the number, proportion, and maturity (adult or pup - where determinable) of individual pinnipeds that responded in various ways is tabulated using the video recordings, along with comparable data, for those that do not overtly respond.

Estimated Numbers of Pinnipeds Affected

No evidence of pinniped injuries, fatalities or pup abandonment related to the monitored launches was evident, nor was it expected, during the monitoring period. Approximately 702 California sea lions, and 8 Pacific harbor seals, were estimated to have been affected during the December 2017 to mid-November 2017 monitoring period. These figures are approximate and likely overestimate California sea lions affected because they; (a) include extrapolations for pinnipeds on beaches that were not monitored, but within the area of potential effect, on any given launch day, (b) are based on proportions of numbers found during breeding season for unmonitored beaches, and (c) very likely count some of the same individuals more than once. The pinnipeds included in these estimates either left the haul-out site in response to the launch, or exhibited prolonged movement or behavioral changes relative to their behavior immediately prior to the launch.

The results from the 2016-2017 monitoring period (and those from previous monitoring periods) suggest that any effects of the launch operations were minor, short-term, and localized, at least for northern elephant seals and California sea lions. Some Pacific harbor seals may have left their haul-out site until the following low tide, but numbers occupying haul-out sites shortly after a launch or the next day, were generally similar to pre-launch levels. It is not likely that any of the pinnipeds on SNI were adversely impacted by such behavioral reactions. Sound levels for one launch (14 September 17) exceeded those which might cause temporary threshold shift (TTS) in harbor seals [129 dB re 20 μPa^2 s Sound Exposure Level (SEL) for M-weighting (SEL-M)], however it is important to note the measurement was taken on a cliff above a pinniped haul out site at Dos Coves where noise is likely masked by the cliff and/or rocks on the beach. Additionally the sound level was only marginally above the level where TTS may occur (129.6 dB re 20 μPa^2 s). Harbor seals were not present on this beach and TTS onset for California Sea Lions has been reported to be 159 dB re 20 μPa^2 s (Kastak et al., 2007). In the unlikely event that any pinnipeds did incur TTS during launches at SNI, this would have presumably been mild and recoverable and thus not have caused permanent damage.

No measured sound levels exceeded the SEL-M criterion for permanent threshold shift. However, peak pressure levels (flat weighting) exceeded the PTS threshold for one launch. Peak pressures of 159.0, dB re 20 µPa were recorded at the pinniped haul out site at Dos Coves (14 September 17). Again, these recordings were only marginally above the PTS peak pressure threshold [149 dB re 20 µPa] and were taken on the cliff above the monitored site. It is likely that the cliff would mask the sound on the haul out beach. Peak pressure levels (flat weighting) were below the 149 dB re 20 µPa PTS threshold for the remaining recordings of missiles/monitoring sites.

1. MONITORING PROGRAM AND MISSILE LAUNCHES DESCRIBED

1.1 Monitoring Program

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

The Naval Air Warfare Center Weapons Division (NAWCWD) holds a Letter of Authorization (LOA) issued by the National Marine Fisheries Service (NMFS) allowing non-lethal takes of pinnipeds incidental to the Navy's missile launch operations on San Nicolas Island (SNI), California. This LOA spans the period of June 2014 through June 2019. The LOA was issued pursuant to small take regulations (See Appendix A) found in 50 Code of Federal Regulations (CFR) 216.151–158 and §101(a)(5)(A) of the Marine Mammal Protection Act (MMPA), 16 United States Code (USC) §1371(a)(5)(A). Those regulations were initially issued for the period 2 October 2003 through 2 October 2008 and were reissued for the period 2 June 2009 through 2 June 2014 and 3 June 2014 through 3 June 2019, with separate LOAs for each year within each regulatory period. The regulations and the associated LOA allow for the 'take by harassment' of small numbers of northern elephant seals (*Mirounga angustirostris*), Pacific harbor seals (*Phoca vitulina*), and California sea lions (*Zalophus californianus*) during routine launches on Navy-owned SNI (Appendix A).

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

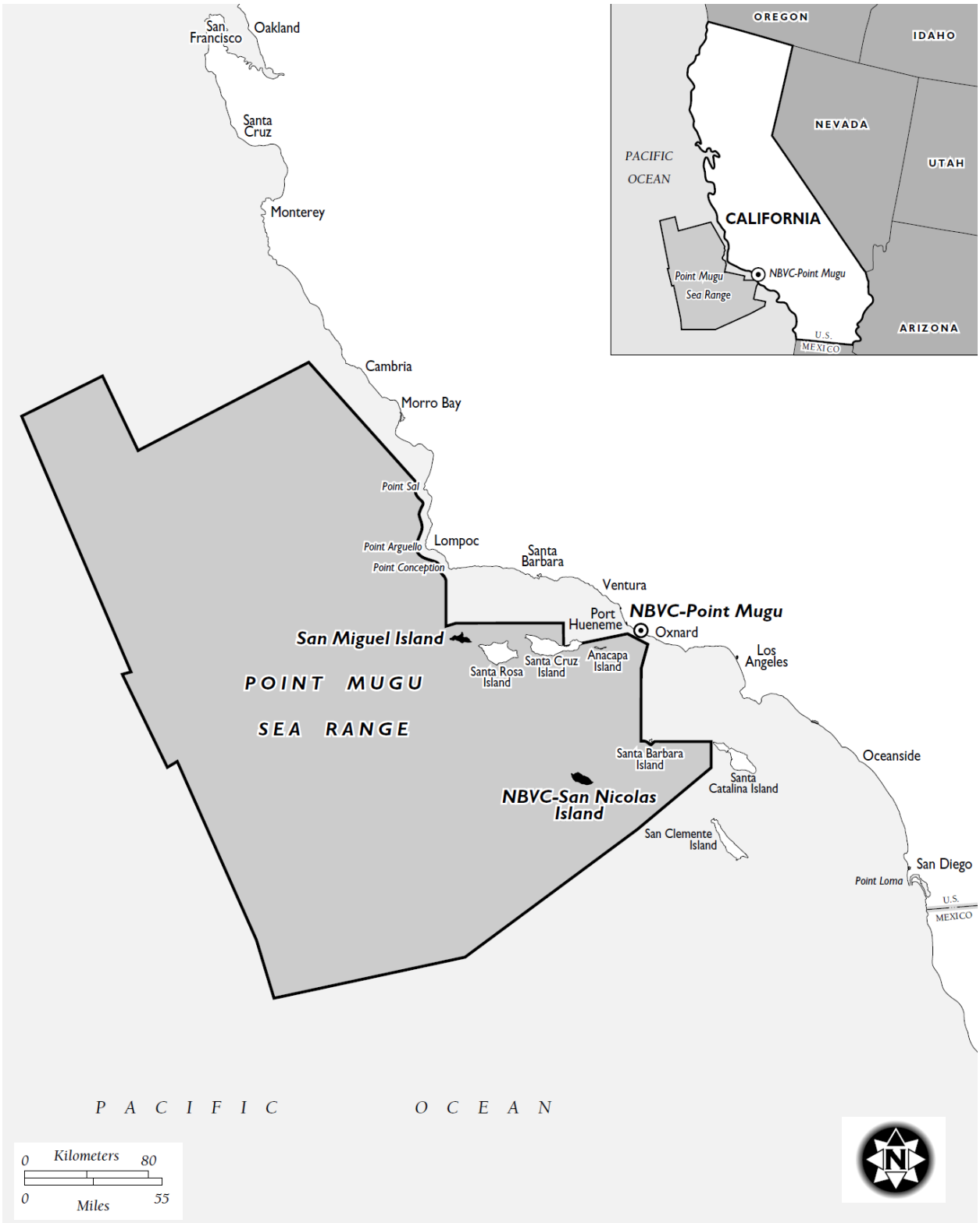


FIGURE 1.1. Regional site map of the Point Mugu Sea Range and San Nicolas Island, California

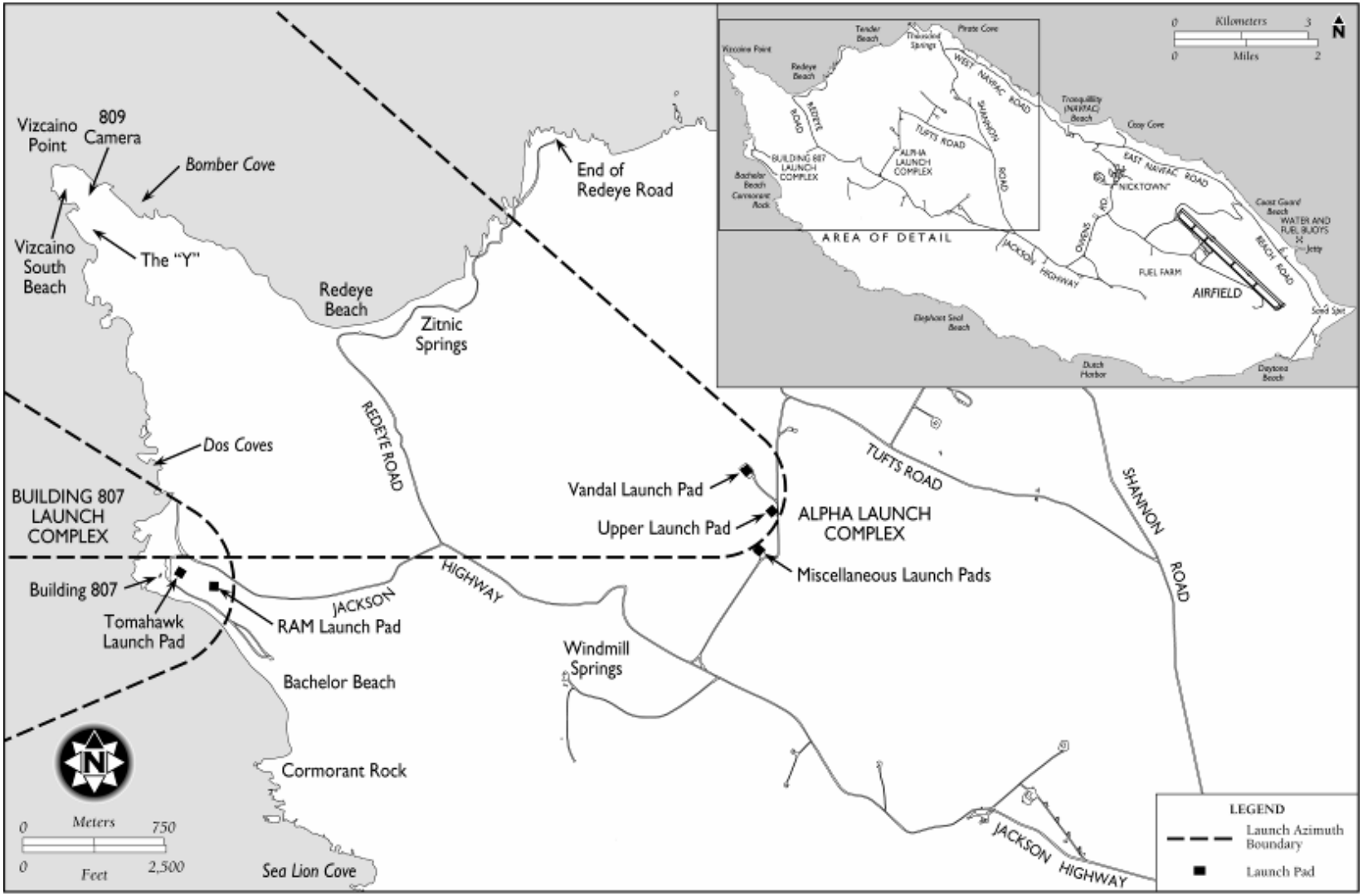


FIGURE 1.2. Map of San Nicolas Island, California, and the general launch azimuths (dashed lines) for each launch complex. These launch azimuths are typical, although occasionally launch paths could pass outside these boundaries.

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

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

This report describes the missiles launched, the associated monitoring program, and the monitoring program results for the December 2016 to mid-November 2017 period. During the monitoring period, five missiles were launched on three separate days: 03 December 2016 (two missiles), 12 May 2017 (two missiles), and 14 September 2017 (one missile). This report describes the missile launches that occurred, the acoustic and visual monitoring during the launches, and estimates the numbers of pinnipeds affected by the launches.

1.1.1 Audio Monitoring

Audio recordings attempt to document launch sounds at several distances from the launch trajectories of the missiles (See Chapter 2 for details). During all launches in this monitoring period audio recorders were placed in the same location as video cameras documenting pinniped reactions, thus obtaining paired acoustic and pinniped-response data, in addition to recording launch sounds, these audio recordings document ambient noise levels prior to and following the launches. Objectives of the audio monitoring program include:

1. Document levels and characteristics of launch sounds at several distances from the missile paths;
2. Document levels and characteristics of ambient sounds at the same locations as launch sounds, as a measure of the background noise against which the pinnipeds will (or will not) detect the launch sounds; and

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

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

3. Determine the sound levels from missile overflights were high enough to have the potential to induce Temporary Threshold Shift (TTS) in pinnipeds exposed to launch sounds[3].

1.1.2 Visual Monitoring

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

Video records document pinniped responses to missile launches. Objectives include the following:

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

1.2 Impact Estimates

The monitoring program for the missile launches on SNI is designed, in part, to provide data necessary to estimate the numbers of pinnipeds affected by launches and the manner in which they were affected. Pinnipeds are assumed to be 'taken by harassment' if there is a reason to believe that auditory impairment (TTS) 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." As a corollary of that, NMFS (2002) states that "…one or more pinnipeds blinking its eyes, lifting or turning its head, or moving a few feet along the beach as a result of a human activity are not considered a 'take' under the MMPA definition of harassment."

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

1. Pinnipeds injured or killed during launches, if any (e.g., by stampedes);
2. Pinnipeds exposed to launch sounds strong enough to cause permanent or temporary auditory impairment (permanent threshold shift [PTS] or TTS);

[3] Based upon available TTS information harbor seals might have TTS onset at a received SEL-M of >129 dB re 20 $\mu Pa^2 \cdot s$ and California sea lions at SEL-M > 159 dB re 20 $\mu Pa^2 \cdot s$. As a conservative measure, all three species seals are assumed to have the same TTS onset level as harbor seals (see Section 4.2.1)

3. Pinnipeds that left the haul-out site, or exhibited prolonged movement[4] or behavioral changes (such as pups separated from mothers) relative to their behavior immediately prior to the launch.

No pinnipeds are known to have been injured or killed since the launch monitoring began in August 2001, and few, if any, are believed to have received sounds strong enough to elicit TTS (Holst, et al. 2011). Thus, the number of pinnipeds counted as potentially affected during the current monitoring period was primarily based on criterion 3 above – the number that left the haul-out site, or exhibited prolonged movement or other behavioral changes relative to their behavior in the hours preceding the launch.

1.3 Missile Types Launched During the Monitoring Period

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

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

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

1.4 Launch Dates and Information

Between December 2016 and mid-November 2017 there were five missile launches from SNI on three separate days (Table 1.1). These launches all involved either single missiles or, in two cases, a dual launch of two missiles launched within a few seconds (s). Missiles launched included five GQM (two dual launches). All launches occurred during daylight hours (between 0600 and 1500 local time). Weather during the launches ranged 58° to 75° Fahrenheit (F) at the control room, with winds between 2 and 14 knots (kts) and skies ranging from clear and sunny to complete overcast or fog (Table 1.1).

GQM

Dual GQM launch (2 missiles) occurred on 03 December 2016 at 09:56 local time, and 12 May 2017 at 09:30 local time. A single GQM launch occurred on 14 September 2017 at 09:45 local time. All five GQMs were launched from the Alpha Launch Complex located approximately 625 ft (190.5 m) ASL on the west-central part of SNI. The GQMs were launched on azimuths of 335º true (03 Dec 16 and 12 May 17) and 270º true (14 Sep 17) at an elevation angle of 14º above horizontal. The missiles crossed the

[4] Prolonged movement, for the purpose of the monitoring and this report, is defined as one or more animals moving in a directed manner either more than 10 m (33 ft) onshore or moving any distance from the shore and entering the ocean.

west end of SNI at an altitude of approximately 1,850 ft (564 m) ASL (Table 1.1). The height above sea level for these launches was calculated based on elevation angle. Elevation angle, however, does not necessarily translate to a straight line for altitude change for GQM, as the missiles may actively alter the rate of climb achieving a higher than expected altitude for a given launch angle and distance from the launcher.

TABLE 1.1. Launch data for the December 2016 to mid-November 2017 report period.

Launch Date	Launch Time (local)	Missile Type	Launch Complex	Launch Azimuth (true)	Elevation Angle / Altitude Over Beach (Feet)	Weather at Control Room (Max Wind speed in knots)[1]	Video Quality	Audio Quality
12/03/2016	09:56	GQM x 2	Alpha	335°	14° / 1,850	11 WNW / 57°	Okay[2]	Good
05/12/2017	09:30	GQM x 2	Alpha	315°	14° / 1,850	13 NW / 53°	Good	Okay[3]
09/14/2017	09:45	GQM x 1	Alpha	270°	14° / 1,850	4 NW / 63°	Good	Good

[1] The weather data were collected at the launch control room located between 2 and 5 kilometers from the missiles' closest point of approach to the shoreline or at the SNI Airfield approximately 10 kilometers from the missile's CPA; therefore weather conditions at pinniped haul-out sites near the closest point of approach may have marginally differed.

[2] All video cameras were fogged up, due to foggy conditions. Animals on the beach were visible in the videos and post scan identification of the animals was possible.

[3] For the GQM x 2 missile launch on 12 May 2017, recordings from all four monitoring sites suffered from various problems. At monitoring site Pirates Cove, the sound of missiles was very weak on both recording channels. At monitoring site Dos Coves, both channels were near flat line. At monitoring site Redeye Beach, the launch event was already in progress at the start of the recording, and the preceding sound file was unavailable. At monitoring site Alpha Pad, the recording was unusually brief, and both channels were near flat line. Thus, none of the acoustic data from the 12 May 2017 launch were analyzed for sound metrics.

2. ACOUSTIC MEASUREMENTS OF MISSILE LAUNCHES

2.1 Introduction

The acoustic measurement program for the monitoring period is consistent in approach and methodology with that used during the preceding years (Ugoretz 2016, Ugoretz 2015, Holst et al. 2011). Recordings of each missile's sound, as well as background sounds, were attempted at up to three pinniped haulout sites as well as the launch pad during each missile flight. ATARs were developed for this purpose by the Navy's acoustical contractor, Greeneridge Sciences Inc. of Santa Barbara, California. The specific design of the ATARs was described previously (Ugoretz 2016, Ugoretz 2015, Holst et al. 2011). Maps of the launch azimuths and monitoring locations are provided in Chapter 3 (Fig. 3.1). Fifteen recordings were obtained during the monitoring period, however on five recordings launch sounds were not properly recorded and the data was not analyzed (Tables 1.1 and 2.1).

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

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

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

2.2 Field Methods

2.2.1 Deployment of ATARs

Prior to each launch, ATARs are positioned at the launch pad and near pinniped haul out sites at varying distances from the planned launch azimuth (Table 2.1). The recordings provide data for quantitative analysis of the levels and characteristics of the received flight sounds.

ATARs are set up between one and four hours prior to the launch and retrieved in the hour following the launch. The ATAR units are deployed at sites as close as practical to as many as three pinniped haul-out sites at various distances from the launch site and launch trajectory. The total number of sites monitored depends upon the presence of pinnipeds on beaches in the potentially impacted area.

In addition to providing information on the magnitude, characteristics, and duration of sounds to which pinnipeds are exposed, acoustic data and monitoring provide associated pinniped behavioral data. These data have contributed to a longer-term dataset, intended to help determine if there is a "dose-response" relationship between received sound levels and pinniped behavioral reactions. 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 acoustic data collected between August 2001 and October 2008 were reported by Holst et al. (2011). In those analyses, factors considered included missile type, launch azimuth, launch characteristics (e.g., low- vs. high-angle launch), as well as weather, which has important effects on the received sounds. Holst et al. reported that the majority of observed California sea lions startled and showed increased vigilance up to 2 min after each launch; responses often included movement on the beach or into the water and were significantly related to received sound level and distance from the vehicle's closest point of approach. Most observed northern elephant seals showed little reaction to launches and merely raised their heads briefly. Nonetheless, their responses were also related to received sound level and distance from vehicle trajectory. Pacific harbor seals were the most responsive with an average of 68% (range 7 to 100%) of observed harbor seals within ~4 km of the launch trajectory departing haul-out sites by entering the water. Within the range of conditions studied, there was no clear correlation between harbor seal response and received sound level or distance from the closest point of approach of the vehicle.

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

Launch Date	Missile	ATAR Locations	Recording Status
12/03/2016	GQM x 2	Alpha Pad*, Dos Coves, B809, Redeye	3 of 4 OK
05/12/2017	GQM x 2	Alpha Pad, Dos Coves, Pirates Cove, Redeye	0 of 4 OK*
09/14/2017	GQM x 1	Alpha Pad, Dos Coves, Redeye, Phoca Reef	4 of 4 OK

* The acoustic data from the recordings' were faulty, a possible hardware problem with the microphones, cables, or batteries.

2.3 Audio Data Analysis Methods

Both time-series and frequency-domain analyses are performed on the acoustic data. Time-series results included signal waveform and duration, peak pressure level (peak), root mean square (rms) sound pressure level (SPL), and SEL. SPL and SEL were determined with three alternative frequency weightings: flat-weighted (SPL-f and SEL-f), A-weighted (SPL-A and SEL-A), and M_{pa}-weighted (SPL-M and SEL-M) basis. The M_{pa}-weighting procedure, appropriate for pinnipeds in air, is described in Southall et al. (2007) and in past monitoring reports (Ugoretz 2016, Ugoretz 2015, Holst et al. 2011). Frequency-domain results included estimation of SPLs in one-third octave bands for center frequencies from 4 to 16,000 kHz. The following subsection describes how these values are defined

2.3.1 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 are 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 is 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 listening to moderate-level sounds, as a first approximation.

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

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

2.3.2 Closest Point of Approach by the Missile

To relate missile sounds to the proximity of the missile's trajectory, the 3-dimensional (3-D) distance from the recording site to the closest point of approach (CPA) of the missile is calculated for each launch date and sound monitoring site. In some cases, the CPA is at the launch pad, depending upon monitoring location and missile trajectory.

2.4 Acoustic Monitoring Results

2.4.1 Missile Flight Sounds

Acoustic monitoring results for all five monitored launches are presented in Table 2.2. Four parameters are reported for the missile flight sounds: peak pressure level, SPL, SEL, and duration. The last three parameters are based on flat-, A-, and M_{pa}-weighting. These values are similar to sound levels recorded during previous launches from SNI (Ugoretz 2016, Ugoretz 2015, Holst et al. 2011). It was expected that A- and M_{pa}-weighted levels would be less than flat-weighted levels, consistent with the greater de-emphasis of low frequency components by A-weighting.

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

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

them as SELs is unconventional. However, for purposes of comparison with the transient missile sounds, one can consider the SPLs for ambient noise to be the SELs in a 1-s period.

TABLE 2.2. Pulse parameters for flat-, A-, and M_{pa}-weighted sound from SNI missile launches, December 2016 to mid-November 2017.

Values highlighted in green exceeded the level at which TTS/PTS onset might occur[1].

Launch Date & Monitoring Site	CPA (km)	Flat-weighted sound				A-weighted sound			M_{pa}-weighted sound		
		Pk	SPL	SEL	Dur	SPL	SEL	Dur	SPL	SEL	Dur
3 December 2016: GQM x 2											
Redeye Beach (1/2)		103.0	89.5	94.6	3.3	81.8	86.4	2.8	87.6	92.0	2.8
Redeye Beach (2/2)		105.0	89.8	95.2	3.5	82.1	87.4	3.4	87.4	92.6	3.3
Dos Coves (1/2)		107.9	90.9	94.5	2.3	80.6	84.8	2.7	86.5	90.6	2.5
Dos Coves (2/2)		109.1	93.0	98.6	3.7	77.6	82.4	3.0	83.4	88.1	2.9
B809 (1/2)		110.3	96.2	101.6	3.5	88.8	93.7	3.1	94.6	99.7	3.3
B809 (2/2)		111.4	96.3	101.9	3.6	88.7	93.9	3.3	94.6	100.0	3.5
Alpha Pad		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
12 May 2017: GQM x 2											
Pirates Cove		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Dos Coves		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Redeye Beach		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Alpha Pad		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
14 September 2017: GQM-163A											
Redeye South		136.8	118.4	117.2	0.8	99.7	101.4	1.5	105.0	106.6	1.4
Dos Coves		159.0	137.8	132.1	0.3	134.6	128.7	0.3	135.5	129.6	0.3
Phoca Reef		101.9	79.8	89.3	8.8	65.3	73.7	6.9	69.4	78.9	8.9
Alpha Pad		136.3	118.3	122.4	2.6	105.1	109.7	2.9	113.5	117.7	2.7

[1] Assumed TTS onset at a received SEL-M of >129 dB re 20 µPa2•s, PTS onset at a received Pk of >149 dB re 20 µPa (see Section 4.2.1)
Note: Peak levels (Pk) and SPLs are in dB relative to 20 µPa. SELs or energy levels are in dB re 20 $\mu Pa^2 \cdot s$. Durations (Dur) are in seconds.
N/A = data not available.

2.4.2 Ambient Noise Levels

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

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

Date	Missile	Site	Flat-weighted	A-weighted	M_{pa}-weighted
3 December 2016	GQM x 2	Redeye Beach (1/2)	66.3	44.6	52.8
		Redeye Beach (2/2)	66.2	44.6	52.8
		Dos Coves (1/2)	74.9	55.7	61.9
		Dos Coves (2/2)	74.9	55.7	61.9
		B809 (1/2)	65.7	50.3	57.4
		B809 (2/2)	65.7	50.3	57.4
		Alpha Pad	N/A	N/A	N/A
12 May 2017	GQM x 2	Pirates Cove	N/A	N/A	N/A
		Dos Coves	N/A	N/A	N/A
		Redeye Beach	N/A	N/A	N/A
		Alpha Pad	N/A	N/A	N/A
14 September 2017	GQM-163A	Redeye South	51.6	38.8	44.5
		Dos Coves	57.2	50.3	54.7
		Phoca Reef	48.0	36.7	43.0
		Alpha Pad	42.2	19.5	24.8

N/A = data not available.

2.5 Discussion and Summary

During the December 2017 to mid-November 2017 period, the sound levels received from the three monitored missile launches were comparable to those recorded from previous launches at SNI (Ugoretz 2016, Holst et al. 2011). The highest measured sound levels (flat-weighted) at or near monitored pinniped haul-out beaches was 159.0 dB re 20 µPa peak pressure (Dos Coves on 14 Sep 2017), the same launch exceeded 129 dB re 20 $\mu Pa^2 \cdot s$ SEL-M, the energy level at which TTS onset may occur in the Pacific harbor seal (Southall et al. 2007, see Section 4.2.1). This GQM launch was at an azimuth of 270° true which is directly over Dos Coves. The sound of 129.6 dB re 20 μPa^2 s was recorded on the cliff above Dos Coves beach in a more exposed location. Sounds at the haul out on the beach were necessarily lower and sound pressure would be blocked by the terrain. Additionally, no harbor seals were present in this location and the sound level for TTS onset in California sea lions, which were present along with northern elephant seals, has been reported to be 149 dB re 20 μPa^2 s (Kastak et al., 2007).

No measured sound levels exceeded the SEL-M criterion for permanent threshold shift (144 dB - Southall et al. 2007). However, peak pressure levels (flat weighting) exceeded the PTS threshold for one launch 159.0 dB re 20 µPa was recorded at Dos Coves on 14 Sep 2017. This recording was only marginally above the PTS peak pressure threshold and was taken on the cliff above the monitored haul out site. It is likely that the cliff would mask the sound on the haul out beach. Peak pressure levels (flat weighting) were below the 149 dB re 20 µPa PTS threshold for the remaining recordings of missiles/monitoring sites. Therefore, it is unlikely that any pinnipeds experienced launch sounds that could have caused TTS or PTS. The possibility of TTS and PTS occurring in pinnipeds hauled out on SNI during missile launches is further discussed in Chapter 4.

3. PINNIPED BEHAVIOR DURING MISSILE LAUNCHES

3.1 Introduction

Three species of pinnipeds are common on SNI beaches – California sea lion, Pacific harbor seal, and northern elephant seal. Northern elephant seals have shown little reaction to previous missile launches and directed monitoring of elephant seals is not required by the current LOA. Therefore this report only details reactions of Pacific harbor seals and California sea lions. Elephant seals were present on some of the monitored haul-outs along the other species and were included in the camera's FOV. On most occasions, reactions were similar to those in the past (generally no movement or very minor movement down the beach) reconfirming their lack of reaction to missile launches. No other pinniped species were recorded during this or previous monitoring since August 2001 (Ugoretz 2016, Ugoretz 2015, Holst et al. 2011).

California sea lions often show startle responses to launches and movement along the beach. In most cases, sea lion behavior returns to pre-launch levels within seconds or minutes following the launches (Holst et al. 2011). Behavior as well as numbers of sea lions hauled-out several hours after a launch appears similar to the behavior and numbers observed before a launch. In contrast, when Pacific harbor seals react to launches, they commonly leave their haul-out sites to enter the water and do not return for several hours or the next tide cycle (Holst et al. 2011). Nonetheless, Holst and Lawson (2002) noted that the behavior and numbers of Pacific harbor seals hauled out on the day following a launch were similar to those on the day of the launch. This pattern was confirmed by launch monitoring on multiple days by Navy biologists.

Due to operational needs, one dual GQM launch occurred during Pacific harbor seal pupping/nursing season (12 May 2017) very late in the breeding season. On this day, only a small number of harbor seals were present on pirates cove beach within the audible range of the launch. No evidence of injury, mortality, or pup abandonment was observed on the day of any launch during the monitoring period, nor was any launch-related injury or mortality expected based on prior monitoring results.

3.2 Field Methods

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

3.2.1 Visual Observations

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

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

During the launches described in this report, use of video methods allowed for observations of up to three pinniped species during the same launch. The actual number of species observed depends on the number of video systems deployed during each launch and on the number of species hauled out at those sampling sites (Table 3.1).

Cameras were placed at locations overlooking haul-out sites prior to each launch. Cameras were placed in a manner to minimize disturbance to pinnipeds. The entire haul-out aggregation at a given site cannot be recorded, as the wide-angle view necessary to encompass an entire beach generally will not allow detailed behavioral observations. Thus, cameras are set to record a focal subgroup within the haul-out aggregation. Prior to selecting a focal subgroup, however, video pans of the entire area are made to allow computation of total animals in the area. Video pans are repeated after the launch to provide information on changes in total numbers of animals present. The number of animals affected at a given location is calculated based on the percentage of the total group monitored and the percentage of the focal group affected.

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

3.2.2 Digital Video Cameras

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

TABLE 3.1. Video monitoring locations and pinniped species present.

	Video Recording Location By Species					
	California Sea Lion				Pacific Harbor Seal	
Launch Date	Dos Coves	B809	Redeye Beach	Vizcaino Point	Phoca Reef	Pirates Cove
12/03/2016	X	X	X			
05/12/2017	X		X			X
09/14/2017	X		X		X	

X - Focal group videotaped
* - No animals present at time of launch

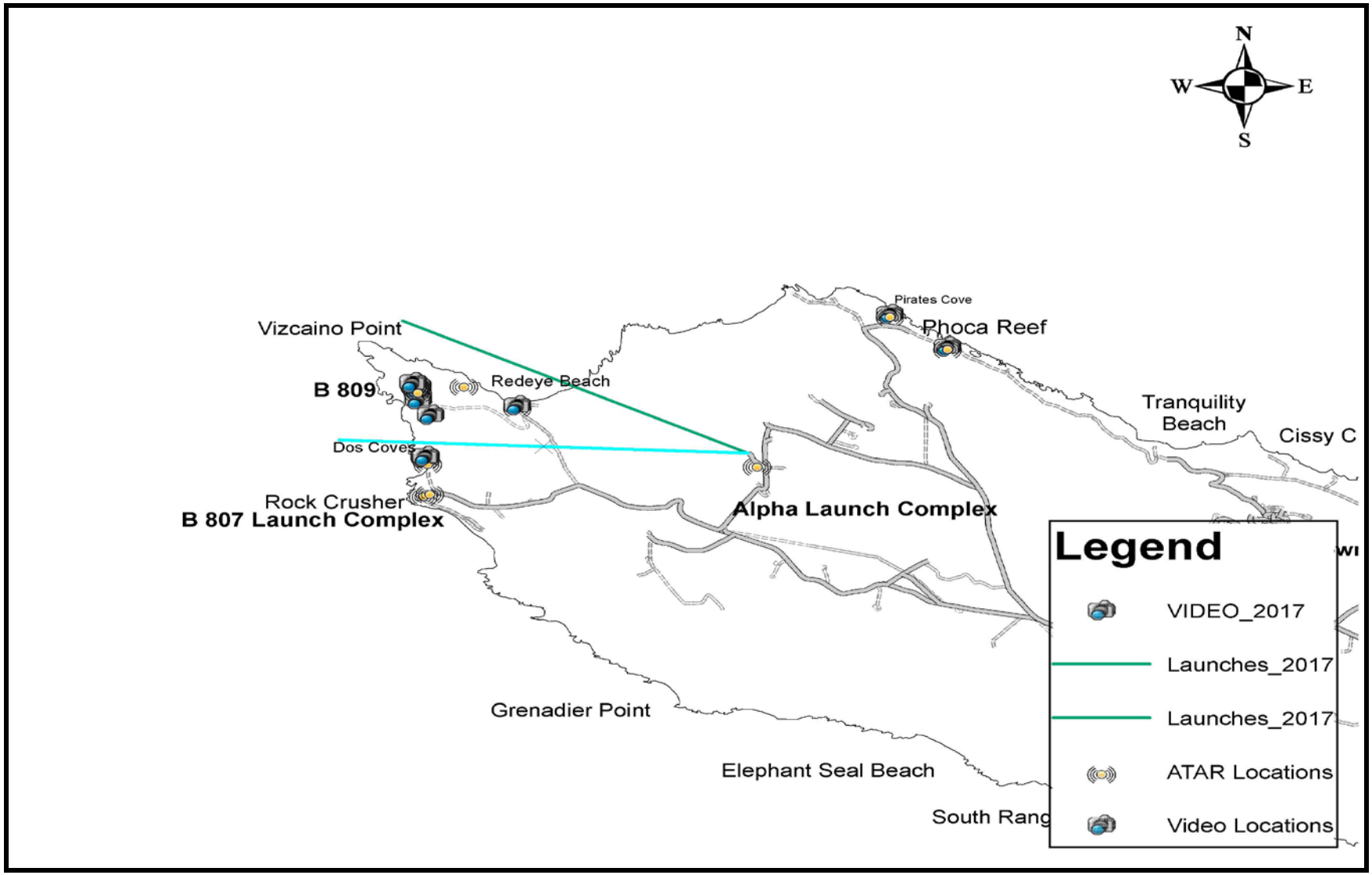


FIGURE 3.1. Launch azimuths, acoustic recording sites (ATARs), and video recording sites.

3.3 Video Monitoring Analysis

Digital video recordings are reviewed by an experienced biologist on a high-resolution color monitor. The recordings before, during, and up to 60 min after each launch are reviewed to document the types and numbers of pinnipeds present, the nature of any overt responses to the launch, and the number of pinnipeds that overtly responded. The number, proportion and age class (adult or pup - where determinable) of the individuals that responded in various ways is determined from the video, along with comparable data for those that did not respond. Following NMFS [2002], subtle behavioral reactions persisting for only a few minutes are considered unlikely to have biologically significant consequences for the pinnipeds. Pinnipeds that move into the water or greater than 10 m (33 ft) along the beach are considered to have been affected. To relate pinniped behavior to the proximity of the missile launch, the 3-D distance from the recording site to the CPA of the missile is calculated.

3.4 Descriptions of Pinniped Behavior during Specific Launches

Video recordings of pinniped behavior during launches from December 2016 to mid-November 2017 were successfully collected on all three dates for California sea lions and on two dates for Pacific harbor seals (Table 3.1). Harbor seals were not present on beaches within audible range of launches on other launch dates. California sea lions were monitored at three separate haul-outs and Pacific harbor seals were monitored at two haul-outs. The video recordings generally provided data on the responses of a focal portion of the total pinnipeds present on a given beach, though on some occasions all animals in the area were recorded.

3.4.1 GQM Dual Launch, 03 December 2016

Video recordings of California sea lions were made at Bldg. 809 (CPA ≈ 1.6 km), Dos Coves (CPA ≈ 1.8 km), and Redeye Beach. (CPA ≈ 1.6 km) (Figure 3.1).

California sea lions. No sea lions were in the vicinity of Bldg. 809 within the camera's FOV at the time of the launch, so focal animal responses were not captured. Approximately 30 sea lions were in the vicinity of Redeye Beach with 30 in the camera's FOV. 10 of the 30 animals reacted, with movement along the slope but not into the water. Of those, 10 moved more than 10 m and were considered to have been impacted. From this, approximately 10 of the sea lions were considered to have been impacted in the area [(10/30)*30]. Approximately 200 sea lions were in the vicinity of Dos Coves during the dual launch with 10 in the camera's FOV. One hundred percent of these reacted to the launch with movement along the beach or into the water. Of those, 7 moved more than 10 m and were considered to have been impacted. From this, approximately 140 of the sea lions were considered to have been impacted in the area [(7/10)*200]. At both Redeye Beach and Dos Coves animals returned to normal resting behaviors after less than five minutes. Based on counts of sea lions at unmonitored beaches on days prior to and following the launch, it is estimated that an additional 0 sea lions were impacted by the launch. Therefore a total of 150 sea lions were considered to have been impacted by the dual launch.

Pacific harbor seals. No harbor seals were observed in the area potentially affected prior to the launches.

3.4.2 GQM Dual Launch, 12 May 2017

Video recordings of California sea lions were made at Dos Coves (CPA ≈ 1.8 km), Redeye Beach (CPA ≈ 1.6 km) and recordings of Pacific harbor seals at Pirates Cove (CPA ≈ 2.3 km) (Figure 3.1).

California sea lions. Approximately 200 sea lions were in the vicinity of Dos Coves during the dual launch with 200 in the camera's FOV. 100 of these reacted to the launch with movement along the slope and 25 into the water. Of those, 70 moved more than 10 m and were considered to have been impacted. Based on this, it is estimated that 70 of the sea lions in the area were considered to have been impacted by the launches [(70/200)*200]. Approximately 40 sea lions were in the vicinity of Redeye Beach with 10 in the camera's FOV. 10 of these reacted to the launch with movement along the slope and 5 into the water. Of those, 7 moved more than 10 m and were considered to have been impacted. It is estimated that 28 of the sea lions in the area were considered to have been impacted by the launches [(7/10)*40]. Based on counts of sea lions at unmonitored beaches on days prior to and following the launch, it is estimated that an additional 0 sea lions were impacted by the launch. Therefore a total of 98 sea lions were considered to have been impacted by the dual launch.

Pacific harbor seals. 8 harbor seals were present on Pirates Cove Beach and in the water adjacent prior to the launch. One mother and pup pair and two other adults moved into the water in response to the launch, but did not depart the immediate vicinity. All animals were present on the beach and in the water adjacent during the post launch scan. Harbor seals were not hauled out at other beaches within the area of potential impact during the launch. Therefore a total of 4 harbor seals were considered to have been impacted by the dual launch.

3.4.3 GQM Launch, 14 September 2017

Video recordings of California sea lions were made at Dos Coves (CPA ≈ 1.8 km), Redeye Beach (CPA ≈ 1.6 km) and recordings of Pacific harbor seals at Phoca Reef (CPA ≈ 2.3 km) (Figure 3.1).

California sea lions. Approximately 250 sea lions were in the vicinity of Dos Coves during the launch with 80 in the camera's FOV. Most of the animals on the beach moved in response to the launches with the majority only moving a short distance along the beach. Of those, 70 moved more than 10 m and were considered to have been impacted. From this, an estimated 219 sea lions were considered to have been impacted in the area [(70/80)*250]. Approximately 35 sea lions were present in the vicinity of Redeye Beach all within the camera's FOV at the time of the pre scan. At the time of the launch the camera at Redeye was not operating correctly and did not record the launch. At the post scan no sea lions were present on the beach. From this, an estimated 35 sea lions were considered to have been impacted by the launch. Based on counts of sea lions at unmonitored beaches on days prior to and following the launch, it is estimated that an additional 200 sea lions were considered to have been impacted by the launch. Therefore a total of 454 sea lions are estimated to have been impacted by the dual launch.

Pacific harbor seals. 6 harbor seals were present on Phoca Reef at the time of the pre scan. 6 harbor seals were present at the time of the launch. 4 harbor seals moved into the water in response to the launch, and departed the camera FOV, and therefore 4 harbor seals are considered impacted by the launch [(4/6)*6]. Harbor seals were not hauled out at other beaches within the area of potential impact during the launch.

3.5 Implementation of Mitigation Measures

Table 3.2 shows a summary of the mitigation measures that were specified by NMFS in the LOA, and how they were implemented during the December 2016 to mid-November 2017 monitoring period.

TABLE 3.2. Implementation of mitigation measures.

Mitigation Measure	Implementation
No personnel at haul-out sites 2 hr before launch	Personnel were prohibited from accessing the haul-out sites at least 2 hr before all launches.
Avoid launches during Pacific harbor seal pupping season	One Dual launch occurred during Pacific harbor seal pupping season (12 May 2017). No harbor seal pups were present on affected beaches during this launch and no evidence of pup abandonment was noted.
Limit launch activities during other pinniped pupping season	One launch occurred early in northern elephant seal pupping season (03 December 2016). The launch had to occur on this date due to operational needs. No impacts were noted to elephant seals during the launch and no pups were abandoned.
No launches of missiles at low elevation from Alpha Launch Complex	The five missiles launched from the Alpha Launch Complex passed over the shoreline at an elevation of approximately 1,850 ft.
Avoid multiple launches in quick succession, especially when pups present	Two dual launches occurred (03 December 2016, and 12 May 2017). The December launch was early in northern elephant seal pupping season and the May launch was during harbor seal pupping season. The launches had to occur on these dates due to operational needs. As noted above, no impacts to pups of either species were observed.
Limit launches during nighttime	No night launches occurred.
Ensure aircraft maintain an altitude of 1000 ft from haul outs	No aircraft were flown near haul-out areas during or immediately following launch operations.
Review launch procedure and monitoring methods with NMFS if pinniped injury or mortality are discovered.	No injured or dead pinnipeds were seen in post launch observations during the monitoring period.

4. TOTAL ESTIMATED NUMBERS OF PINNIPEDS AFFECTED

4.1 Pinniped Behavioral Reactions to Noise and Disturbance

Some of the pinnipeds on the beaches at SNI exhibit disturbance reactions to missile launches, but others do not. The levels, frequencies, and types of noise that elicit a response are known or expected to vary between and within species, individuals, locations, and seasons. Reactions to the same missile types also varied from one launch to the next, possibly due to weather conditions, ambient noise or other factors. It is possible that pinnipeds hauled out on land may react to the sight (light at night), or the combined sight plus sound, of a missile launch. Furthermore, pinnipeds, at times, react to the sight and sound of seabirds reacting to a launch. Thus, responses are not expected to be a direct function of received sound level. However, some correlation between pinniped responses and received sound level has been shown, at least for California sea lions and elephant seals, based on data from previous monitoring periods (Holst et al. 2011).

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

Although it is possible that pinnipeds exposed to launch noise might "stampede" from the haul-out sites in a manner that causes injury or mortality, this was judged unlikely prior to the monitoring program. Review of video records of pinnipeds during launches at SNI indicates that this assumption was generally correct. However, monitoring conducted during 2002-2003 showed that, in some cases, several Pacific harbor seal pups were knocked over by adult seals as both pups and adults moved toward the water in response to the launch though no injuries were observed (Holst 2008). Similarly, during the 2004-2005 monitoring period, several California sea lion pups were knocked over by adult sea lions as the adults moved along the beach in response to a launch (Holst and Greene 2008). The pups were momentarily startled, but did not appear to be injured.

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

In this report, consistent with previous related reports (Holst et al., 2008, 2011; Ugoretz and Greene 2012, Ugoretz, 2013, Ugoretz 2014, Ugoretz 2015, and Ugoretz 2016), it is assumed that only those animals meeting either of the following criteria are affected by launches:

1. Pinnipeds exposed to launch sounds strong enough to cause TTS; and
2. Pinnipeds that left the haul-out site, or exhibited prolonged movement (> 10 m) or prolonged behavioral changes (such as pups separated from mothers) relative to their behavior immediately prior to the launch.

In practice, since August 2001, no pinnipeds have received sounds strong enough to elicit PTS, and few, if any, are believed to have received sounds strong enough to elicit TTS (see §4.2, below). Thus, the number of pinnipeds counted as potentially affected during the monitoring period was based on criterion (2) – the number that left the haul-out site, or exhibited prolonged movement.

The numbers of such affected pinnipeds were calculated for both observed animals and animals on unobserved beaches in the area of potential affect for each launch during the December 2017 to mid-November 2017 period. Disturbance reactions were short-lived for California sea lions and did not appear to extend into subsequent days. Pacific harbor seals were present during two launches in this monitoring period. Those that reacted moved into the water. Based on this and past monitoring, it is assumed that no long-term affects occurred.

4.2 Possible Effects on Pinniped Hearing Sensitivity

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

4.2.1 Temporary Threshold Shift

There are few published data on TTS thresholds for pinnipeds in air exposed to impulsive or brief non-impulsive sounds. J. Francine, quoted in NMFS (2001, p. 41837), has mentioned evidence of mild TTS in captive California sea lions exposed to a 0.3 s transient sound with an SEL of 135 dBA re 20 $\mu Pa^2 \cdot s$ (see also Bowles et al. 1999). Katsak, et al. (2007) estimated TTS onset for California sea lions in air at 159 dB re 20 $\mu Pa^2 \cdot s$. However, mild TTS may occur in harbor seals exposed to received levels lower than 135 dB SEL (A. Bowles, pers. comm., 2003). Initial evidence from more prolonged (non-pulse) exposures suggests that the TTS threshold on an SEL basis may actually be around 129–131 dB re 20 $\mu Pa^2 \cdot s$ (M_{pa}-weighted) for harbor seals, within their frequency range of good hearing (Kastak et al. 2004; Southall et al. 2007). The same research teams have found that the TTS thresholds of California sea lions and northern elephant seals exposed to strong sounds are higher as compared to harbor seals (Kastak et al. 2005). Based on these studies and other available data, Southall et al. (2007) proposed that sounds may induce mild TTS if the received peak pressure is ~143 dB re 20 μPa, or if received SEL-M is ~129 dB re 20 $\mu Pa^2 \cdot s$ (for pulses) or 131 dB re 20 $\mu Pa^2 \cdot s$ (for non-pulses received in air). Those levels apply specifically to harbor seals and are not expected to elicit TTS in elephant seals or California sea lions (Southall et al. 2007). Thus, as a conservative estimate, it is assumed that all three species might have TTS onset at a received SEL-M of >129 dB re 20 $\mu Pa^2 \cdot s$.

The sounds received from missile launches on SNI are sometimes impulse sounds (e.g., when there is a sonic boom or near the launcher). At other times and locations they are non-impulsive. During past monitoring of missile launches from SNI during 2001-2016, few if any pinnipeds were exposed to sound levels above 122 dB SEL-M (Ugoretz 2016, Ugoretz 2015, Ugoretz 2014, Holst et al. 2008, 2011). In addition, peak pressure levels at pinniped haul-out beaches were generally <143 dB re 20 μPa, although for some launches that produced a sonic boom (impulse), peak pressure levels were as high as 159 dB

(Holst et al. 2008). Thus, it is possible that a few pinnipeds, particularly Pacific harbor seals, may incur TTS during some missile launches, especially larger missiles, from SNI. Because of their higher TTS thresholds, it is likely that fewer California sea lions and northern elephant seals may incur TTS as compared to Pacific harbor seals.

During the December 2017 to mid-November 2017 monitoring period, SEL-M near pinniped beaches reached up to 129.6 dB re 20 μPa^2 s and peak pressure levels were as high as 159.0 dB re 20 µPa (flat weighted). However, these maximums were recorded on open ground on a cliff above the beach at Dos Coves. Pinnipeds present in the area were below this cliff and sheltered from direct launch sounds by it. Thus, it is unlikely that any animals incurred TTS during the monitoring period.

4.2.2 Permanent Threshold Shift

Southall et al. (2007) estimate that received SELs would need to exceed the TTS threshold by at least 15 dB for pulses and 13.5 dB for non-pulses in air for there to be risk of PTS. In the harbor seal, the SEL-M that is estimated to result in onset of PTS is 144 dB re 20 $\mu Pa^2 \cdot s$ (Southall et al. 2007). As already noted above, the SEL-M measurements nearshore did not exceed the SEL-based PTS threshold. Even SEL-M measurements taken close to the launcher were far less than 144 dB re 20 $\mu Pa^2 \cdot s$, with a maximum of 137.3 dB re 20 $\mu Pa^2 \cdot s$ (Table 2.2).

However, there is some possibility that a few pinnipeds at SNI might receive peak pressures exceeding those that elicit onset of TTS or perhaps even PTS. In animals (or humans) exposed to strong impulsive sound (e.g., close to an artillery shot), there is a possibility of PTS as a result of the high peak pressure even if the received energy did not exceed the SEL criterion for PTS onset. When considering peak pressures rather than energy levels, PTS onset may occur when the received level is as little as 6 dB higher than the TTS threshold, or 149 dB re 20 µPa in the case of the harbor seal (Southall et al. 2007). During the December 2016 – mid-November 2017 monitoring period, peak pressure exceeded 149 dB re 20 µPa on one occasion. During the GQM launch on 14 September 2017 peak pressure levels (flat weighting) of 159.0 dB re 20 µPa were recorded at Dos Coves (Table 2.2). As previously discussed, these levels only marginally exceeded the PTS onset level and, given the location of animals on the beach below the cliff where the ATAR was located, and animals were sheltered from the sound by the topography. It is unlikely that they were exposed to sounds above 149 dB re 20 µPa.

Given the higher TTS thresholds in northern elephant seals and California sea lions than in harbor seals, PTS thresholds in those other species are also expected to be higher than in the harbor seal. Thus, it is unlikely that PTS occurred in California sea lions or northern elephant seals during those launches. Pacific harbor seal haul-out sites are located farther from the launch complexes at SNI, so peak levels at haul-out locations will be lower than nearer the launch pads. Thus, Pacific harbor seals are also unlikely to incur PTS during launches at SNI. During the monitoring period, it is unlikely that the sounds were strong enough at pinniped haul-out sites to have induced PTS in any pinniped species.

4.2.3 Conclusions Regarding Effects on Pinniped Hearing Sensitivity

Overall, the results to date indicate that there is little potential for appreciable TTS or PTS in pinnipeds hauled out on SNI near the missile launch paths during launch operations. This conclusion is necessarily speculative given the limited TTS data (and lack of PTS data) for pinnipeds in air exposed to strong sounds for brief periods. In the event that levels are occasionally sufficiently high to cause TTS, these levels probably would be only slightly above the presumed thresholds for mild TTS. Thus, in the event that TTS did occur, it would typically be mild and reversible and thus PTS would necessarily not

occur. Given the relatively infrequent launches from SNI, the low probability of TTS during any one launch, and the fact that a given pinniped is not always present on land, there appears to be no likelihood of PTS from the cumulative effects of multiple launches.

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

4.3 Estimated Numbers of Pinnipeds Affected by Launches

The approach to estimating the numbers of pinnipeds affected by launches between December 2016 and mid-November 2017 was based on audio, video, and direct observations of pinnipeds, combined with estimates of the numbers of hauled out pinnipeds in the same general vicinity not videotaped but exposed to the same launches. The latter animals are presumed to have reacted in the same manner as those whose responses were videotaped. For pinniped groups that extended farther along the beach than encompassed by the FOV of the video camera, an estimate of the total number of individuals that were hauled out was made based on a pre-launch video pan of the area. For pinnipeds on unobserved beaches, the percentage of animals affected on the nearest observed beaches were applied to the average counts of animals found on the unobserved beaches during peak breading season.

The proportions of animals in the focal subgroups affected during each launch (based on the disturbance criteria listed in §4.1) are extrapolated to the estimated total number of individuals hauled out in this area (Tables 4.1 and 4.2). It is not possible to extrapolate the proportions of animals affected on the monitored beaches to the entire island as not all beaches can be observed on the day of a launch. However, whenever possible surveys of surrounding beaches are conducted during monitoring set up to determine if additional pinnipeds are in the area. Additionally, individual pinnipeds may be affected on more than one occasion, but are counted here as separate individuals. Thus, while the overall estimate of pinnipeds affected may be over- or underestimated it is likely that the totals presented here are overestimates.

Northern fur seals (*Callorhinus ursinus*) and Guadalupe fur seals (*Arctocephalus townsendi*) were not observed on SNI during launches in the December 2016 – mid-November 2017 monitoring period, and none were evident in the video segments that were analyzed.

Observations from 2001-2017 continue to show that all of the haul-out sites continue to be occupied on subsequent days following the launches. There was no evidence of injury or mortality during any of the launches.

TABLE 4.1. Estimated numbers of California sea lions affected by launches - December 2017 to mid-November 2017.

Launch Date	Missile Type	Monitoring Site	# of Focal Animals Potentially Affected	Total # Estimated Affected in Area	Subtotals
03 December 2016	Dual GQM	Dos Coves	10	*140*	
		Building 809	0	*0*	
		Redeye Beach	30	*10*	
		Unmonitored Beaches	N/A	*0*	150
12 May 2017	Dual GQM	Dos Coves	200	*70*	
		Redeye Beach	10	*28*	
		Unmonitored Beaches	N/A	*0*	98
14 September 2017	GQM	Dos Coves	80	*219*	
		Redeye Beach	35	*35*	
		Unmonitored Beaches	N/A	*200*	454
				Total number of sea lions potentially affected:	***702***

Note: Numbers in *italics* are estimates based upon the proportion of pinnipeds affected within a focal group and expanded to the entire number of animals present in the area.
N/A - Not Applicable

TABLE 4.2. Estimated numbers of Pacific harbor seals affected by launches - December 2017 to mid-November 2017.

Launch Date	Missile Type	Monitoring Site	# of Focal Animals Potentially Affected	Total # Estimated Affected in Area	Subtotals
03 December 2016	Dual GQM	Dos Coves	N/A	N/A	*0*
		Building 809	N/A	N/A	
		Redeye Beach	0	0	
		Unmonitored Beaches	N/A	N/A	
12 May 2017	Dual GQM	Pirates Cove	8	8	*4*
		Dos Coves	N/A	N/A	
		Redeye Beach	0	0	
		Unmonitored Beaches	N/A	N/A	
14 September 2017	GQM	Phoca Reef	6	6	*4*
		Dos Coves	N/A	N/A	
		Redeye Beach	0	0	
		Unmonitored Beaches	N/A	N/A	
		Total number of harbor seals potentially affected:			**8**

Note: Numbers in italics are estimates based upon the proportion of pinnipeds affected within a focal group and expanded to the entire number of animals present in the area.
Dash (-) - unknown number hauled out during the launch assumed to be zero based on observed beaches and/or tide.

4.4 Summary

No evidence of pinniped injuries or fatalities related to launch noises or other launch operations was evident, nor was it expected. It is also unlikely that any pinnipeds were exposed to received levels of sound energy above levels at which PTS or TTS would occur.

702 California sea lions, and 8 Pacific harbor seals, are estimated to have been affected during the December 2017 to mid-November 2017 monitoring period. These figures are approximate, because they (a) include extrapolations for pinnipeds on beaches that were not monitored on any given launch day, (b) very likely count some of the same individuals more than once, and (c) may exclude pinnipeds on some beaches that were not monitored. The pinnipeds included in these estimates left the haul-out site in response to the launch, or exhibited prolonged movement or behavioral changes relative to their behavior immediately prior to the launch.

The results from the December 2017 to mid-November 2017 monitoring period (and those from previous monitoring periods) suggest that any effects of the launch operations were minor, short-term, and localized. Some Pacific harbor seals left their haul-out site on land, but numbers occupying haul-out sites shortly after a launch or the next day are generally similar to pre-launch levels. It is not likely that any of the pinnipeds on SNI were adversely impacted by such behavioral reactions.

These results are supported by continuing population increases of pinnipeds on San Nicolas Island. Counts of all three species of pinnipeds have significantly increased on SNI over the past three decades (Barlow, et al., 1997, Fluharty, 1999, Le Boeuf, et al., 1978, Lowry 2002, Lowry and Maravilla, 2005, Lowry, et al., 1996 and 2008 and Lowry, Pers. Comm.). This includes increases in pinniped counts in the portions of the island closest to the missile launch trajectories.

5. ACKNOWLEDGEMENTS

United States Navy staff Lisa Thomas, John Ugoretz, and Claudia Makeyev provided critical support collecting the audio and video recordings from SNI along with ancillary visual observations, weather data, and other information.

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 and Katherine Kim of Greeneridge Sciences Inc. analyzed the recordings and prepared the figures of launch-by-launch acoustic results.

We are grateful to all concerned.

This Page Intentionally Blank

6. LITERATURE CITED

Barlow, J., K.A. Forney, P.S. Hill, R.L. Brownell Jr., J.V. Carretta, D.P. DeMaster, F. Julian, M.S. Lowry, T. Ragen, and R.R. Reeves. 1997. U.S. Pacific marine mammal stock assessments: 1996. NOAA-TM-NMFS-SWFSC-248. U.S. National marine Fisheries Service, Southwest Fisheries Science Center, La Jolla, CA. 223 p.

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

Fluharty, M.J. 1999. Summary of Pacific harbor seal, *Phoca vitulina richardsi*, surveys in California, 1982 to 1995. Marine Region Administrative Report 99-1. California Department of Fish and Game. 49 pp.

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

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

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

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

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

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

Holst, M., C.R. Greene, Jr. W.J. Richardson, T.L. McDonald, K. Bay, S.J. Schwartz, and G. Smith. 2011. Responses of Pinnipeds to Navy Missile Launches at San Nicolas Island, California. Aquatic Mammals, 37(2), 139-150.

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

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

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

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

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

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

Le Boeuf, B.J., M.L. Bonnell, M.O. Pierson, D.H. Dettman, and G.D. Farrens. 1978. Final Report, 1975 - 1976, Marine Mammal and Seabird Survey of the Southern California Bight Area. Volume III - Principal Investigators' Reports. The Regents of the University of California, University of California, Santa Cruz, CA. 472 pp.

Lowry, M., Marine Mammal Turtle Division, Southwest Fisheries Science Center, National Marine Fisheries Service, NOAA, DOC, 14 November 2013, Personal Communication.

Lowry, M.S. 2002. Counts of northern elephant seals at rookeries in the southern California Bight: 1981-2001. NOAA-TM-NMFS-SWFSC-345, U.S. Dept. Comm., NOAA, NMFS, SWFSC.

Lowry, M. S. and O. Maravilla-Chavez. 2005. Recent Abundance of California Sea Lions in Western Baja California, Mexico and the United States. In D. K. Garcelon and C. A. Schwemm (editors), Proceedings of the Sixth California Islands Symposium, Ventura, California, December 1-3, 2003. p. 485-497. National Park Service Technical Publication CHIS-05-01, Institute for Wildlife Studies, Arcata, California.

Lowry, M.S., W.L. Perryman, M.S. Lynn, R.L. Westlake, and F. Julian. 1996. Counts of northern elephant seals, m*irounga angustirostris*, from large-format aerial photographs taken at rookeries in Southern California during the breeding season. Fish. Bull. 94:176-185.

Lowry, M.S., J.V. Carretta and K.A. Forney. 2008. Pacific Harbor Seal Census in California During May-July 2002 and 2004. California Fish and Game 94(4):180-193.

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

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

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

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

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

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

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

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

Ugoretz, J. 2013. Pinniped Monitoring During Missile Launches on San Nicolas Island, California, September 2012 - September 2013. Naval Air Warfare Center Weapons Division, Point Mugu, CA. 65 p.

Ugoretz, J. 2014. Final Comprehensive Report - Pinniped Monitoring During Missile Launches on San Nicolas Island, California, June 2009 - June 2014. Naval Air Warfare Center Weapons Division, Point Mugu, CA. 73 pp.

Ugoretz, J. 2015. Pinniped Monitoring During Missile Launches on San Nicolas Island, California, December 2014 - November 2015. Naval Air Warfare Center Weapons Division, Point Mugu, CA. 36 pp.

Ugoretz, J. 2016. Pinniped Monitoring During Missile Launches on San Nicolas Island, California, December 2015 – November 2016. Naval Air Warfare Center Weapons Division, Point Mugu, CA. 35 pp.

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

This Page Intentionally Blank

APPENDIX A:
SMAL TAKE REGULATIONS
3 JUNE 2014 – 3 JUNE 2019

Title 50: Wildlife and Fisheries
Subpart F—Taking of Marine Mammals Incidental To Target and Missile Launch Activities From San Nicolas Island, CA

Source: 79 FR 32684, June 3, 2014, unless otherwise noted.

Effective Date Note: At 79 FR 32684, June 3, 2014, subpart F was added, effective June 3, 2014, through June 3, 2019.

§217.50 Specified activity and specified geographical region.

(a) Regulations in this subpart apply only to the incidental taking of marine mammals specified in paragraph (b) of this section by the Naval Air Warfare Center Weapons Division, U.S. Navy, and those persons it authorizes to engage in target missile launch activities and associated aircraft and helicopter operations at the Naval Air Warfare Center Weapons Division facilities on San Nicolas Island, California.

(b) The incidental take of marine mammals under the activity identified in paragraph (a) of this section is limited to the following species: Northern elephant seals (*Mirounga angustirostris*), harbor seals (*Phoca vitulina*), and California sea lions (*Zalophus californianus*).

(c) This Authorization is valid only for activities associated with the launching of a total of 40 vehicles (e.g., RAM, Coyote, MSST, Terrier, SM-3, or similar) from Alpha Launch Complex and smaller missiles and targets from Building 807 on San Nicolas Island, California.

§217.51 Effective dates.

Regulations in this subpart are effective from June 3, 2014, through June 3, 2019.

§217.52 Permissible methods of taking.

(a) Under Letters of Authorization issued pursuant to §216.106 and 217.57 of this chapter, the Holder of the Letter of Authorization may incidentally, but not intentionally, take marine mammals by harassment, within the area described in §217.50, provided the activity is in compliance with all terms, conditions, and requirements of the regulations and the appropriate Letter of Authorization.

(b) The activities identified in §217.50 must be conducted in a manner that minimizes, to the greatest extent practicable, any adverse impacts on marine mammals and their habitat.

(c) The incidental take of marine mammals is authorized for the species listed in §217.50(b) and is limited to Level B Harassment.

§217.53 Prohibitions.

Notwithstanding takings contemplated in §217.50 and authorized by a Letter of Authorization issued under §§216.106 and 217.57 of this chapter, no person in connection with the activities described in §217.50 may:

(a) Take any marine mammal not specified in §217.50(b);

(b) Take any marine mammal specified in §217.50(b) other than by incidental, unintentional harassment;

(c) Take a marine mammal specified in §217.50(b) if such taking results in more than a negligible impact on the species or stocks of such marine mammal; or

(d) Violate, or fail to comply with, the terms, conditions, and requirements of this subpart or a Letter of Authorization issued under §§216.106 and 217.57 of this chapter.

§217.54 Mitigation.

(a) When conducting operations identified in §217.50(c), the mitigation measures contained in the Letter of Authorization issued under §§216.106 and 217.57 must be implemented. These mitigation measures include, but are not limited to:

(1) The holder of the Letter of Authorization must not enter pinniped haul-out sites below the missile's predicted flight path for 2 hours prior to planned missile launches.

(2) The holder of the Letter of Authorization must avoid, whenever possible, launch activities during harbor seal pupping season (February to April), unless constrained by factors including, but not limited to, human safety, national security, or for vehicle launch trajectory necessary to meet mission objectives.

(3) The holder of the Letter of Authorization must limit, whenever possible, launch activities during other pinniped pupping seasons, unless constrained by factors including, but not limited to, human safety, national security, or for vehicle launch trajectory necessary to meet mission objectives.

(4) The holder of the Letter of Authorization must not launch vehicles from the Alpha Complex at low elevation (less than 1,000 feet (305 m)) on launch azimuths that pass close to pinniped haul-out sites when occupied.

(5) The holder of the Letter of Authorization must avoid, where practicable, launching multiple target missiles in quick succession over haul-out sites, especially when young pups are present.

(6) The holder of the Letter of Authorization must limit launch activities during nighttime hours, except when required by the test objectives.

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

(8) If post-launch surveys determine that an injurious or lethal take of a marine mammal has occurred or there is an indication that the distribution, size, or productivity of the potentially affected pinniped populations has been affected, the launch procedure and the monitoring methods must be reviewed, in cooperation with NMFS, and, if necessary, appropriate changes must be made through modification to a Letter of Authorization, prior to conducting the next launch of the same vehicle under that Letter of Authorization.

(9) Additional mitigation measures as contained in a Letter of Authorization.

(b) [Reserved]

§217.55 Requirements for monitoring and reporting.

(a) Unless specified otherwise in the Letter of Authorization, the Holder of the Letter of Authorization must notify the Administrator, West Coast Region, NMFS, by letter or telephone, at least 2 weeks prior to activities possibly involving the taking of marine mammals. If the authorized activity identified in §217.50 is thought to have resulted in the mortality or injury of any marine mammals or in any take of marine mammals not identified in §217.50(b), then the Holder of the Letter of Authorization must notify the Director, Office of Protected Resources, NMFS, or designee, by telephone (301-427-8401), and the Administrator, West Coast Region, NMFS, or designee, by telephone (562-980-3232), within 48 hours of the discovery of the injured or dead animal.

(b) The National Marine Fisheries Service must be informed immediately of any changes or deletions to any portions of the proposed monitoring plan submitted, in accordance with the Letter of Authorization.

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

(d) The holder of the Letter of Authorization must implement the following monitoring measures:

(1) Visual land-based monitoring.

(i) Prior to each missile launch, an observer(s) will place three 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.

(ii) Systematic visual observations, by those individuals, described in paragraph (c) of this section, of 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 target missiles.

(iii) Systematic visual observations, by those individuals, described in paragraph (c) of this section, of 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, Tomahawk, RAM target and similar types of missiles.

(iv) 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.

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

(ii) Acoustic recordings will be supplemented by the use of radar and telemetry systems to obtain the trajectory of target missiles in three dimensions.

(iii) 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.

(e) The holder of the Letter of Authorization must implement the following reporting requirements:

(1) For each target missile launch, the lead contractor or lead observer for the holder of the Letter of Authorization must provide a status report to NMFS, West Coast Regional Office, providing reporting items found under the Letter of Authorization, unless other arrangements for monitoring are agreed upon in writing.

(2) The Navy shall submit an annual report describing their activities and including the following information:

(i) Timing, number, and nature of launch operations;

(ii) Summary of mitigation and monitoring implementation;

(iii) Summary of pinniped behavioral observations; and

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

(3) The Navy shall submit a draft comprehensive technical report to the Office of Protected Resources and West Coast Regional Office, NMFS, 180 days prior to the expiration of the regulations in this subpart, providing full documentation of the methods, results, and interpretation of all monitoring tasks for launches to date plus preliminary information for missile launches during the first 6 months of the regulations.

(4) A revised final comprehensive technical report, including all monitoring results during the entire period of validity of the Letter of Authorization, will be due 90 days after the end of the period of effectiveness of the regulations in this subpart.

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

(f) Activities related to the monitoring described in paragraphs (c) and (d) of this section, or in the Letter of Authorization issued under §§216.106 and 217.57 of this chapter, including the retention of marine mammals, may be conducted without the need for a separate scientific research permit.

(g) In coordination and compliance with appropriate Navy regulations, the NMFS may, at its discretion, place an observer on San Nicolas Island for any activity involved in marine mammal monitoring either prior to, during, or after a missile launch in order to monitor the impact on marine mammals.

§217.56 Applications for Letters of Authorization.

To incidentally take marine mammals pursuant to the regulations in this subpart, the U.S. citizen (as defined by §216.6 of this chapter) conducting the activity identified in §217.50 (the U.S. Navy) must apply for and obtain either an initial LOA in accordance with §217.57 or a renewal under §217.58.

§217.57 Letters of Authorization.

(a) A Letter of Authorization, unless suspended or revoked, will be valid for a period of time not to exceed the period of validity of this subpart.

(b) Each Letter of Authorization will set forth:

(1) Permissible methods of incidental taking;

(2) Means of effecting the least practicable adverse impact on the species, its habitat, and on the availability of the species for subsistence uses (i.e., mitigation); and

(3) Requirements for mitigation, monitoring, and reporting.

(c) Issuance and renewal of the Letter of Authorization will be based on a determination that the total number of marine mammals taken by the activity as a whole will have no more than a negligible impact on the affected species or stock of marine mammal(s).

§217.58 Renewals and Modifications of Letters of Authorization.

(a) A Letter of Authorization issued under §§216.106 and 217.57 of this chapter for the activity identified in §217.50 will be renewed or modified upon request of the applicant, provided that:

(1) The proposed specified activity and mitigation, monitoring, and reporting measures as well as the anticipated impacts, are the same as those described and analyzed for these regulations (excluding changes made pursuant to the adaptive management provision of this chapter), and;

(2) NMFS determines that the mitigation, monitoring, and reporting measures required by the previous LOA under these regulations were implemented.

(b) For LOA modification or renewal requests by the applicant that include changes to the activity or the mitigation, monitoring, or reporting measures (excluding changes made pursuant to the adaptive management provision of this chapter) that do not change the findings made for the regulations or result in no more than a minor change in the total estimated number of takes (or distribution by species or years), NMFS may publish a notice of proposed LOA in the Federal Register, including the associated analysis illustrating the change, and solicit public comments before issuing the LOA.

(c) An LOA issued under §§216.106 and 217.57 of this chapter for the activity identified in §217.50 may be modified by NMFS under the following circumstances:

(1) Adaptive management. NMFS may modify (including augment) the existing mitigation, monitoring, or reporting measures (after consulting with the Navy regarding the practicability of the modifications) if doing so creates a reasonable likelihood of more effectively accomplishing the goals of the mitigation and monitoring set forth in the preamble for these regulations.

(i) Possible sources of data could contribute to the decision to modify the mitigation, monitoring, and reporting measures in an LOA:

(A) Results from the Navy's monitoring from the previous year(s);

(B) Results from other marine mammal and/or sound research or studies; or

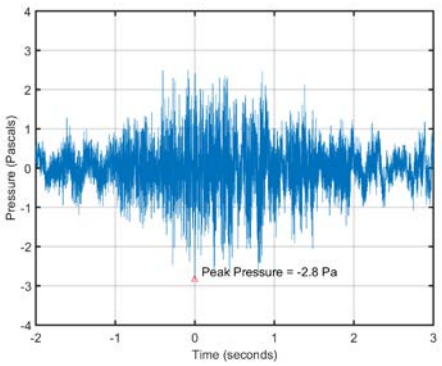
(C) Any information that reveals marine mammals may have been taken in a manner, extent, or number not authorized by these regulations or subsequent LOAs.

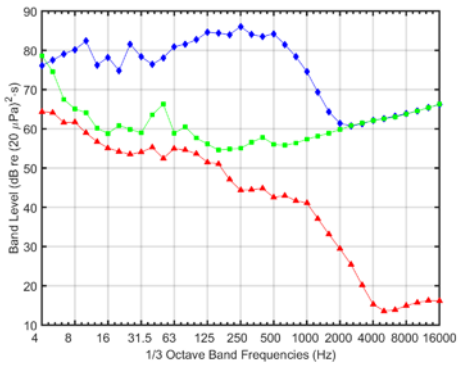
(ii) If, through adaptive management, the modifications to the mitigation, monitoring, or reporting measures are substantial, NMFS will publish a notice of proposed LOA in the Federal Register and solicit public comment.

(2) Emergencies. If NMFS determines that an emergency exists that poses a significant risk to the well-being of the species or stocks of marine mammals specified in §217.50(b), a Letter of Authorization may be modified without prior notice or opportunity for public comment. Notice would be published in the Federal Register within 30 days of the action

This Page Intentionally Blank

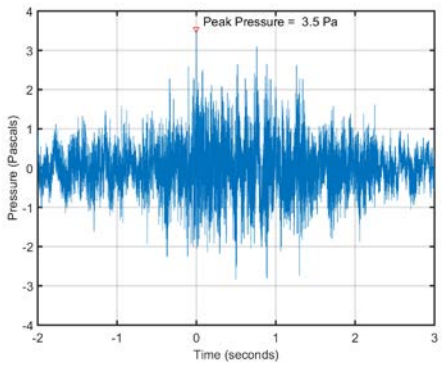
APPENDIX B:
ACOUSTIC DATA
FOR MISSILE LAUNCHES BETWEEN
DECEMBER 2016 – NOVEMBER 2017

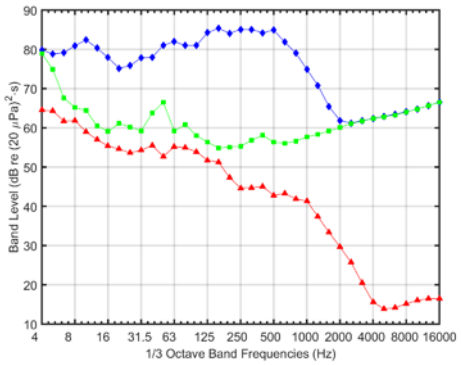




Redeye Beach (1/2) - A

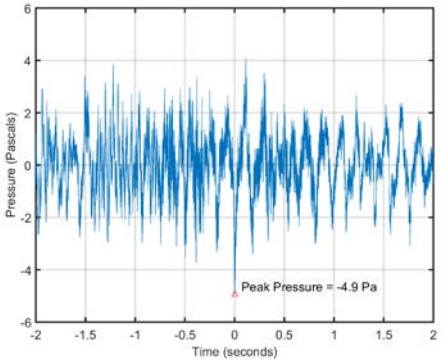
Redeye Beach (1/2) - B

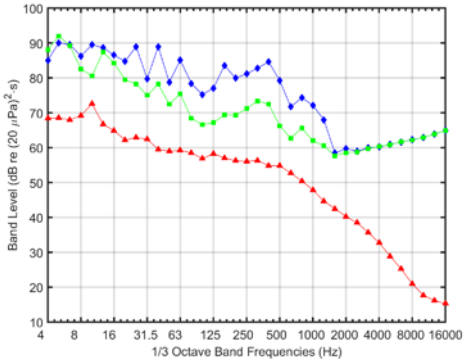




Redeye Beach (2/2) - A

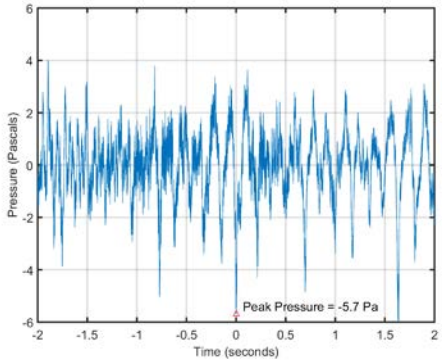
Redeye Beach (2/2) - B

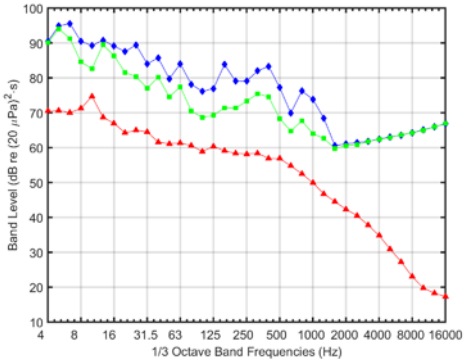




Dos Coves (1/2) - A

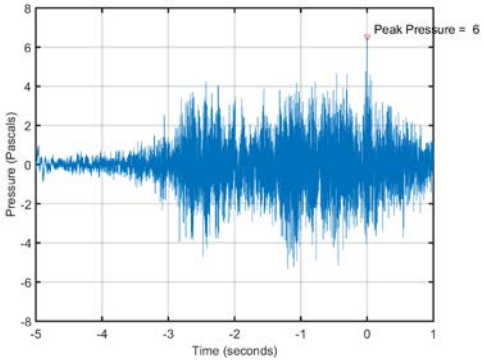
Dos Coves (1/2) - B

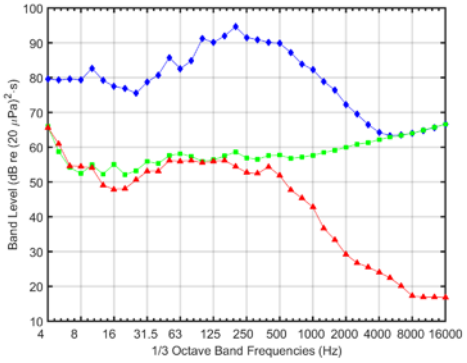




Dos Coves (2/2) - A

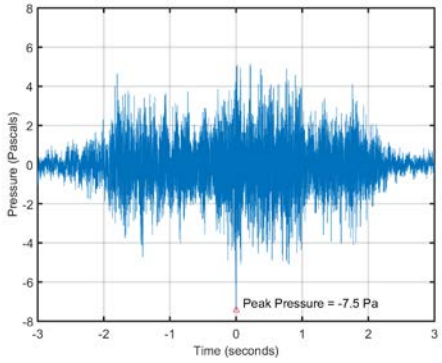
Dos Coves (2/2) - B

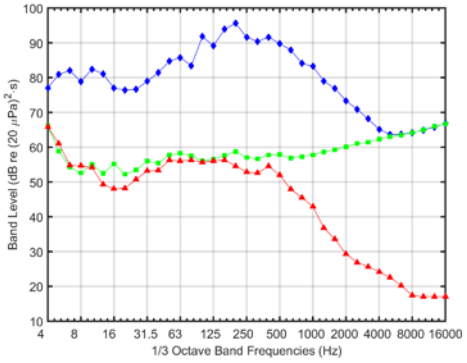




Vizcaino Point (1/2) - A

Vizcaino Point (1/2) - B

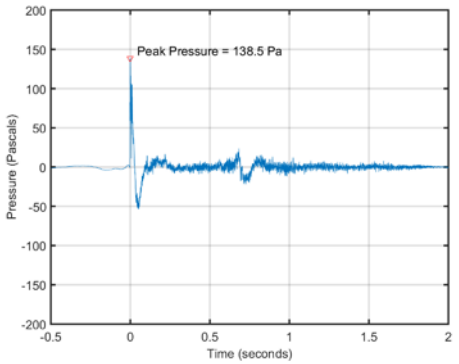




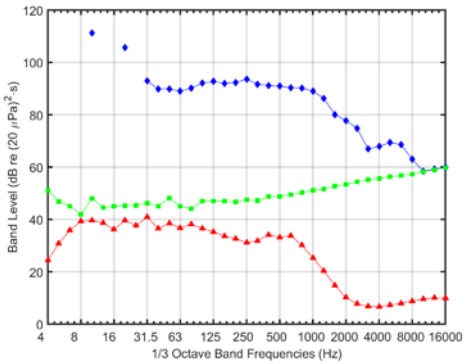
Vizcaino Point (2/2) - A

Vizcaino Point (2/2) - B

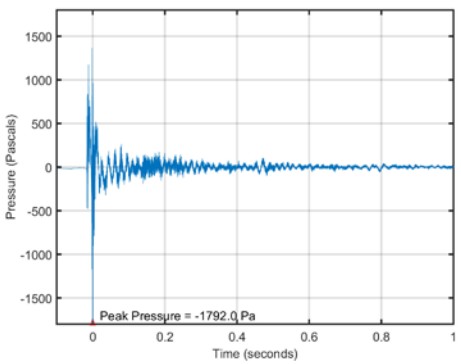
FIGURE 1. (A) Pressure waveform and (B) one-third octave band levels for a GQM x 2 flight at 09:56:00 on 3 December 2016.
In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).



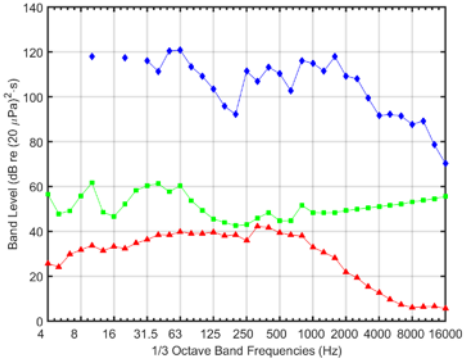
Redeye Beach - A



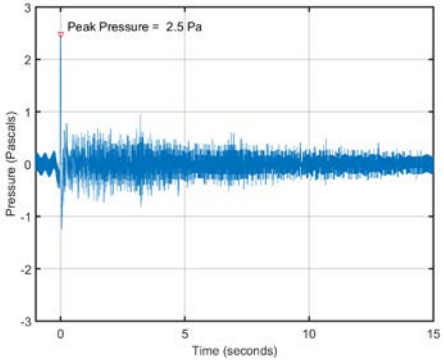
Redeye Beach - B



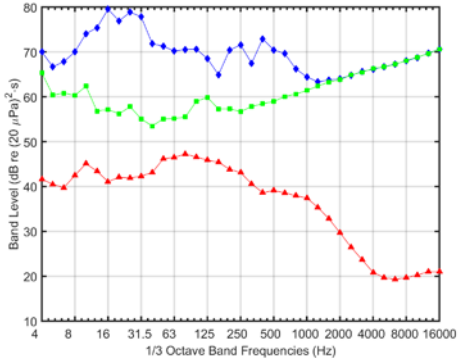
Dos Coves - A



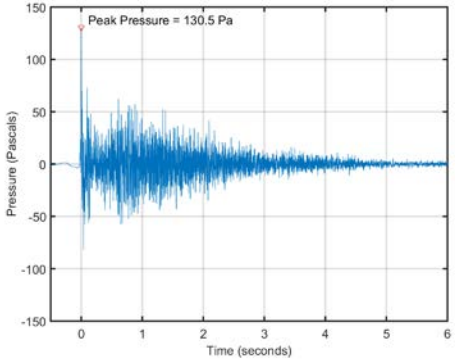
Dos Coves - B



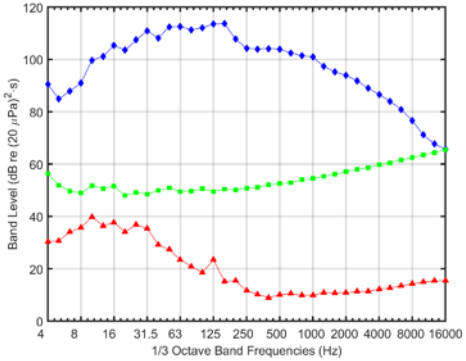
Phoca Reef - A



Phoca Reef - B



Alpha Pad - A



Alpha Pad - B

FIGURE 2. (A) Pressure waveform and (B) one-third octave band levels for a GQM-163A flight at 09:45:00 on 14 September 2017.
In (B), ◊ = missile sound energy; □ = instrumentation noise energy; Δ = ambient noise power. Band frequencies in Hertz (Hz).