# FINAL ANNUAL REPORT
# LETTERS OF AUTHORIZATION:
# Taking Marine Mammals Incidental to Space Vehicle and Missile Launches, and Aircraft Test Flight and Helicopter Operations, at Vandenberg Air Force Base, California
# 1 December 2009 to 30 November 2010

*Submitted to:*
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Division of Permits, Conservation, and Education
Office of Protected Resources
1315 East-West Highway
Silver Spring, MD 20910

*Submitted by:*
United States Air Force
30th Space Wing
30 CES/CEA
1028 Iceland Avenue
Vandenberg Air Force Base, CA 93437

*Prepared by:*


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# 1 Executive Summary

This report is prepared in accordance with a National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS: also called NOAA Fisheries Service) five-year permit for the incidental harassment of marine mammals (NOAA 2009a), and with two Letters of Authorization (LOAs) issued by NOAA to the United States Air Force, Vandenberg Air Force Base (VAFB), 30th Space Wing (NOAA 2009b and 2010). The period covered by this report extends from 1 December 2009 through 30 November 2010, which overlaps the two LOAs. The report is also required in support of VAFB's pending request to renew the 2010 LOA.

This report describes pinniped monitoring conducted in association with space vehicle and missile launches, together with fixed-wing aircraft and helicopter operations. Species of concern at VAFB include Pacific harbor seals (*Phoca vitulina richardsi*), California sea lions (*Zalophus californianus c.*) and northern elephant seals (*Mirounga angustirostris*). At San Miguel Island (SMI), which sometimes is impacted by sonic booms from space vehicles, the northern fur seal (*Callorhinus ursinus*) is considered a species of concern in addition to the three species mentioned for VAFB. (No monitoring was required at SMI during the period covered by this report.) During the reporting period there were ten launches involving five space vehicles and five missiles, as described below.

One of the space vehicle launches occurred on 22 April 2010, within the harbor seal pupping season (1 March through 30 June) when monitoring is mandatory at VAFB. Monitoring was not required at SMI for this launch because the vehicle's westerly trajectory was not expected to result in any impacts there. No indications of abnormal behavior, injury or mortality were reported as a result of this launch (ManTech SRS 2010).

None of the other four space vehicle launches took place during the pupping season. Three of these launches were not monitored because acoustic modeling indicated that no sonic boom exceeding the accepted threshold of one pound per square foot (1 psf) would occur over the northern Channel Islands, including SMI. (Had this threshold been exceeded, monitoring would have been required there.) One launch was not modeled or monitored because the vehicle's westerly trajectory would carry it north of the northern Channel Islands. NOAA Fisheries Service concurred with this, since no impacts to the islands were anticipated. Finally, no Auditory Brainstem Response (ABR) studies were required for any of the space vehicle launches.

Five missile launches occurred during the reporting period, all from north VAFB. The westward trajectory of these launches from this area did not necessitate any sonic boom modeling for the northern Channel Islands, particularly SMI, so no biological monitoring was required there. Two of the missile launches occurred outside of the harbor seal pupping season, so no monitoring was needed for them. Three of the missile launches occurred in June, so monitoring was conducted at VAFB for all three of these launches. No indications of abnormal behavior, injury or mortality were reported as a result of these launches (MMCG and SAIC 2010a, b and c). Finally, no ABR studies were required for any of the missile launches.

During the reporting period, 977 operations were conducted from the VAFB airfield. Most of these consisted of training exercises involving "touch and goes" (West 2010). A few were logistics flights involving the transfer of supplies and personnel. Helicopter operations were greatly reduced from previous years because the helicopter squadron had been transferred from VAFB to other bases. About two helicopter flights a week are now flown over VAFB. Three helicopter search and rescue operations were flown. These involved the Santa Barbara County Sheriff's Department and the U.S. Coast Guard. No indications of abnormal pinniped behavior, injury or mortality were reported as a result of these operations (Evans 2010).

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# 2 Introduction

This report is prepared in accordance with a NOAA - NMFS five-year permit for the incidental harassment of marine mammals (NOAA 2009a). This permit was issued on 6 February 2009 and is valid through 6 February 2014. This report also is in accordance with two LOAs issued by NOAA to the United States Air Force, VAFB, 30th Space Wing. The LOAs cover the periods from 7 February 2009 through 6 February 2010, and from 7 February 2010 through 6 February 2011, respectively (NOAA 2009b and 2010). The period covered by this report extends from 1 December 2009 through 30 November 2010, thus overlapping the two LOAs.

This report provides background information on various operations at VAFB that have the potential for harassment, injury or mortality of marine mammals. Such operations include space vehicle and missile launches as well as fixed-wing aircraft and helicopter operations. The background section also describes marine mammal species of concern in the areas of operation. Species of concern at VAFB include Pacific harbor seals (*Phoca vitulina richardsi*), California sea lions (*Zalophus californianus c.*) and northern elephant seals (*Mirounga angustirostris*). At SMI, the northern fur seal (*Callorhinus ursinus*) is a species of concern in addition to the three species mentioned for VAFB, but no monitoring was required there because in three cases, the modeled sonic booms did not exceed the 1 psf threshold. In other cases, modeling was not required because of the vehicles' and missiles' westerly trajectories. NOAA Fisheries Service concurred with this, since no impacts to the northern Channel Islands were anticipated. Finally, no Auditory Brainstem Response (ABR) studies were required.

The methods section describes techniques used to model sonic booms over the northern Channel Islands. It discusses pinniped monitoring techniques conducted in association with space vehicle and missile launches. It also mentions methods used during monthly pinniped surveys. The results section summarizes the results of the modeling, monitoring and surveys.

The conclusions section analyzes the results of the modeling, monitoring and surveys. It concludes with a discussion of the relative effectiveness of this effort. A literature cited section is included to guide the reader to various references used in the preparation of this report.

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# 3 Background

## 3.1 VAFB Operations

### 3.1.1 Space Vehicle Launches

Five launches of space vehicles occurred during the reporting period (Table 3.1.1, below). These included two Delta II rockets, two Minotaur IV rockets and one Atlas V rocket. The first Delta II rocket carried a NASA wide-field infrared satellite used to research the origins of planets, stars and galaxies and to provide information to astronomers. The second Delta II rocket carried a satellite for the Italian Space Agency and the Italian Defense Agency. The first Minotaur IV rocket carried a Hypersonic [reentry] Technology Vehicle for the Defense Advanced Research Projects Agency (DARPA). The second Minotaur IV vehicle carried a surveillance satellite that can detect and track orbiting objects in space as it orbits in space. The Atlas V rocket carried a classified payload for the National Reconnaissance Office (NRO). All of the rockets were launched from various space launch complexes, three on south VAFB and two on north VAFB. Each space launch complex (SLC) is usually abbreviated and numbered. During the period of this report, launches were made from SLC-2W (west), SLC-3E (east), and SLC-8. The locations of these sites in relation to pinniped haul-out areas are shown in Figures 1 and 2.

***Table 3.1-1. Space Vehicle Launches***

| *Vehicle* | *Facility* | *Planned launch date* | *Actual launch date* | *Time* |
|---|---|---|---|---|
| Delta II | SLC-2W | 7 December 2009 | 14 December 2009 | 0609 (PST) |
| Minotaur IV HTV-2A | SLC-8 | 20 April 2010 | 22 April 2010 | 1600 (PDT) |
| Atlas V NRO L-41 | SLC-3E | 8 September 2010 | 20 September 2010 | 1703 (PDT) |
| Minotaur IV | SLC-8 | 8 July 2010 | 25 September 2010 | 2141 (PDT) |
| Delta II | SLC-2W | 29 October 2010 | 5 November 2010 | 1920 (PDT) |
| Minotaur IV NRO L-66 | SLC-8 | 9 November 2010 | Rescheduled 5 February 2011* | |
| Taurus Glory F-01 | 576E | 22 November 2010 | Rescheduled 23 February 2011* | |

*These are included because they were originally scheduled for the reporting period.

### 3.1.2 Missile Launches

Five missile launches occurred during the reporting period (Table 3.1.2). These included four Minuteman III launches. Minutemen IIIs are Intercontinental Ballistic Missiles (ICBMs), launched from silos on north VAFB. The fifth launch involved a Missile Defense Agency (MDA) missile, also launched from a silo on north VAFB. Each launch facility is abbreviated and numbered. During the period of this report, launches were made from LF-04, LF-09, LF-10, LF-23, and LF-24.

***Table 3.1-2. Missile Launches***

| **Missile** | **Facility** | **Planned launch date** | **Actual launch date** | **Time** |
|---|---|---|---|---|
| Minuteman III | LF-23 | 31 January 2010 | 22 January 2010 | 0300 (PST) |
| MDA | LF-24 | 6 June 2010 | 6 June 2010 | 1525 (PDT) |
| Minuteman III | LF-10 | 16 June 2010 | 16 June 2010 | 0300 (PDT) |
| Minuteman III | LF-04 | 30 June 2010 | 30 June 2010 | 0300 (PDT) |
| Minuteman III | LF-09 | 15 September 2010 | 17 September 2010 | 0300 (PDT) |

### 3.1.3 Fixed-wing Aircraft and Helicopter Operations

Various types of fixed-wing aircraft fly from VAFB. All aircraft are required to maintain a 1000-foot "bubble" around pinniped haul-out and rookery sites; in other words, they must stay 1000 feet above or around any pinniped site. Helicopters, used mainly for launch surveillance and search and rescue operations, must also maintain the same bubble. Exceptions can be made if an emergency search and rescue operation, a security breach or an aircraft emergency occurs.

During the reporting period, 977 operations were conducted from the VAFB airfield. Most of these consisted of training exercises involving "touch and goes" (West 2010). A few were logistics flights involving the transfer of supplies and personnel. Helicopter operations were greatly reduced from previous years because the helicopter squadron stationed at VAFB had been relocated in 2007 to other Air Force bases in Montana, Wyoming and North Dakota. . About two helicopter flights a week are now flown over VAFB. Three helicopter search and rescue operations were flown. These involved the Santa Barbara County Sheriff's Department and the U.S. Coast Guard (Evans 2010).

## 3.2 Pinniped Species of Concern

NMFS is concerned about the potential impacts of anthropogenic noise on marine mammals (Carretta et al. 2009). Such potential impacts include harassment from launch or aircraft noise, particularly sonic booms, which may result in a startle response. In some cases, sudden disturbances from a variety of causes have resulted in the trampling of pups by adult animals, resulting in injuries or mortalities. Other potential noise impacts include temporary [hearing] threshold shift (TTS), in which an animal's hearing is temporarily diminished over part or all of its hearing range. Severe cases can involve permanent [hearing] threshold shift, in which the animal's hearing is permanently diminished over part or all of its hearing range. The requirements of the incidental harassment permit and LOAs, including mitigation monitoring, ensure that such impacts are very unlikely to occur as a result of VAFB operations.

Harbor seals are the most abundant pinnipeds at VAFB. The last estimate of total population size at VAFB was 1,115, made in 2002, while the greatest number seen hauled out at any one time was 502 (SRS Technologies 2003). Harbor seals regularly haul out on isolated sandy coves, ledges and rocks. Three main harbor seal haul-out sites exist on north VAFB (Figure 1). On south VAFB (Figure 2), a small haul-out area exists on some rocks and ledges immediately offshore from the breakwater at Vandenberg Harbor. Approximately 0.7 kilometers (km) to the west, a series of rockbound sandy coves, ledges and offshore rocks begins, extending for about 1.9 km northwest to south Rocky Point. Here, harbor seals haul out and bear their young. Although individual sites have been named, the animals freely wander from one location to the next depending upon tides, potential threats from land and other factors. This stretch is really an almost continuous haul-out and rookery area. South Rocky Point, the northernmost haul-out site on south VAFB, lies about 1.8 km south of SLC-8, the nearest launch facility.

These are distinctly separate sites. One is at the end of Spur Road, another at Purisima Point, and a third at Lion's Head. (Purisima Point is currently restricted because of recently discovered unexploded ordnance.) The first two sites lie between 0.7 and 1.3 km from the nearest launch facilities, while the last site (Lion's Head) is about 1.3 km from the nearest facility (Figure 1).

California sea lions haul out in late spring and summer at north Rocky Point, about 1.5 km west of the nearest launch facility. A few pups have been born there some years, but the site is not considered an established rookery. Sea lions are frequently seen immediately offshore of VAFB and individuals occasionally haul out at various locations throughout the base. These are considered transients, or in some cases, stranded animals.

Northern elephant seals haul out occasionally at VAFB, usually as individuals. A small haul-out area at Point Conception, south of VAFB, has been established by these seals. Challenges related to private land access have temporarily halted monitoring there.

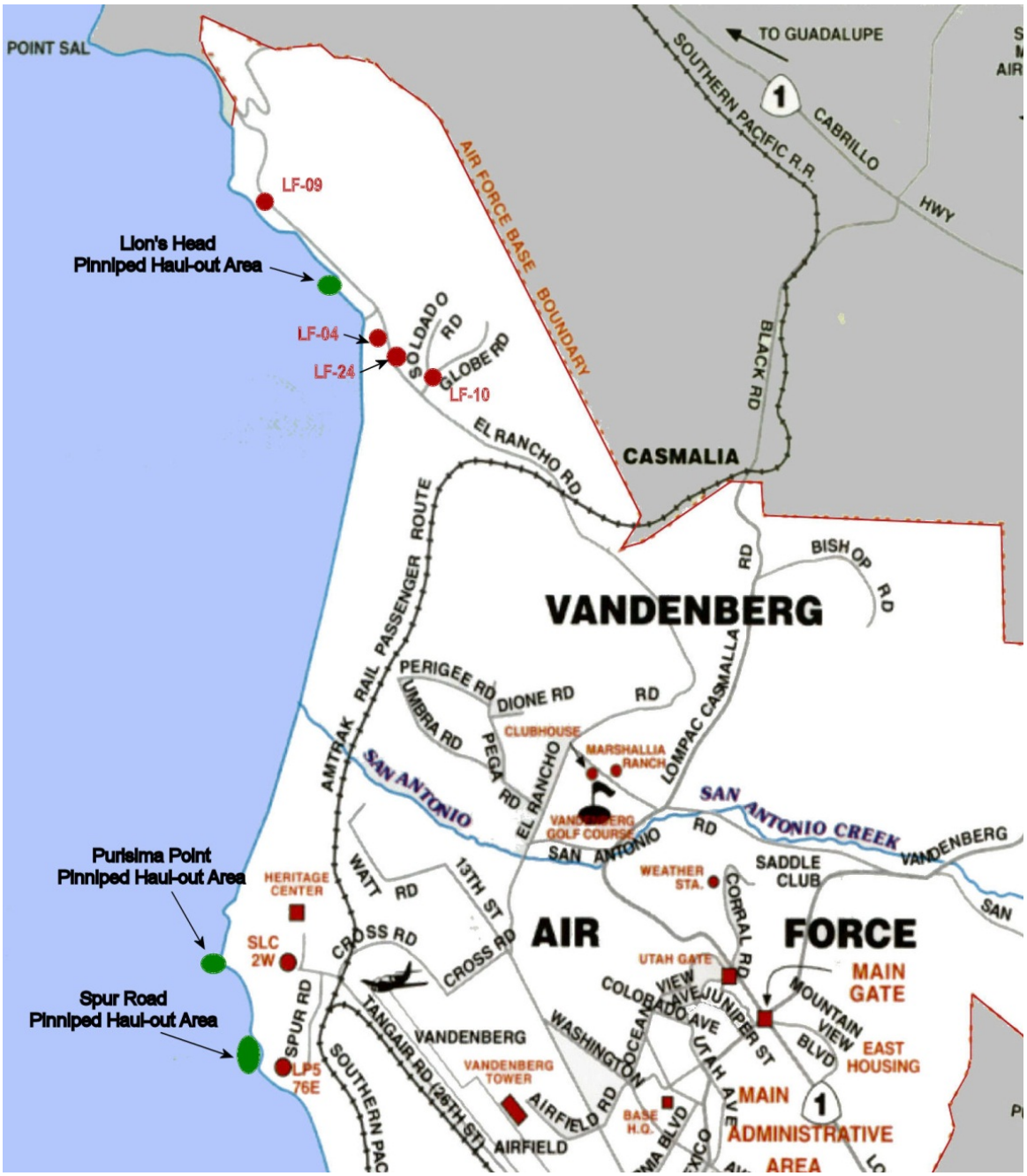


***Figure 1. Launch Sites and Pinniped Haul-out Areas on North VAFB***

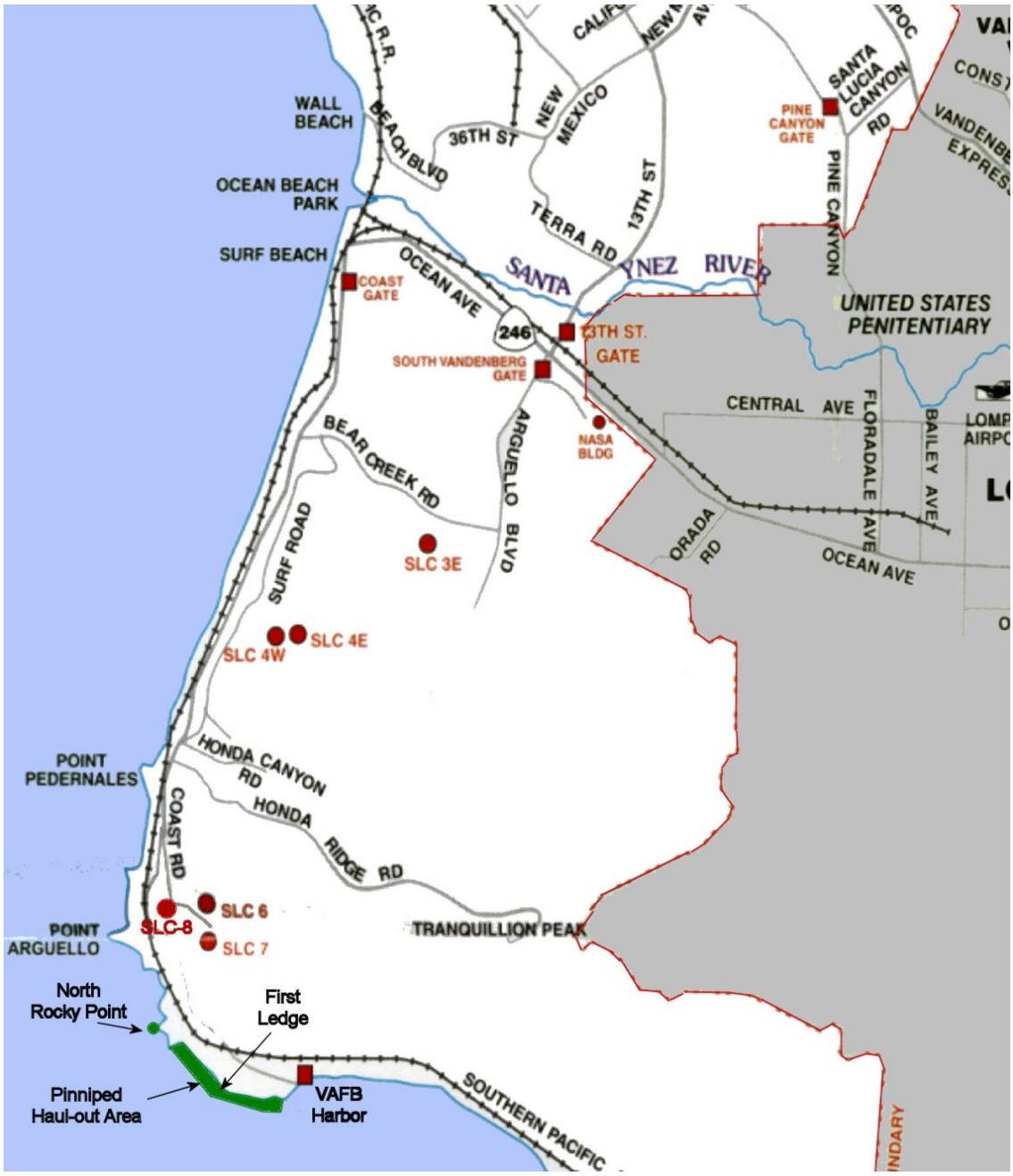


***Figure 2. Launch Sites and Pinniped Haul-out Areas on South VAFB***

# 4 Methods

## 4.1 Sonic Boom Modeling

Pre-launch sonic boom modeling was performed prior to four of the five scheduled space vehicle launches. Nominal flight trajectory information from each launch vehicle was incorporated into PCBoom3, a sonic boom prediction program, along with numerous samples of various meteorological conditions that might be expected during each launch. From these data, the models predicted peak amplitudes and impact locations. For the other space vehicle launch, modeling was not required because of the vehicle's westerly trajectory. NOAA Fisheries Service concurred with this, since no impacts to the northern Channel Islands were anticipated. Since the missile launches were to be performed at north VAFB in a westerly trajectory north of SMI, no modeling was necessary for these launches, either.

## 4.2 Biological Monitoring

Biological monitoring was conducted by two firms. For the 22 April 2010 Minotaur IV launch, ManTech SRS conducted the monitoring. For the one MDA and two Minuteman III launches, the MMCG - SAIC team conducted the monitoring. Methods used were essentially the same except as noted otherwise in the following sections.

### 4.2.1 Timing

Pinniped monitoring is required by the LOAs during the harbor seal pupping season, from 1 March through 30 June. Monitoring must start at least 72 hours before each launch and continue to 48 hours after the launch. Follow-up monitoring must also be conducted two weeks after each launch during pupping season. Monitoring should be conducted as close to each launch window as possible; this involves several hours of monitoring. Marine mammal counts are made hourly during each monitoring period, or more often if substantial changes occur in the number of animals present. Nighttime monitoring is not allowed because of personnel safety concerns—the bluffs overlooking the haul-out sites are unstable and subject to sudden collapse. Visual monitoring is not allowed during launches because of personnel safety concerns, but the monitors returned to the observation points as soon as the launch area was reopened. This was not always possible on launch days, especially with afternoon launches. In some cases, remote video monitoring was possible during launches.

### 4.2.2 Site Selection

The closest harbor seal haul-out areas to SLC-8, used for the 22 April 2010 Minotaur IV launch, lie between 1.6 and 2 km from the launch complex. More distant haul-outs were only counted at the beginning and end of each day because they were too far away to be counted hourly (ManTech SRS 2010).

The closest harbor seal haul-out area to the three missile launch sites was at Lion's Head. This haul-out area was selected because it was between 1.3 and 2.7 km from the various launch facilities used in June. The next closest site, at Purisima Point, was more than 11 km away from the nearest of the three missile launch facilities used in June. Moreover, it is currently restricted because of unexploded ordnance. The last haul-out site was about 13 km from the launch facility (MMCG and SAIC 2010).

### 4.2.3 Monitoring

Monitors observed harbor seals from the bluffs overlooking the haul-out sites. When possible, animals in view from a distance were counted prior to reaching the observation point in case something disturbed them before the observer arrived. By approaching very slowly and maintaining a minimal profile, disturbances to the animals were avoided. High-end binoculars, which provided clear and bright magnification of the animals, were used. Counts were made hourly or more often if any significant changes occurred. Only harbor seals hauled out of the water were counted, in accordance with accepted NOAA Fisheries Service monitoring methods. (Animals in the water, especially when numerous, are impossible to distinguish from one another as they surface to breathe, submerge, then re-surface, often in another location.) Sightings of other marine mammal species, whether in the water or not, were also recorded, along with other wildlife such as seabirds or terrestrial animals on or over the bluff. Such sightings were anecdotal and not meant to be comprehensive because the focus was upon pinnipeds.

### 4.2.4 Data Recording

Data were recorded as to species observed, total number of animals observed, number of males and females (if determinable), number of adults, juveniles and pups, and their behavior. Remarks were recorded as appropriate, including the nature and cause of any disturbance, including natural factors as well as human-related disturbances, such as people on the bluffs or beaches, in boats, low-flying aircraft, or passing trains. Anecdotal information was recorded on other wildlife.

Environmental data recorded included time and level of tides, visibility, percentage and type of cloud cover, air temperature, wind direction and velocity, and swell direction and height. In recording environmental data for the Minotaur IV launch, tidal data were obtained from a tidal prediction program, JTides 5.2, using data from Port San Luis. Although another station, Avila, was closer, it was felt that conditions at Port San Luis more accurately reflected conditions at VAFB. Swell data were obtained from a NOAA buoy approximately 31.5 km west-northwest of Point Arguello. Wind data were obtained from weather station PTGC1 at Point Arguello (ManTech SRS 2010).

For the three missile launches, environmental conditions were recorded upon arrival and hourly thereafter until departure. Environmental data were also recorded when any significant changes occurred, such as sudden increases in wind or rapid onset of fog. Tidal data were obtained for Point Arguello from NOAA. From these data, tides at Point Sal, the closest station to Lion's Head on north VAFB, could easily be calculated. Air temperature, wind direction and velocity, and swell direction and height were recorded onsite, since such conditions can affect haul-out patterns at a given site (MMCG and SAIC 2010).

### 4.2.5 Time-lapse Photography

In two instances, time-lapse photography was used to count seals before, during and after launches. (The other launches occurred in darkness.) For the 22 April 2010 Minotaur IV launch, time-lapse video was employed at a single selected site, called First Ledge, on south VAFB. The camera was focused on a small section of this single site (ManTech SRS 2010).

Most remote video monitoring equipment has a limited recording time—usually up to about two hours—unless a steady power supply is provided and/or the camera is set for time-lapse recording. Since the window for the 6 June 2010 Minuteman III launch extended from 1200 to 1600 (four hours) and slips in the schedule were possible, the MMCG - SAIC team opted to position a digital camera overlooking the Lion's Head observation site. The camera was fitted with an extended life battery and a very large memory capacity. Thus, the camera could record a high-resolution photograph every minute for six hours, covering not only the launch window but an overlap in case of schedule changes. The camera was

set to begin recording at 1100 and continue until 1700. Each image had a time-date stamp, ensuring that an accurate record could be obtained of harbor seal haul-out activities before, during and after the launch The camera was firmly mounted on a special solid platform made specifically for this purpose. It was enclosed in a humidity-controlled, weathertight housing (MMCG and SAIC 2010).

## 4.3 Monthly Surveys

During the monthly surveys, the MMCG - SAIC team had one NOAA-approved monitor, as required in the LOAs, visit each site. In addition, another person accompanied the monitor for safety reasons. In case of accident, the safety person could have radioed for assistance. The team arrived at the first site approximately two hours before the minus tide and departed from the last site approximately two hours after the tide. Approximately two hours were allowed for south VAFB and an additional two hours for north VAFB. Counts were made and recorded at each site, then the team would move to the next site. Other than not repeating the counts every hour, the same monitoring protocols described in Section 4.2.3, above, were used.

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# 5 Results

## 5.1 Sonic Boom Modeling

None of the three models indicated a threshold in excess of 1 psf, thus no marine mammal monitoring was required for the northern Channel Islands, including SMI.

## 5.2 Biological Monitoring

### 5.2.1 Visual Monitoring

#### 5.2.1.1 22 April 2010 Minotaur IV Launch

During the pre-launch monitoring period, from 17 through 21 April, 20 to 160 adult harbor seals were observed. The daily maximum ranged from a total of 111 to 160 animals. Pup counts ranged from 12 to 48, with daily maximums of between 31 and 48 animals. Post-launch monitoring yielded from 115 to 167 adults, with daily maximums of 165 to 167. Pup counts ranged from 17 to 39, with daily maximums of 38 to 39 pups. Six dead pups were recorded prior to the launch. One of them was "torn open." This was an unusually high number of pup mortalities. Previous counts revealed a high of four dead pups in 2004. Only one dead pup was noted after the launch. It had a deep, two-inch gash on its side. Whether this was one of the six pups or yet another one was not discussed. None of the dead pups was recovered, for two reasons: First, recovering the dead pups would have disturbed the other animals, possibly resulting in the abandonment of pups. Second, the haul-out sites along this stretch of coast lie beneath steep, unstable bluffs subject to sudden collapse, rendering access from the bluffs very dangerous to personnel. On follow-up counts made two weeks after the launch, between 67 and 161 harbor seals were counted, along with 22 to 34 pups. One of the adults had a deep wound, possibly inflicted by a shark.

In addition to the harbor seals, two northern elephant seals were observed at separate locations, both during the pre-launch surveys on 17 April. One appeared emaciated. Three California sea lions were also observed, either juveniles or adult females both before and after the launch, on 18, 23 and 29 April. No disturbances from human activities were reported (ManTech SRS 2010).

#### 5.2.1.2 6 June 2010 MDA Launch

During the pre-launch monitoring period, from 3 through 5 June, from 0 to 13 harbor seals were noted. Following the launch, from 0 to 11 animals were noted. During the two-week follow-up count, numbers ranged from zero to four. One juvenile was seen on one occasion. No pups were observed. This was not unexpected because only one pup was observed at Lion's Head during monthly surveys conducted from February through June. The one pup was noted on 21 April 2010. Since harbor seal pups are weaned at four to six weeks of age, it would have been weaned by the time of the 6 June 2010 launch. No pups were reported in surveys performed after the June launches, during the period from July through November (MMCG and SAIC 2010).

No northern elephant seals were observed. On two occasions (both 8 June), individual California sea lions hauled out on the rocks and nearby beach. On another occasion (14 June), one was noted swimming immediately offshore. Interestingly, one to two southern sea otters were observed hauled out on the same rocks as the harbor seals on five of the monitoring days (8 and 14-17 June, inclusive). In one instance, several harbor seals, a sea lion and a sea otter were hauled out close to one another (Figure 3). Individuals were also noted nearby in the water; in some cases, some of these may have been the ones that later hauled out. No disturbances from human activities were observed (MMCG – SAIC 2010a).

***Figure 3. A southern sea otter (lower left), four Pacific harbor seals (center left) and a California sea lion (center right) hauled out at Lion's Head.***

#### 5.2.1.3 16 June 2010 Minuteman III Launch

During the pre-launch monitoring period, from 13 through 15 June, from zero to five harbor seals hauled out at Lion's Head. On the day of the launch, from zero to one seal was hauled out. The following day, up to three were hauled out. During the two-week follow-up period, numbers ranged from zero to three. One juvenile was seen on one occasion. No pups were seen (see 6 June MDA launch, above).

Only one sea lion was noted on 14 June, swimming a short distance offshore. No northern elephant seals were seen. From zero to four sea otters were observed hauled out on the same rocks used by the harbor seals. These were very likely some of the same individuals observed during the previous monitoring efforts.

During the follow-up counts two weeks later, one sea otter was observed hauled out. In addition, three coastal bottlenose dolphins (*Tursiops truncatus*) were noted swimming a short distance offshore. No disturbances from human activities were reported (MMCG – SAIC 2010b).

#### 5.2.1.4 30 June 2010 Minuteman III Launch

During the pre-launch surveys, counts of harbor seals ranged from zero to four. On launch day, the count was zero to three, as it was during the post-launch monitoring. No seals were seen during the two-week follow-up count because the rocks were awash. No pups were noted during any of the surveys (see 6 June MDA launch, above).

One sea otter was reported hauled out on one occasion. Up to two sea otters were seen close offshore. Coastal bottlenose dolphins were noted near shore on 28 June (two animals) and 30 June (3 animals). No disturbances from human activities were seen (MMCG – SAIC 2010c).

### 5.2.2 Environmental Conditions

Please see the appendix for a summary of environmental conditions recorded during the launch monitoring efforts, including the two-week follow-up counts.

### 5.2.3 Time-lapse Monitoring

#### 5.2.3.1 22 April 2010 Minotaur IV Launch

Immediately prior to the 22 April 2010 Minotaur IV launch, 15 adult harbor seals and 3 pups were present on a selected part of a haul-out area called First Ledge at south VAFB. Within 18 seconds of the launch at 1600, all but two adults had gone into the water. The remaining two moved to within three meters of the water but remained on the ledge. By 1610, the first adult had hauled back out, followed by a few more later. By 1740, waves covered the ledge and all animals had returned to the water (ManTech SRS 2010).

#### 5.2.3.2 6 June 2010 MDA Launch

Between 1100 and 1400 on the 6 June Minuteman III launch, eight to nine adult harbor seals and one to two southern sea otters (*Enhydra lutris nereis*) were hauled out on the rocks. By 1500, all had gone into the water because the incoming tide and surf was washing over the rocks. No animals were present at Lion's Head during the launch at 1525 because waves were still washing over the haul-out spot. At 1700, Lion's Head was still deserted.

By using the time-lapse digital camera, a long recording period was possible. This allowed the camera to capture a six-hour window instead of the two-hour window from the standard video camera, thus covering the launch delays and ensuring that the entire launch window (1200-1600), plus an overlap in either direction, was covered. Since each image was high resolution, the entire haul-out area and all of the animals there could be covered in one frame. Moreover, it was possible to zoom in on specific places within the haul-out area to obtain an accurate count (MMCG – SAIC 2010a). (Figures 4 through 7).


***Figure 4. Lion's Head haul-out site at 1300: several seals present.***


***Figure 5. Lion's Head haul-out site at 1524, just before launch time: no seals present.***


***Figure 6. Lion's Head haul-out site at launch time, 1525: no seals present.***


***Figure 7. Overall view of Lion's Head haul-out site at launch time: no seals present***

#### 5.2.3.3 16 and 30 June 2010 Minuteman III Launches

The 16 June Minuteman III launch occurred at 0300; the 30 June launch at approximately 0303. Since these launches occurred in darkness, no time-lapse monitoring was performed.

## 5.3 Fixed-wing Aircraft and Helicopter Operations

No indications of abnormal behavior, injury or mortality were reported as a result of fixed-wing aircraft and helicopter flights (Evans 2010).

## 5.4 Monthly Marine Mammal Surveys

Marine mammal surveys are conducted monthly at all known haul-out and rookery sites at VAFB. The results of these surveys are reported monthly, quarterly and annually in separate reports. The results of these surveys can differ from the launch monitoring reports. The monthly surveys are typically conducted during the lowest daytime tides of each month, when the greatest numbers of animals are usually hauled out, whereas the launch surveys are conducted 72 hours before each launch, during each launch itself when possible, and for 48 hours after each launch. Thus, the launch dates and times do not coincide with the lowest tides of the month.

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# 6 Discussion

## 6.1 Effects of Environmental Conditions on Haul-out Patterns

Numerous environmental factors affect pinniped haul-out patterns. Tides would seem to be the most obvious: When tides are high, less haul-out area is exposed, especially when breakers are large and sweep over the haul-out areas. However, beach erosion and subsequent buildup of beaches can also affect available haul-out space in relation to tides (Section 6.2).

Breakers are another obvious factor: When breakers are large and sweep over haul-out spots, animals can be washed into the surf. This is why MMCG – SAIC considered onsite breaker height more important than offshore swell height in recording environmental conditions (Section 4.2.4). When breakers are small, much more haul-out area is available.

Wind and the resultant wind chill, along with temperature, combine to either make haul-out sites desirable or untenable. On very hot, still days, the animals can overheat and must go into the water frequently to stay cool. Conversely, on cool, windy days the animals often remain hauled out for extended periods.

The presence of abundant prey has been suggested as a cause for animals to remain offshore for longer periods. If abundant prey remains nearby, however, the opposite is true: The animals do not have to expend time and energy traveling great distances or seeking prey—it's there for the taking in a short period of time.

Still another factor is daytime versus night. In undisturbed areas, harbor seals typically haul out in the greatest numbers in the afternoons, regardless of tides and breakers, provided abundant haul-out space is available. In areas where haul-out space is limited, tides and breakers can affect haul-out patterns, thus the seals may haul out during the days when tides and breakers are favorable. In areas subject to chronic disturbance—often from people and dogs on the beach—harbor seals often shift to a nighttime haul-out pattern to avoid harassment (Howorth 1995).

## 6.2 Seasonal and Cyclic Effects

In the previous section, the effect of tides, breakers, wind, temperature, and light on haul-out patterns was discussed. In winter, unusually high tides, large surf and strong currents can strip away sand from beaches, resulting in less haul-out area. With the sand gone, the water actually becomes deeper near shore, meaning even moderately high tides can smother haul-out beaches. Conversely, when sand is deposited during mild conditions and the beaches are built back up, tides must be much higher to reach the same point on shore because the deep area near shore has since been buried in sand. Thus, more haul-out area is available.

Conversely, sand deposition can render rocks isolated by water accessible from land or even bury the rocks, sometimes making such areas less desirable as haul-out sites because of their accessibility from land. As an example, during the 13 July monthly marine mammal survey, harbor seals were present at Small Haul-out 1, an offshore rock surrounded by water near Vandenberg Harbor. However, the next five haul-out sites to the north, all of which had been occupied in previous months, were vacant. These haul-out sites had become accessible from shore because of sand deposition, potentially rendering the seals vulnerable to attack from terrestrial predators (Section 6.4). Immediately to the north, in areas that were not accessible from shore, large numbers of harbor seals were congregated.

The natural history of each species also is a significant factor in haul-out patterns. Harbor seals generally haul out in substantial numbers during the pupping and breeding season, from March through June at VAFB. Overlapping this to some extent is the molting season, which extends from May into summer. In general, the largest numbers of harbor seals haul out during molting season. Some overlap of haul-out patterns occurred during the course of these monitoring efforts. Following the molt, the numbers of animals hauled out dwindle until the next pupping and breeding season.

Last year's El Niño was discussed as a possible cause for this year's harbor seal pup mortalities at VAFB. Limited prey was assumed as the cause (ManTech SRS 2010), although whether the presumed lack of prey prevented mothers from having enough milk or prevented newly weaned pups from finding enough to eat was not specified. El Niño events sometimes spawn more storms, which can be more violent than usual. If these are coupled with storm surges, large breakers, strong currents, and/or very high tides, pups can be smashed against the shore or carried away from the rookeries. Although harbor seal pups can swim within minutes of birth, they often cannot survive heavy surf. If they do not remain where their mothers left them, they sometimes cannot be found, resulting in their becoming orphaned. This is a very common occurrence in other harbor seal rookeries along the mainland coast of Santa Barbara County. Every year, orphaned pups are rescued near rookeries at Ellwood and Carpinteria following unusually high tides, large surf, strong currents, or storms. This has become so predictable that rescuers check the beaches near the rookeries immediately following such conditions. Many years ago, such pups were observed from hidden locations so that the mothers could reclaim them, but rescuers soon found that the mothers never returned unless the pups were very close to where they had been left. Pups that were able to stay in the rookeries, regardless of whether an El Niño were present or not, mostly fared very well and showed no signs of starvation (Santa Barbara Marine Mammal Center unpublished reports).

Increased numbers of dead seals, sea lions and sea otters showing indications of shark bites were reported by VAFB and U.S. Coast and Geodetic Survey biologists (Evans 2010). Unusual numbers of live-stranded seals and sea lions with bite wounds inflicted by great white sharks (*Carcharodon carcharias*) have been reported over the past two years in other parts of Santa Barbara County (Santa Barbara Marine Mammal Center unpublished reports).

## 6.3 Effects of Human Activities

Chronic disturbances from humans have caused harbor seals to switch to a nighttime haul-out pattern or even to abandon haul-out areas entirely. Such activities include people and dogs on the beach, water sports and many other factors (Howorth 1995). From numerous observations, Lion's Head appears to be a site undisturbed by such activities. The seals were aware of people on the bluffs but made no move to enter the water, which would be expected in areas characterized by chronic human disturbance. Moreover, from one to four sea otters consistently hauled out at Lion's Head during June 2010. Although sea otters frequently haul out in Alaska, such behavior is uncommon and noteworthy in California and tends to occur in undisturbed areas.

Close approaches by humans from shore out to the harbor seals would very likely frighten the seals into the water. However, no humans were observed onshore near the harbor seal haul-out areas during the course of many surveys on VAFB conducted by the monitoring team. Humans silhouetted on the bluffs could also frighten the seals into the water, especially if they appeared suddenly, made rapid movements or made a lot of noise. This was not observed, however. (The monitoring team itself routinely avoided making sudden movements and noise, and maintained a low profile to prevent such disturbances.)

The 6 June launch had no impact on haul-out patterns because no animals were hauled out then because of high tides and large breakers. During the 16 and 30 June launches, the number of animals hauled out the day after each launch remained the same. Moreover, in the days and weeks following the launches,

the seals maintained their usual haul-out patterns, suggesting that launch effects, if any, had been transitory.

## 6.4 Possible Effects of Terrestrial Predators

Coyotes (*Canis latrans*) sometimes prey upon harbor seals, especially pups. Such behavior has been documented at VAFB (Hanan 1995) and in other parts of California (Howorth 1995) as well as in Washington State (Gearin *et al.* 1990; Gearin 1995), among other areas. During this monitoring effort, coyotes were observed along the top of the bluffs and on the beaches. In addition, coyote sign were evident along a narrow wash leading to the beach at Lion's Head. These signs included scat and tracks on the bluff, in the wash and on the beach, along with bird carcasses with canid teeth marks on the bones. The wash provides a source of fresh water for game, as was evident from the well-worn trails to the spring there. Moreover, cottontail rabbits (*Sylvilagus* sp.) and deer mice (*Peromyscus* sp.), as well as many species of birds, were abundant along the bluff tops, providing a ready source of year-round food.

At south VAFB, observers reported seeing the flipper of a harbor seal pup on a trail above the beach. Nearby was some coyote scat containing seal fur. The monitors concluded that coyotes might have been scavenging carcasses rather than preying upon live seals (ManTech SRS 2010). Although coyotes do scavenge dead animals, they also attack and sometimes kill pups and juveniles. They will also attack adults.

As canid predators, coyotes are attracted to the smell of blood and other products associated with birth. With frequent onshore winds, scents from nearby harbor seal birthing activities would be conveyed landward and could serve as a magnet to coyotes, which do prey on newborn pups and will attack juveniles and adults. Coyote predation of pinnipeds at VAFB and at other parts of the mainland coast has been observed by numerous researchers (Gearin *et al.* 1990; Gearin 1995; Hanan 1995; Howorth 1995).

Behavioral observations of the seals suggest their wariness of coyotes. At Lion's Head, as well as at most other harbor seal haul-outs at VAFB, the seals haul out on rocks surrounded by fairly deep water, even when beaches and rocks closer to shore are readily accessible. As the tide comes in and waves begin washing the rocks upon which the seals haul out, the seals move onto rocks closer to shore. Before doing this, however, they carefully scrutinize the shore and surrounding area, presumably for any threats from land. If sand deposition has filled in the channels surrounding the rocks, making them accessible from land, the seals avoid hauling out on them (Section 6.2). Once on the rocks, they position themselves so that at least some of the seals have a clear view of shore. The seals are quick to react to any movement from shore or from the bluffs. As the tide goes out, the reverse process occurs, with the seals moving to rocks surrounded by water and farther from shore. Interestingly, sea otters there follow the same haul-out patterns.

At south VAFB, some harbor seals do haul out in small coves. These areas, however, are surrounded by high cliffs, making access from land a virtual impossibility. In areas that lack terrestrial predators (e.g., many parts of the Channel Islands), pinnipeds remain on the same beaches and rocks throughout tidal cycles.

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# 7 Conclusions

The monitoring was effective. Consistent results were obtained. No indications of abnormal behavior, injury or mortality were reported as a result of launch or aircraft operations. No ABR studies were required or performed.

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