

**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**

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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) five-year Letter of Authorization (LOA) to the U.S. Air Force, Vandenberg Air Force Base (VAFB), 30th Space Wing (30 SW) for the incidental harassment of marine mammals related to U.S. Air Force Launches and Operations at Vandenberg Air Force Base (NOAA 2019a). The current LOA was issued on 10 April 2019, after publication of the Federal Register Final Rule on 12 April 2019 (NOAA 2019b) related to VAFB's request for unintentional take of marine mammals pursuant to the Marine Mammal Protection Act (MMPA) regulation.

In May 2021, Vandenberg Air Force Base was officially designated Vandenberg Space Force Base (VSFB) and the 30th Space Wing was redesignated 30th Space Launch Delta (or 30 SLD). "Historic" references to VAFB are still found occasionally within this document.

VSFB submitted an application to NMFS for a new LOA on November 2, 2022.

This report summarizes results of monthly pinniped surveys in addition to describing pinniped monitoring conducted in association with space vehicle (rocket) and missile launches, together with fixed-wing aircraft, helicopter and unmanned aerial vehicle operations. Species of interest at VSFB included in the LOA are Pacific harbor seals (*Phoca vitulina*), California sea lions (*Zalophus californianus*), Northern elephant seals (*Mirounga angustirostris*) and Steller sea lions (*Eumetopias jubatus*). At San Miguel Island (SMI), which is occasionally impacted by sonic booms from rockets, the Northern fur seal (*Callorhinus ursinus*) and Guadalupe fur seal (*Arctocephalus townsendi*) are considered species of interest in addition to the four species mentioned for VSFB.

During the reporting period (1 January to 31 December 2022), VSFB launched 14 rockets and three missiles. Rocket launches included the final launch of two programs. Atlas V (10 November 2022) from (Space Launch Complex 3 (SLC 3) and Delta IV (24 September 2022) from SLC-6. SLC-3 is currently being modified to host a new United Launch Alliance (ULA) program, "Vulcan." SLC-6 will most likely be modified to host a different rocket program, however that is not certain as of the date of this report. 2022 saw the first successful launch of Firefly Alpha on October 1 2022, after a failed launch attempt in September 2021.

One small rocket launch, Minotaur II from Test Pad 01 (TP-01) suffered a catastrophic failure immediately after lift-off (7 July 2022). No debris from this launch failure entered the Pacific Ocean. VSFB avoided launches when possible during the Pacific harbor seal pupping season (1 March through 30 June) or if they would produce a sonic boom over the Northern Channel Islands (NCI) during the Pacific harbor seal pupping season. On-base pinniped monitoring was required for nine rocket launches, but no missile launches. Northern Channel Islands pinniped monitoring was required for a Falcon 9 rocket launch on 13 May and a Delta IV-Heavy launch on 24 September. Five first stage recoveries ("boost back") of the Falcon 9 required monitoring at VSFB; all other Falcon 9 first stage recoveries landed on an offshore, autonomous barge, west of Baja California, Mexico. When SpaceX recoveries occur offshore, Space Force determined that it was reasonable to conclude that these recoveries did not result in take to pinnipeds.

During the reporting period, 8,831 operations were conducted from the VSFB airfield. No indications of significant disturbances, abnormal pinniped behavior, injury or mortality were reported as a result of these operations (R. Evans, pers. comm., 2022).

LOA monitoring requirements were followed during 2022 and no incidents of injury or mortality of a pinniped caused by VSFB operations were documented.

Introduction

This report presents information to satisfy the requirements of the LOA (NOAA 2019a) issued to VSFb by NMFS. In accordance with a condition in the 2014 LOA (NOAA 2014, page 1, item #4), instead of notifying NMFS "at least two (2) weeks prior to conducting any launch activities that may result in taking marine mammals by harassment," VSFb has agreed to send quarterly advisories and updates to NOAA. These quarterly advisories were submitted in January, April, July and October 2021 (R. Evans, pers. comm., 2021).

Historically, Pacific harbor seals (*Phoca vitulina*; hereafter harbor seal) have been the most abundant pinnipeds on VSFb, at least during most months. In recent years, northern elephant seals (*Mirounga angustirostris*; hereafter elephant seal) are present in higher numbers than harbor seals in most months and California sea lions (*Zalophus californianus*) are often present in large numbers in the early summer. Steller sea lions (*Eumetopias jubatus*) are also present, albeit rarely; all species except Steller sea lions increasing in recent years (MSRS 2014, CEMML 2016a, CEMML 2016b). For about 4 years, between 2016 and 2019, very large numbers of juvenile California sea lions were observed near South Rocky Point (Figure 1) in the early summer months, however this did not occur in 2020 or 2021 for unknown reasons. During the latter half of 2016 and throughout 2019, elephant seal numbers had a marked increase and in 2017 established a rookery at Amphitheater Cove. Elephant seal pups were first documented in January 2017, again observed in January-March, all years 2018-2021. The revised 2017 LOA (NOAA 2017), required launch monitoring of the elephant seal rookery beginning 01 January 2018. 2021 is the first year where a second, small rookery was established at "Boathouse Beach" on South VSFb; two pups were born and weaned, whereas more than 40 were born and weaned at "Amphitheater," which is located approximately 2 miles northwest.

Potential impacts to pinnipeds on VSFb include harassment from noise, particularly sonic booms, generated from rocket or missile launches, SpaceX Falcon 9 boostback to land (return of the first stage of the rocket for later re-use, which occurred 5 times in 2022), or aircraft noise, which may result in a startle response. In rare cases, sudden disturbances from a variety of causes have resulted in the trampling of pups by adult animals, resulting in injuries or mortalities, though this has not been observed at VSFb. Other potential noise impacts could result in temporary 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 threshold shift (PTS), in which the animal's hearing is permanently diminished over part or all of its hearing range.

During the 2021 reporting period, monitoring on the Northern Channel Islands (NCI) was required for one launch (SpaceX Falcon 9 in September). Monitoring on VSFb was required for one rocket (Delta IV-Heavy in April). This report describes the methods and results of the marine mammal monitoring efforts and discusses the impacts of Air Force/Space Force operations. A new commercial launch entity, Firefly Space, began operations at Space Launch Complex 2 (SLC-2) in calendar year 2021. Other new entities plan to initiate operations at facilities to include SLC-8, SLC-11 and SLC-5 in 2022 or early 2023.

In 2021, Space Exploration Technologies (SpaceX) continued conducting their "boost-back" action, however all such actions in 2021 landed on an offshore, autonomous barge; this action

results in no noise impacts to the mainland or the Channel Islands. The first stage of the rocket is then refurbished and re-used. Starting in 2022 or 2023, significant modifications will be initiated at SLC’s 3 and 6 for new rocket types and perhaps new launch proponents. Test Pad 01 (TP-01) was used for one launch of a very small rocket in 2020 and a missile test in 2021. At least three other existing facilities (TP-01, LF-576E and SLC-8) are also planned for new programs and launch proponents in the next few years, as forecasts for more satellite and micro-satellite “constellations” are now commonplace. The formerly dormant SLC-5 will be reconfigured for a new program in the next 1-3 years, and the construction of two new SLC’s, tentatively named SLC-9 and SLC-11 are under consideration.

In July of 2016, VAFB concluded informal Section 7 consultation under the Endangered Species Act with NMFS. NMFS concurred that VAFB rocket launches are “not likely to adversely affect” the Guadalupe fur seal on the NCI.

2.0 Operations

Operations that occur on VSFb covered by the LOA include rocket and missile launches as well as fixed-wing aircraft and occasional helicopter activities. Operations activities which occurred in 2021 are detailed below. The locations of launch sites in relation to pinniped haul-out areas on VSFb are shown in Figures 1 and 2.

2.1 Rocket Launches

Fourteen rocket launches occurred during the reporting period (Table 1).

Table 1. Rocket Launches in 2022

Vehicle Type	Facility	Launch Date
Falcon 9 ¹	SLC-4E/W	2 February
Falcon 9 ²	SLC-4E	25 February
Falcon 9 ¹	SLC-4 E/W	17 April
Falcon 9 ²	SLC-4	13 May
Falcon 9 ¹	SLC-4E/W	18 June
Falcon 9 ²	SLC-4E	11 July
Falcon 9	SLC-4E	31 August
Delta IV-Heavy ³	SLC-6	24 September
Firefly Alpha	SLC-2W	1 October
Falcon 9 ²	SLC-4E	5 October
Falcon 9	SLC-4E	28 October
Atlas V ³	SLC-3E	10 November
Falcon 9 ¹	SLC-4E/W	16 December
Falcon 9 ¹	SLC-4E/W	29 December

¹ These launches included “boostback” of the first stage to LZ-4 (or SLC-4W), located about 200 yards west of launch pad SLC-4E

² Included “boost back” and landing to an off-shore autonomous barge

³ Final launches of these two rocket types/programs at VSFb. SLC-3 is being retrofitted to launch a new United Launch Alliance program “Vulcan.” There are no currently announced plans for the future of SLC-6.

2.2 Missile Launches

Three missile launches occurred during the reporting period from Launch Facilities TP-01, LF-09 and LF-10, LF-24 and TP-01 (Table 2); all of these facilities are on north VSFB. The locations of these sites in relation to pinniped haul-out areas on VSFB are shown in Figure 2. Two launches were unarmed Minuteman III (MM-III) Intercontinental Ballistic Missile (ICBM) test launches, one was a test launch of a Minotaur II, in preparation for additional testing in support of an incoming program, the Ground Based Strategic Defense System (which will replace the MM-III as early as 2025. However, this launch attempt resulted in a catastrophic failure; the rocket exploded less than 20 seconds after lift-off and crashed back onto land adjacent to the launch pad. A 110-acre fire resulted. The Minotaur II is considered a small rocket in some configurations, however for this report it is considered a missile.

Table 2. Missile Launches in 2022

Missile Type	Facility	Launch Date
Minotaur II+ ¹	TP-01	7 July
Minuteman III	LF-09	16 August
Minuteman III	LF-10	7 September

¹ Catastrophic failure, refer to text

2.3 Fixed-wing Aircraft and Helicopter Operations

Various types of fixed-wing aircraft fly from VSFB. In accordance with the LOA, all aircraft and helicopter flight paths maintain a minimum distance of 1,000 feet from recognized pinniped haul outs and rookeries, except during emergencies or security incidents. Class 0-2 unmanned aerial systems may be flown within 300 feet of recognized pinniped haul outs and rookeries.

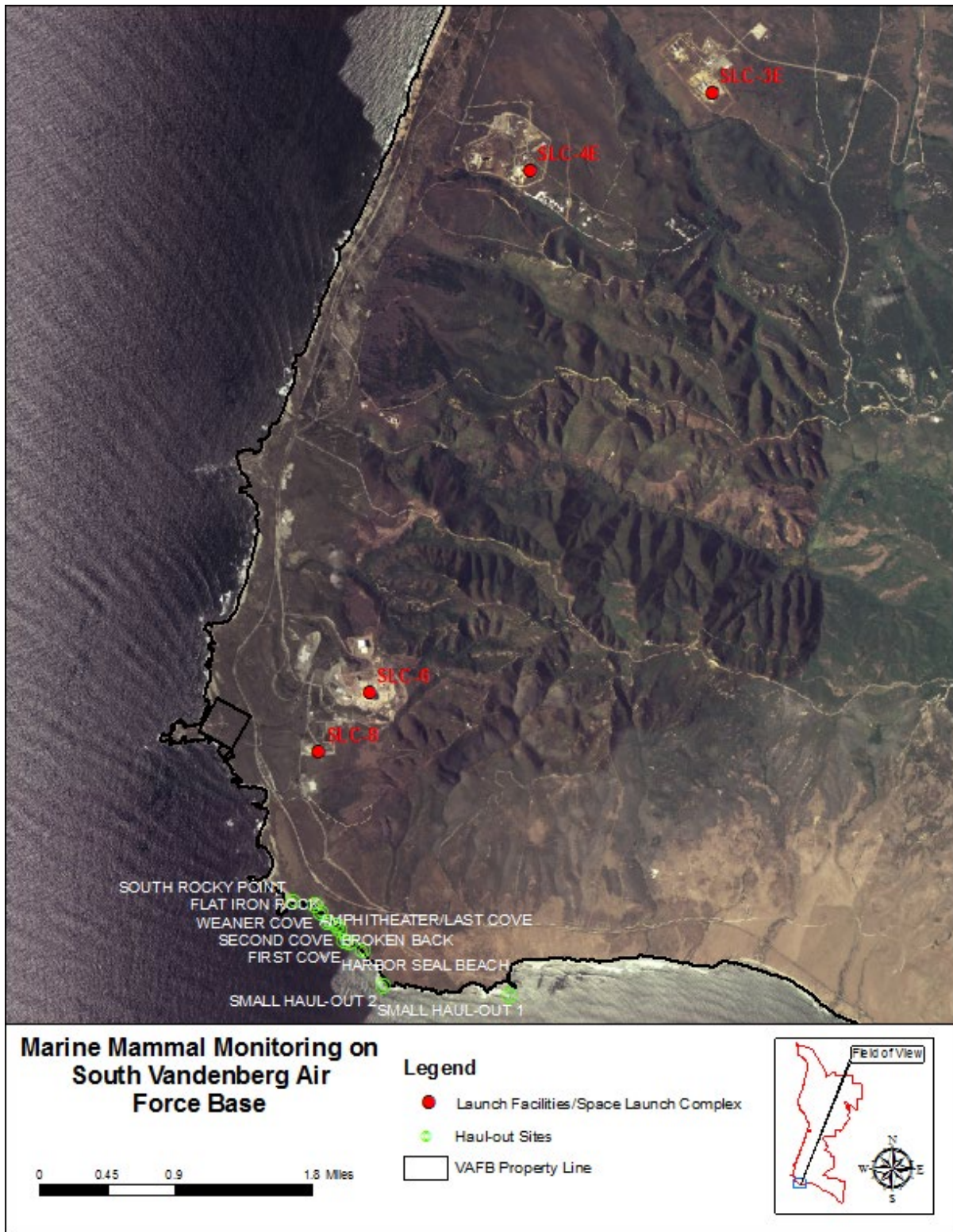


Figure 1. Launch Sites and Pinniped Haul-out Areas on South VSFB.

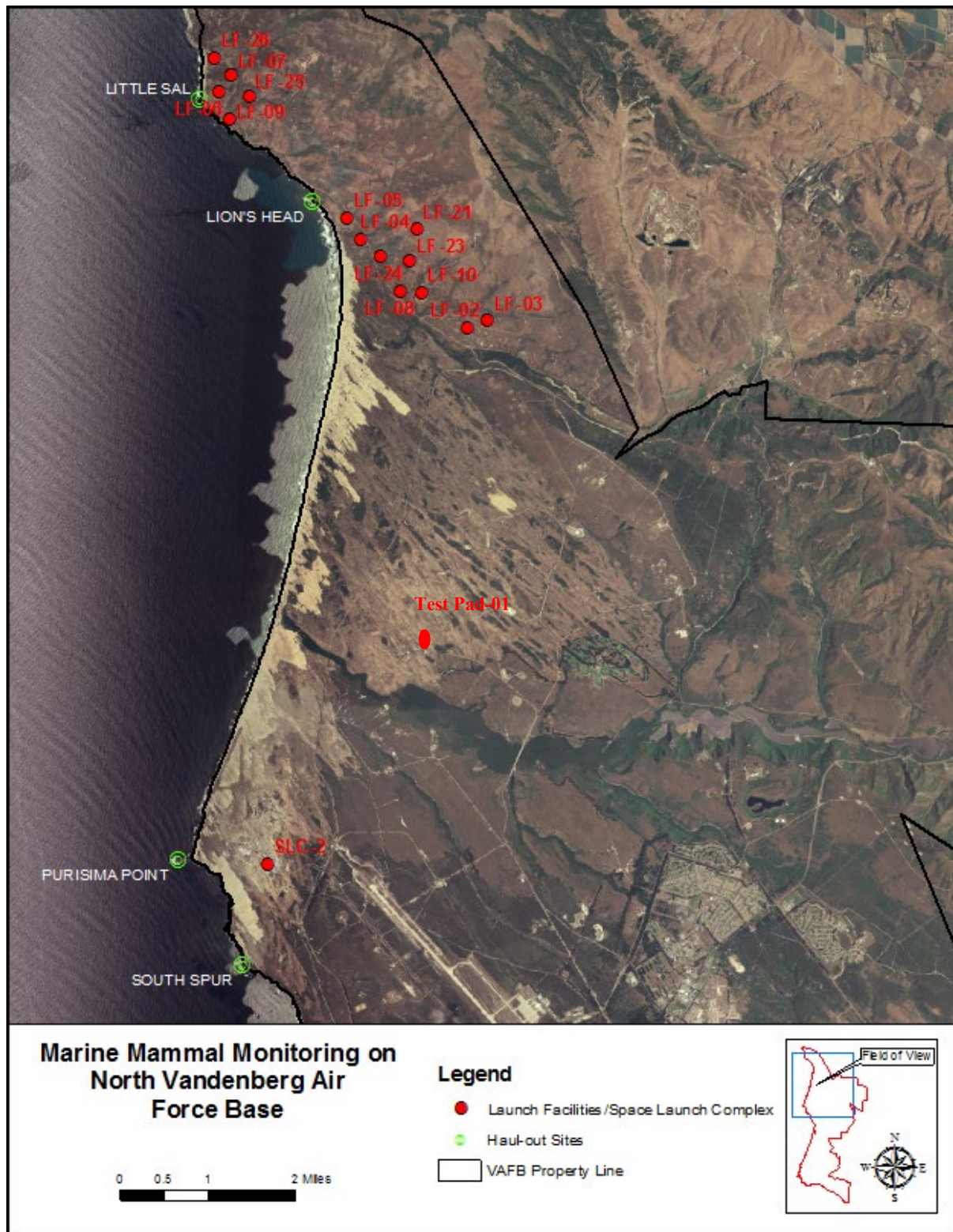


Figure 2. Launch Sites (many inactive) and Pinniped Haul-out Areas on North VSFB.

3.0 Methods

3.1 Sonic Boom Modeling

As required in the LOA, sonic boom modeling is performed prior to all rocket launches. Modeling is not necessary for the missile launches because these vehicles are launched with a westward trajectory and their sonic booms do not impact marine mammal haul-outs on VSFb or the NCI (NOAA 2014a). The modeling programs incorporate nominal flight trajectory information, rocket weight, length, engine thrust, engine plume drag, and meteorological conditions to predict the peak amplitude and impact location of potential booms. Among other factors, meteorological conditions include jet stream presence or absence, and if present, its direction, altitude, and velocity. Cloud type, altitude, and density are also considered. From these data, models predict peak amplitudes and impact locations.

3.2 Acoustic Monitoring

Acoustic monitoring is conducted on NCI when sonic boom modeling predicts impacts to the NCI in excess of the thresholds defined in the LOA. In order to record and analyze the level of the sonic boom that impacts the NCI as a result of the launch, monitors utilize a calibrated sound level meter with all the necessary accessories. Measurements could be downloaded to a laptop and analyzed. A separate system with a calibrated digital audio tracking (DAT) recorder, preamplifier, and specialized microphone is used to obtain sonic boom measurements. The microphone is mounted on a tripod and fitted with a windscreen. The DAT tapes are analyzed in the laboratory to determine various acoustic properties of the rocket noise and sonic boom. Monitoring on NCI was not required in 2020.

Acoustic monitoring is also required on VSFb for five landings of the Falcon 9 first stage (boostback) at SLC 4-W. Acoustic monitoring on south VSFb was required for the several Falcon 9 launches.

3.3 Launch Monitoring

With the current LOA (NMFS 2019a), monitoring on the NCI is required if sonic boom modeling predicts a sonic boom greater than 2 pounds per square foot (psf) is likely to impact one or more of the NCI between 1 March and 31 July, greater than 3.0 psf between 1 August and 30 September, and greater than 4 psf between 1 October and 28 February. Beginning 01 January 2018, pinniped monitoring was required on VSFb when launches occur during elephant seal pupping season (1 January through 28 February). A continuing requirement is pinniped monitoring during the harbor seal pupping season (1 March through 30 June). Note that elephant seal weaners are expected to still be present at their rookery for the first few weeks of March, therefore harbor seal monitoring will also incorporate this species. Starting in 2019, VSFb extended monitoring for launches until 31 July to account for recent increases in California sea lion numbers in the early summer months, though no successful pupping of this species has yet been documented on VSFb.

Monitoring must begin at least 72 hours prior to each launch and continue 48 hours after the launch. During pupping season, follow-up monitoring must be conducted on VSFb once

approximately two weeks after each launch. Monitoring must be conducted as close to the launch window as possible, or at times with tides approximately equivalent to those expected during the launch window.

On VSF, monitoring sites are selected based on proximity of the launch location to the nearest active haul-out sites. The haul-outs that are monitored for rocket launches from South VSF include Amphitheater Cove and may include North and South Rocky Point (Figure 1). Amphitheater Cove has historically been utilized as a harbor seal rookery and is now also utilized as an elephant seal rookery. On the NCI, the monitoring location is selected based on the density and level of predicted sonic boom impacts and the nearest active haul-out of pupping pinnipeds.

Pinniped monitors used high quality binoculars and spotting scopes to make hourly counts and record species, number of individuals, sex, age class, and behavior within a predefined focal area. Several counts are conducted each day. Monitors may use night vision goggles (Exelis AN/PVS-7D or similar) if monitoring occurs during hours of darkness. Remarks are recorded, including the nature and cause of any natural or human-related disturbance, such as low-flying aircraft or boat traffic. Incidental information may be recorded for other wildlife species. Environmental data collected includes tide level and time, visibility, percentage and type of cloud cover, air temperature, wind direction and velocity, and swell direction and height. On VSF, direct observations during launch events are usually not allowed due to safety concerns; therefore video is utilized during daytime launches on VSF to record the reactions of pinnipeds to the launch. Post-launch, the video equipment is collected and video reviewed with responses noted such as alert or flushing into the water. Alert is usually considered insignificant. When flushing is observed, the amount of time it takes for the number of hauled-out animals to return to the pre-launch count is determined if recording length allows.

3.4 Fixed-wing Aircraft and Helicopter Operations

The VSF airfield (30 OSS/OSAB) keeps records of the number and nature of all fixed-wing aircraft and helicopter operations completed at VSF.

3.5 Monthly Surveys

The Center for Environmental Management of Military Lands (CEMML) and U.S. Air Force / Space Force personnel, 30th Civil Engineer Squadron (30 CES) biologists surveyed marine mammal haul-out sites on North and South VSF (Figures 1 and 2) monthly from January to December 2022. For each survey, high quality binoculars and/or a spotting scope are utilized depending on conditions. Monthly surveys are ideally timed to coincide with the lowest weekday late morning or afternoon low tides. The location, species, number of individuals, age class, and sex (when possible) were recorded for each site and ocean and weather conditions are documented. On VSF, most observations are made from cliffs overlooking haul-outs. Purisima Point has been omitted from all surveys throughout 2015-2022 because a permitted biologist must accompany anyone accessing Purisima Point during the California least tern and Western snowy plover breeding season (1 March to 30 September). The site was not included in the remaining months (1 October to 28 February) in order to keep data consistent throughout the year.

Starting in 2017, several haul outs on South VSFB (Harbor Seal Beach, First Cove, First Ledge, Second Cove, Broken Back, and Weaner Cove) were omitted from almost all surveys. This was due to significant decreased use of these sites starting in 2016, likely linked to increased cliff erosion in the area. This allowed for adequate time to survey more heavily utilized haul outs (Amphitheater, South Rocky, and North Rocky). In 2022, these locations were surveyed via spotting scope from the apex of South Rocky Point, a vantage point that allows surveyors to see most of the coastline. Additionally, three vantage points are now used to thoroughly survey North Rocky Point, which takes additional time.

4.0 Results

Based on modeling of launches and time of year, ten monitoring efforts were required during 2021. Launch mitigation requirements are presented in Table 3 and discussed in detail in the following subsections.

Table 3. Launch Monitoring Requirements in 2022¹

Rocket or Missile	Launch Date	NCI	VSFB	Video	Video Result	Boom Model
Falcon 9	2 February	No	Yes	Yes	No impact	Yes
Falcon 9	25 February	No	Yes	Yes	No impact	Yes
Falcon 9	17 April	No	Yes	Yes	No impact	Yes
Falcon 9	13 May	Yes	Yes	Yes	No impact	Yes
Falcon 9	18 June	No	Yes	Yes	No impact	Yes
Falcon 9	10 July	No	Yes	Yes	No impact	Yes
Falcon 9	22 July	No	Yes	Yes	No impact	Yes
Falcon 9	12 August	No	No	No	No video	Yes
Falcon 9	31 August	No	No	No	No video	Yes
Delta IV-Heavy	24 Sept	Yes	No	Yes	No impact	Yes
Firefly Alpha	1 October	No	No	No	No video	Yes
Falcon 9	5 October	No	No	No	No video	Yes
Falcon 9	28 October	No	No	No	No video	Yes
Atlas V	10 November	No	No	No	No video	Yes
Falcon 9	16 December	No	Yes	No	No video	Yes
Falcon 9	29 December	No	Yes	No	No video	Yes

4.1 Sonic Boom Modeling

Sonic boom modeling was conducted for all rocket launches that occurred during the 2022 reporting period. The boom model predicted impacts that would require monitoring on the NCI for only the 13 May Falcon 9 and the 24 September Delta IV Heavy launch.

4.2 Acoustic Monitoring

Modeling predicted sonic booms could impact the NCI as a result of two launches during the 2022 reporting period (17 April, 24 September); however, as discussed in additional detail below, in both cases, the modeled boom was much higher than the actual boom).

4.3 Launch Monitoring

Ten launches required monitoring during the 2022 reporting period. Nine launches required monitoring on VSFb (since the mission occurred during the pinniped pupping season, 1 January through 31 July OR included a Falcon 9 terrestrial boost-back), and two on NCI (one launch, on 13 May, required both). Full details of the monitoring for those launches can be found in the respective launch and landing monitoring reports sent to NMFS previously (refer to literature cited section), summaries follow (the 29 December 2022 launch report --Falcon 9-EROS C-- has not yet been sent to NMFS).

4.3.1 Falcon 9 (NROL-82)

A SpaceX Falcon 9 launch on 2 February did not require monitoring on the Northern Channel Islands, but monitoring was required on VSFb. This launch included boost-back of the first stage to the terrestrial landing pad at SLC-4 West. Results indicated that there was no impact on pinnipeds by the launch or landing activities. There were no California or Steller sea lions observed during the launch monitoring period.

Overall, pre- and post-launch counts demonstrate that there was no impact on harbor seals or Northern elephant seals from this mission and no pinnipeds were observed to have any injuries, mortality, or abnormal behavior.

4.3.2 Falcon 9 (Starlink 4-11)

A SpaceX Falcon 9 launch on 25 February did not require monitoring on the Northern Channel Islands but monitoring was required on VSFb. Because this launch included boost-back of the first stage to an autonomous barge located west of Baja California (Mexico), no monitoring of the boost-back and landing was required. There were no California or Steller sea lions observed during the launch monitoring period.

Overall, pre- and post-launch counts demonstrate that there was no impact on harbor seals or Northern elephant seals from this mission and no pinnipeds were observed to have any injuries, mortality, or abnormal behavior.

4.3.3 Falcon 9 (NROL-85)

A SpaceX Falcon 9 launch on 17 April did not require monitoring on San Miguel Island but monitoring was required on VSFb. This launch included boost-back of the first stage to the terrestrial landing pad at SLC-4 West. Results indicated that there was no impact on pinnipeds by the launch activities. No Steller sea lions were observed during the launch monitoring period.

Overall, pre- and post-launch counts demonstrate that there was no impact on California sea lions, harbor seals or elephant seals from this mission and no pinnipeds were observed to have any injuries, mortality, or abnormal behavior related to the launch.

4.3.4 Falcon 9 (Starlink 4-13)

A SpaceX Falcon 9 launch on 13 May required monitoring on the Northern Channel Islands and VSF. Because this launch included boost-back of the first stage to an autonomous barge located west of Baja California (Mexico), no monitoring of the boost-back and landing was required. The model determined that a boom in excess of 5 psf could impact the islands, however the actual boom was recorded at 1.58 psf. Results indicated that there was no impact on pinnipeds by the launch activities. About 60 California sea lions were monitored on VSF (none on Santa Rosa Island); no Steller sea lions were observed at any location during the launch monitoring period.

Overall, pre- and post-launch counts demonstrate that there was no impact on harbor seals or Northern elephant seals from this mission and no pinnipeds were observed to have any injuries, mortality, or abnormal behavior related to the launch.

4.3.5 Falcon 9 (SARah-1)

A SpaceX Falcon 9 launch on 18 June did not require monitoring on the Northern Channel Islands, but monitoring was required on VSF. This launch included boost-back of the first stage to the terrestrial landing pad at SLC-4 West. Results indicated that there was no impact on pinnipeds by launch activities. No Steller sea lions were observed during the launch monitoring period.

Overall, pre- and post-launch counts demonstrate that there was no impact on harbor seals or Northern elephant seals from this mission and no pinnipeds were observed to have any injuries, mortality, or abnormal behavior related to the launch.

4.3.6 Falcon 9 (Starlink 3-1)

A SpaceX Falcon 9 launch on 10 July did not require monitoring on the Northern Channel Islands, but monitoring was required on VSF. Because this launch included boost-back of the first stage to an autonomous barge located west of Baja California (Mexico), no monitoring of the boost-back and landing was required. Results indicated that there was no impact on the pinnipeds by the launch activities. No California or Steller sea lions were observed during the launch monitoring period.

Overall, pre- and post-launch counts demonstrate that there was no impact on harbor seals or Northern elephant seals from this mission and no pinnipeds were observed to have any injuries, mortality, or abnormal behavior related to the launch.

4.3.7 Falcon 9 (Starlink 3-2)

A SpaceX Falcon 9 launch on 22 July did not require monitoring on the Northern Channel Islands, but monitoring was required on VSF. Because this launch included boost-back of the first stage to an autonomous barge located west of Baja California (Mexico), no monitoring of the boost-back and landing was required. Results indicated that there was no impact on the pinnipeds by the launch activities. No California or Steller sea lions were observed during the launch monitoring period.

Overall, pre- and post-launch counts demonstrate that there was no impact on harbor seals or Northern elephant seals from this mission and no pinnipeds were observed to have any injuries, mortality, or abnormal behavior related to the launch.

4.3.8 Delta IV-Heavy (NROL-91)

A SpaceX Falcon 9 launch on 24 September required monitoring on the Northern Channel Islands (San Miguel Island), but monitoring was not required on VSF. The model determined that a boom in excess of 3 psf could impact the NCI, however the actual recorded boom was only 0.2 psf; this allowed the monitoring team to depart the islands earlier than the LOA specified 2-days after launch. Results indicated that there was no impact on pinnipeds by launch activities on the Island. No Steller sea lions or harbor seals were observed during the launch monitoring period.

Overall, pre and post launch counts demonstrate that there was no impact on California sea lions (thousands of them were monitored) or Northern elephant seals (an average of about 50 monitored) from this mission and no pinnipeds were observed to have any injuries, mortality, or abnormal behavior.

4.3.9 Falcon 9 – SWOT

A SpaceX Falcon 9 launch on 16 December did not require monitoring on the Northern Channel Islands, but monitoring was required on VSF. This launch included boost-back of the first stage to the terrestrial landing pad at SLC-4 West. Results indicated that there was no impact on pinnipeds by launch activities. No Steller sea lions were observed during the launch monitoring period.

Overall, pre- and post-launch counts demonstrate that there was no impact on harbor seals, Northern elephant seals or California sea lions from this mission and no pinnipeds were observed to have any injuries, mortality, or abnormal behavior related to the launch.

4.3.10 Falcon 9 – EROS-C

A SpaceX Falcon 9 launch on 29 December did not require monitoring on the Northern Channel Islands, but monitoring was required on VSF. This launch included boost-back of the first stage to the terrestrial landing pad at SLC-4 West. Preliminary results indicated that there was no impact on pinnipeds by launch activities. No Steller sea lions were observed during the launch monitoring period. This report has not yet been transmitted to NMFS (it is due before 28 March, 2023).

4.4 Fixed-wing Aircraft, Helicopter and Unmanned Aerial Vehicle Operations

During the reporting period, 8,831 operations were conducted from the VSFB airfield. Most of these consisted of overflights or training and proficiency flights involving practice approaches and touch and goes. VSFB had 534 operations that were either unmanned vehicles or helicopters, which are not allowed to fly lower than 1,000 feet over the coastline. Some were logistics flights involving the transfer of supplies, equipment and personnel. The total number of take-offs and landings (including touch and goes) was 3963; additionally, 4331 overflights below 2,500 feet in altitude (but not above the coastline), and 322 Unmanned Aerial Systems ("drone") operations were recorded. Distinguished Visitor flights included the Vice President of the United States and the United States Space Force Commander.

No indications of significant disturbances, abnormal pinniped behavior, injury, or mortality were reported as a result of these operations (R. Evans, pers. comm. 2022).

4.5 Monthly Marine Mammal Surveys

Monthly surveys were conducted throughout 2022. None of the monthly surveys suggested any changes in haul-out patterns as a result of launches. Table 4 displays the monthly survey results of harbor seals and Table 5 indicates the monthly survey results of harbor seals and elephant seals at Amphitheater Cover on VSFB from 2014-2021.

4.5.1 Pacific Harbor Seal

Harbor seals use many of the locations along the VSFB coastline to haul out throughout the year. Harbor seals regularly utilize Amphitheater Cove as a rookery, give birth and nurse young from 1 March to 30 June. Mating occurs in the water after pups are weaned. Because harbor seals are not all hauled out on shore at one time, a 1.54 correction factor is applied to the number of hauled out harbor seals observed to account for individuals in the water (Harvey and Goley 2011). All harbor seal counts in this document are calculated and reported based on this correction factor, unless otherwise stated.

Harbor seal totals in 2022 varied from a low of 35 in August to a high of 154 in June (Table 4), with an average monthly count of 83 for the survey period. Pups were observed in March, April, May and June, with a peak of 32 in April 2022. No harbor seal mortalities were detected in 2022.

On North VSFB, the Spur Road haul out had the most individuals observed with a peak of 16 in November 2022 (Table 6) and Lion's Head had the least individuals observed. On South VSFB, Amphitheater consistently had the most individuals observed. Amphitheater had a peak of 73 in June 2022 (Table 6). East Islet and South Arguello Ridge were not surveyed. North Rocky Point, South Rocky Point, First Cove, and Harbor Seal Beach were among several surveyed locations with no harbor seals recorded.

Table 4. 2022 Monthly Pacific Harbor Seal Survey Results.

Month	Adult[^]	Juvenile[^]	Pup[^]	Total[^]
January	80	0	0	80
February	82	0	0	82
March	85	0	12	97
April	75	0	32	108
May	109	0	14	123
June	152	0	2	154
July	91	3	0	94
August	35	0	0	35
September	57	8	0	65
October	45	0	0	45
November	62	0	0	62
December	54	0	0	54

[^]Numbers reflect 1.54x correction factor

There has been significant variation in the number of harbor seals utilizing Amphitheater Cove from 2014 through 2022 (Table 5). A drastic increase occurred from 2014 to 2015 and a decrease occurred from 2016 to 2021. This is not a product of survey intensity as a survey was conducted nearly every month for all 8 years at Amphitheater Cove. One explanation could be the increased use of Amphitheater by elephant seals, discussed further in Section 4.5.2. When looking at the data presented in Tables 5 and 6, it is notable that from 2014 to 2015 when harbor seal numbers increased, the elephant seal numbers remained relatively similar. From 2015 to 2016 harbor seal numbers stayed relatively similar while elephant seal numbers significantly increased. From 2016 to 2020 the harbor seal numbers decreased dramatically and the elephant seal numbers dramatically increased, a significant increase was noted in 2021 and 2022. It is not directly known if use of Amphitheater by elephant seals is affecting the number of harbor seals utilizing the site, or if another unknown factor is contributing to this affect. In 2017-2022, both harbor seals and elephant seals utilized the Amphitheater haul out for giving birth and weaning pups.

Table 5. Historic Pacific Harbor Seal and Northern Elephant Seal Survey Results at Amphitheater Cove.

Year	Pacific Harbor Seals			Northern Elephant Seals		
	Average [^]	Total [^]	Highest Count [^] (Month)	Average	Total	Highest Count (Month)
2014	4	37	23 (December)	3	31	24 (April)
2015	178	1962	590 (October)	1	12	10 (June)
2016	130	1428	339 (May)	19	213	84 (November)
2017	37	450	80 (February)	58	692	197 (October)
2018	35	414	131 (June)	77	919	209 (November)
2019	26	310	57 (April)	100	1202	300 (May)
2020	32	382	77 (April)	78	930	302 (May)
2021	57	685	162 (June)	85	931	195 (May)
2022	83	998	154 (June)	84	1007	209 (October)

[^]Numbers reflect 1.54x correction factor for PHS, rounded to nearest whole number

Table 6. 2022 Monthly Pacific Harbor Seal Results by Haul-Out (North to South).

Haul-Outs	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Little Sal	1	0	0	1	1	0	5	4	3	2	4	2
Lion's Head	1	1	2	2	1	0	1	1	0	0	0	0
Purisima Point	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Spur Road	12	9	8	2	0	6	5	4	15	7	16	12
East Islet	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
S. Arguello Ridge	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
North Rocky Point	0	0	0	0	0	0	0	0	0	0	0	0
South Rocky Point	0	0	0	0	0	0	0	0	0	0	0	0
Amphitheater	30	25	46	62	60	73	25	3	23	20	19	21
Weaner Cove	0	0	0	0	0	0	0	0	0	0	9	9
Flat Iron Rock	0	0	0	0	11	19	14	3	0	0	0	0
Broken Back	0	0	0	0	3	0	0	0	0	0	0	0
Second Cove	0	0	0	0	0	0	0	0	0	0	0	0
First Ledge	0	0	0	0	0	0	0	0	0	0	0	0
First Cove	0	0	0	0	0	0	0	0	0	0	0	0
Harbor Seal Beach	0	0	0	0	0	0	0	0	0	0	0	0
Small Haul Out 2	8	9	4	3	4	2	11	0	1	0	0	0
Boathouse Beach	NS ¹	NS ¹	NS ¹	NS ¹	NS ¹	NS ¹	NS ¹	8	0	0	0	0
Small Haul Out 1	0	9	11	8	3	5	0	0	0	0	2	8
Total	94	99	162	134	95	229	0	28	54	69	100	149

¹Numbers reflect 1.54x correction factor, rounded to nearest whole number

*NS = Not Surveyed

1 Survey site was not added to survey until August.

4.5.2 Northern Elephant Seal

Elephant seals historically hauled out in low numbers on VSFb beaches, with a total of 10 elephant seals observed on monthly counts between 2007 and 2010. Beginning in 2013, greater than average numbers of elephant seals were observed at South Rocky Point with numbers peaking for the decade at 191 individuals, primarily sub-adult males, in November 2013 (MSRS 2014). Greater than average numbers were again reported in 2014, with a total of 237 observations. There were smaller numbers in 2015 with a total of 41 individuals observed (likely due to South Rocky Point not being surveyed during the majority of months), and again, an increase in 2016 with a total of 288. A very significant increase began in 2017, with a total of 916 animals observed in 2017, 919 in 2018, 1,345 in 2019, 1,396 in 2020, and 1,015 in 2021. This trend showed a minor decrease in 2021 and 2022, with a total of 1,007 elephant seals detected during 2022 surveys (Table 7). These numbers peaked in May with 230 elephant seals counted. Three confirmed elephant seal mortalities were recorded (February, March and May) reported to NMFS (R. Evans, pers. comm., 2022). No formal surveys occurred at Point Conception in 2022, primarily due to access restrictions deemed necessary by The Nature Conservancy, land managers for the Jack and Laura Dangermond Preserve (which is located between VSFb and Point Conception).

Table 7. 2022 Monthly Northern Elephant Seal Results.

Month	Adult	Juvenile	Pup	Total
January	38	0	13	51
February	32	8	23	63
March	1	49	0	50
April	105	5	20	130
May	0	230	0	230
June	31	0	3	34
July	19	0	0	19
August	1	9	0	10
September	75	6	0	81
October	209	0	0	209
November	79	0	0	79
December	51	0	0	51

Elephant seal pupping was first documented at Amphitheater Cove in January 2017, with pups documented on 09 Jan 2017 during routine monthly surveys. In 2017, a maximum of 19 pups were observed. Twenty-five elephant seal pups were observed in 2018, 31 in 2019, 34 in 2020 33 in 2021 and 20 in 2022. Since 2018, the Air Force has conducted additional surveys of Amphitheater Cove in order to document pupping in late December and early January with intent to record the first pup each season, which we then compare to other regional pupping locations. As of February 2022, we have not observed elephant seal pups on any Vandenberg rookery earlier than 3 January.

In early March 2019, VSFB and scientists affiliated with the California Polytechnic State University, San Luis Obispo (Cal Poly-SLO) flipper tagged 25 elephant seal pups under authority of permit 19108-01, issued to Dr. Daniel Costa (University of California at Santa Cruz). Dr. Heather Liwanag (Cal Poly-SLO) obtained a permit under her name (#22187); her team tagged 34 elephant seal pups on 29 February 2020; and 35 tagged in late Feb 2021. A fifth year of flipper tagging is planned for late February 2023, and VSFB has secured funding for a three-year satellite telemetry tagging project in cooperation with Dr. Liwanag, which started in 2022.

4.5.3 California Sea Lion

During 2022, the highest number of California sea lion observations was 112 adults in May (Table 8). This is an increase from 2021, for unknown reasons (Table 9). Typically California sea lions haul out at North Rocky Point, recently with more frequent hauled-out individuals observed at Amphitheater and South Rocky Point. The large increase in sub-adult California sea lion counts, as seen in 2018 and 2019 (Table 9) did not occur in 2020-2022, for reasons unknown (but not believed to be in any way related to Vandenberg operations).

Table 8. 2021 Monthly California Sea Lion Results.

Month	Adult	Juvenile	Pup	Total
January	1	0	0	1
February	1	0	0	1
March	0	0	0	0
April	3	0	0	3
May	112	0	0	112
June	41	0	0	41
July	26	0	0	26
August	0	0	0	0
September	5	0	0	5
October	2	0	0	2
November	9	0	0	9
December	16	0	0	16

Table 9. Historic and Current Summary of California Sea Lion Survey Results.

Year	Average	Total	Highest Count (Month)
2011	4	45	21 (Jul & Sep)
2012	33	398	150 (Aug)
2013	4	53	25 (Jan)
2014	136	1366	416 (May)
2015	18	201	156 (Jan)
2016	11	118	39 (Sep)
2017	21	255	68 (Sep)
2018	175	2103	980 (May)
2019	259	3111	1122 (June)
2020	14	167	62 (July)
2021	12	126	72 (June)
2022	18	216	112 (May)

Historically, stillborn pups have been irregularly detected at North Rocky Point and pregnant California sea lions observed were usually sick or in poor condition (MSRS 2015); therefore, North Rocky Point is not considered a rookery.

As detailed above, from 2017-2019, the Air Force observed enormous increases in early summer use of (primarily) the South Rocky Point haul-out by (mostly) juvenile and sub-adult California sea lions. It is possible that a majority of these animals are “displaced” as a result of increasingly high numbers of both California sea lions and elephant seals at the NCI. Also as noted above, this phenomenon did NOT reoccur in 2020 or 2021.

In 2022, at least 35 California sea lion mortalities were confirmed and reported, This contrasts with 2019, in which more than 80 California sea lions were found dead on VSFB beaches, and more than 1,600 were found dead between San Luis Obispo and Orange Counties (NMFS, J. Greenman, 2019, unpublished data). However it is significantly higher than 7 mortalities recorded at VSFB in 2021. These deaths were primarily attributed to domoic acid toxicity, though a smaller number were likely due to natural causes, predation by great white sharks and other factors.

4.5.4 Steller Sea Lion

Steller sea lions were first reported on VSFB at North Rocky Point in April 2012 during a monthly count (MMCG and SAIC 2013). Since May 2012 they have been observed irregularly in low numbers on North Rocky Point (MMCG and SAIC 2013, MSRS 2014, 2015; prior year LOA reports). There are approximately 65 breeding rookeries and more than 300 haul-outs utilized by Steller sea lions across their range (Fisheries and Oceans Canada 2010) (Figure 3). The range of the Steller sea lion stretches from Japan to Alaska to southern California, and there are two distinct populations, the western population and the eastern population (separated at 144° W longitude

(near Cape Suckling, just east of Prince William Sound, Alaska (Alaska Fisheries Science Center 2015; Figure 5).

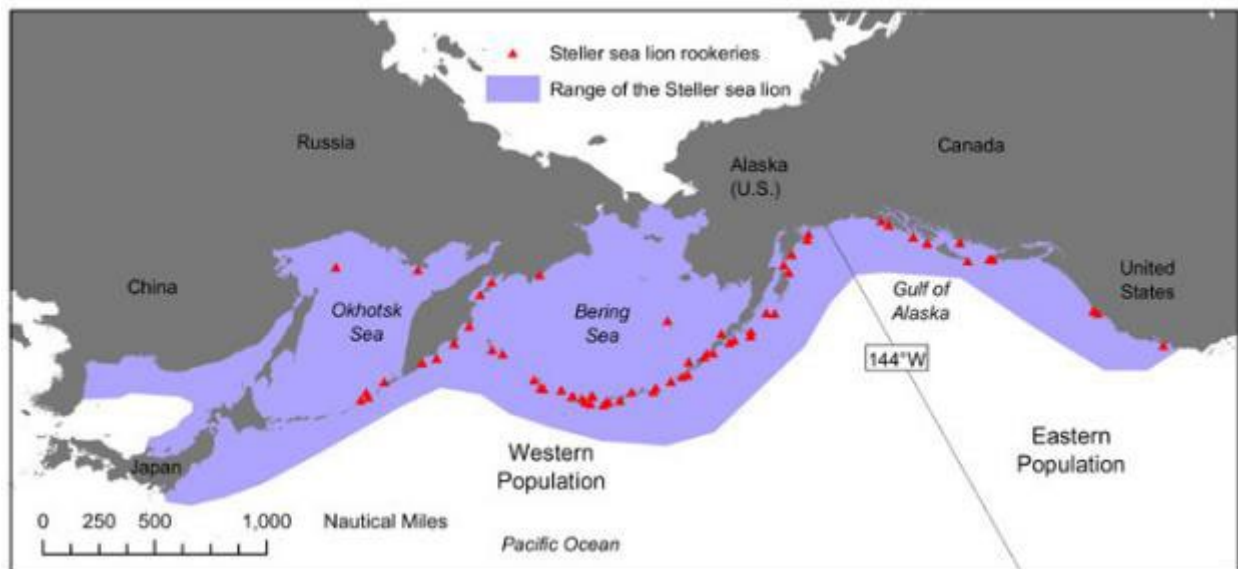


Figure 3. Steller Sea Lion Range and Rookeries (Alaska Fisheries Science Center 2015).

Steller sea lions are non-migratory, but they will disperse long distances from natal rookeries throughout the year (Bigg 1985). Availability of forage fish is likely the primary factor driving Steller sea lion use of widely dispersed haul-outs like North Rocky Point (Fisheries and Oceans Canada 2010). Prior to May 2012, Steller sea lions had not been observed during VSFB monthly counts for 20 years). Studies in British Columbia document Steller sea lions returning to historical haul outs after decades of abandonment or extirpation (Bigg 1985).

No Steller sea lions were observed during 2022 monthly surveys on VSFB. No Steller sea lion mortalities were documented in 2021 (R. Evans, pers. comm., 2021).

4.5.5 Incidental Sightings

Two deceased delphinids, one believed to be a white sided-dolphin (April) and 1 (presumed) bottlenose dolphin (October), were found on Vandenberg beaches in 2021. Also, one humpback whale was found near Jalama Beach in late September; this carcass was apparently washed out to sea by tides and then was most likely washed up again on south Minuteman Beach, about 20 miles upcoast, as in November, a “badly decomposed” humpback was found at the second location. Vandenberg reported all of these mortalities to NMFS.

Several incidental sightings of non-pinniped marine mammals or other notable observations occurred during 2021 surveys. One of the more common incidental observation is of southern sea otters (*Enhydra lutris nereis*) which are often detected using the boat harbor kelp bed area. Sea otters documented in this area include: two in April (during Delta IV-Heavy monitoring).

5 Discussion

5.1 Effects of Natural Factors

Both seasonal and cyclic effects have been discussed in previous documents with haul-out numbers being affected by high tides, strong surf, pupping, breeding, and molting seasons (MMCG & SAIC 2012a and 2012b). Landslides also affect available haul-out locations, such as the continued landslide at Weaner Cove (MMCG & SAIC 2012b), which continues to be monitored (MSRS 2014, 2015, CEMML 2016a, 2018). Predation risk from coyotes (*Canis latrans*) can make harbor seals wary of hauling out (Gearin *et al.* 1990; MMCG & SAIC 2012a), causing them to haul out in fewer numbers and quickly reacting to any movement from shore or from the bluffs. Some evidence suggests that there may be an increase in white shark (*Carcharodon carcharias*) predation on harbor and elephant seals in the region, which may be a contributing factor in the declining number of harbor seals observed on VSFB (MMCG & SAIC 2011 and 2012b); however, more study would be required to determine if sharks are having a significant impact on this population. Additionally, elephant seals have become more prevalent at Amphitheater Cove as they have established rookery. It is unknown what effect this is having or may have on harbor seals' use of Amphitheater Cove in the future; they continue to use this site as a rookery.

5.2 Effects of VSFB Operations

No SpaceX “boost back” and terrestrial landings occurred at VSFB in 2021. These are likely to become more frequent in the near future, with at least four planned for 2022. There was no evidence of injury, mortality, or abnormal behavior as a result of missile or any rocket launches. No abnormal activity or mortalities were observed during the active monitoring of seven rocket launches this year or during monthly marine mammal surveys. No observations indicated that activities associated with airfield operations caused any significant effects on pinniped counts, or have caused injury, mortality, or significant abnormal behavior.

6 Conclusion

Seven rocket launches required monitoring; all concluded that no abnormal behavior, injuries, or mortalities resulted from the launch of the Delta IV-Heavy or the Falcon 9-Starlink, and their associated sonic booms. In prior years, consistent results have been obtained showing no indications of significant disturbances, abnormal behavior, injury, or mortality as a result of launch or aircraft operations. Responses to launches, when they did occur, were short-lived and insignificant. VSFb recommends that we continue to discuss reduction of future monitoring requirements.

Monthly surveys provided routine assessment of potential effects of launch operations on pinniped populations at VSFb. Fluctuations in monthly counts were mostly due to environmental conditions, such as natural landslides and changing tides, rather than the disturbances associated with the launches. Monthly pinniped counts across VSFb show a cyclical, but stable population of harbor seals hauled out on VSFb and an unusually high number of California sea lions hauled out on VSFb during early summer months, however not in 2020-2022. Elephant seal pupping continued for a sixth year

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