Incidental Harassment Authorization Application Boost-Back and Landing of the Falcon 9 First Stage at SLC-4 West

Vandenberg Air Force Base, California, and Contingency Landing Options Offshore

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACRONYMS AND ABBREVIATIONS

BIA	Biologically Important Areas
˚C	degrees Celsius
˚F	degrees Fahrenheit
dB	decibel
dBA	A-weighted decibe
dB_{RMS}	root mean square value of decibel
dB re uPa	decibels referenced to micropascals
ESA	Endangered Species Act
ft.	foot or feet
FTS	Flight System Termination
IHA	Incidental Harassment Authorization
km	kilometer
km^2	square kilometer(s)
lb.	pound(s)
LOA	Letter of Authorization
LOX	liquid oxygen
m	meter
MECO	Main Engine Cut Off
mi.	mile(s)
MMPA	Marine Mammal Protection Act
nm	nautical miles
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
psf	pounds per square foot
PTS	permanent threshold shift
rms	root mean squared
SLC	Space Launch Complex
SLC-4W	Space Launch Complex 4 West
SLC-4E	Space Launch Complex 4 East
SpaceX	Space Exploration Technologies Corporation
TTS	temporary threshold shift
U.S.	United States
U.S.C.	United States Code
USAF	United States Air Force
VAFB	Vandenberg Air Force Base

1 Description of Activity

1.1 Introduction

Space Exploration Technologies Corporation's (SpaceX) has prepared this application for an Incidental Harassment Authorization (IHA) for the taking, by Level B harassment, of small numbers of six species of marine mammals incidental to Falcon 9 First Stage recovery activities and the Pacific Ocean offshore of California. Under the Marine Mammal Protection Act (MMPA), 16 United States (U.S.) Code (U.S.C.) Section 1361 *et seq.*, the Secretary of Commerce shall allow, upon request, the incidental, but not intentional, taking of marine mammals by U.S. citizens who engage in a specified activity (other than commercial fishing) within a specified geographic region. The term "take" means "to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal" (16 U.S.C. § 1362[13]). IHAs are for actions that result in harassment (i.e., injury or disturbance) only and are effective for one year.

Vandenberg Air Force Base (VAFB) occupies approximately 99,100 acres (400 square kilometers [km^2]) of central Santa Barbara County, California, approximately halfway between San Diego and San Francisco (Figure 1-1). The Santa Ynez River and State Highway 246 divide VAFB into two distinct parts: North Base and South Base. Space Launch Complex (SLC) 4 West (SLC-4W), which is located on South Base, approximately 0.5 miles (mi.) (0.8 kilometer [km]) inland from the Pacific Ocean, is the primary landing facility for the Falcon 9 First Stage on VAFB (Figure 1-2). SLC-4 East (SLC-4E), which is located approximately 715 feet (ft.) (218 meters [m]) east of SLC-4W, is the launch facility for the Falcon 9 Program (Figure 1-2). Although SLC-4W is the preferred landing location for the Falcon 9 First Stage, SpaceX has identified two contingency landing locations in the Pacific Ocean that would be exercised if there were critical assets on south VAFB that would not permit an overflight of the First Stage or other reasons that would not permit landing at SLC-4W (e.g., heavy payload). These contingency landing locations are depicted in Figure 1-3 and are referred to as the Contingency Landing Location and Iridium Landing Area.

SpaceX is currently operating the Falcon 9 Launch Vehicle Program at SLC-4 on VAFB. National Oceanic and Atmospheric Administration (NOAA) Fisheries Office of Protected Resources previously issued regulations and Letters of Authorization (LOA) that authorize the take of marine mammals, by Level B harassment, incidental to launches of up to 50 rockets per year from VAFB (79 Federal Register 10016). This LOA is effective from March 2014 to March 2019 and includes Falcon 9 launches at VAFB.

SpaceX received an IHA from NOAA Fisheries, dated May 19, 2016, for Falcon 9 First Stage recovery activities. This IHA was valid from June 30, 2016, to June 29, 2017. On August 2, 2016, SpaceX notified NOAA Fisheries that it was proposing to perform barge landings southwest of San Nicolas Island ("Iridium Landing Area") because of mission restrictions. NOAA Fisheries concurred that a take of marine mammals would not likely occur from this change and a revision to the IHA was not warranted (Jordan Carduner, NOAA Fisheries, pers. comm. August 3, 2016). Only one landing occurred during the IHA period, which was in the Iridium Landing Area. Therefore, the Falcon 9 boost-back and landing did not result in any takes of marine mammals during this period.

SpaceX proposes to perform Falcon 9 First Stage boost-back and landings, up to 12 events per year, at either SLC-4W or the contingency landing locations, which is an increase from the prior year.

Figure 1-1. Regional Location of VAFB

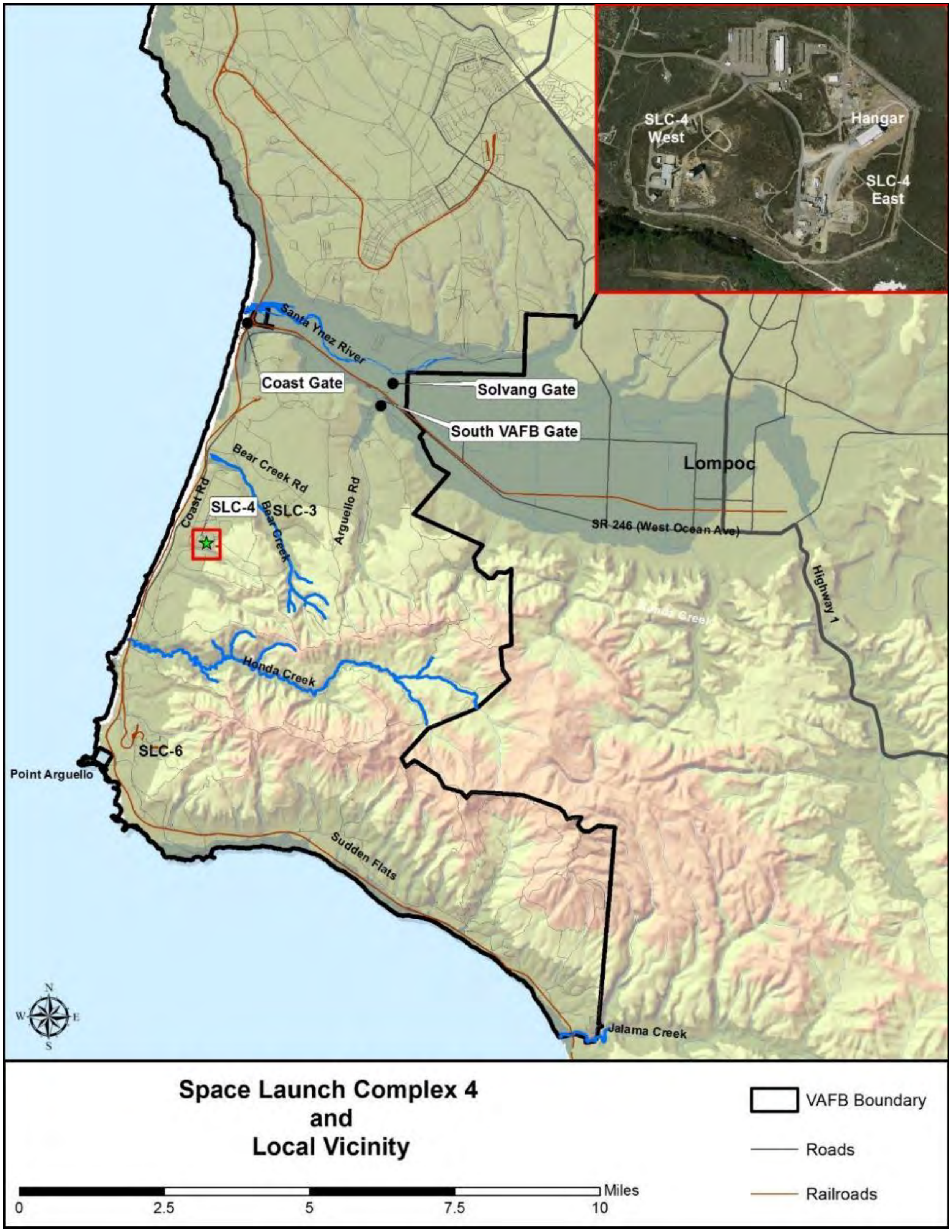


Figure 1-2. Location of SLC-4 and Vicinity

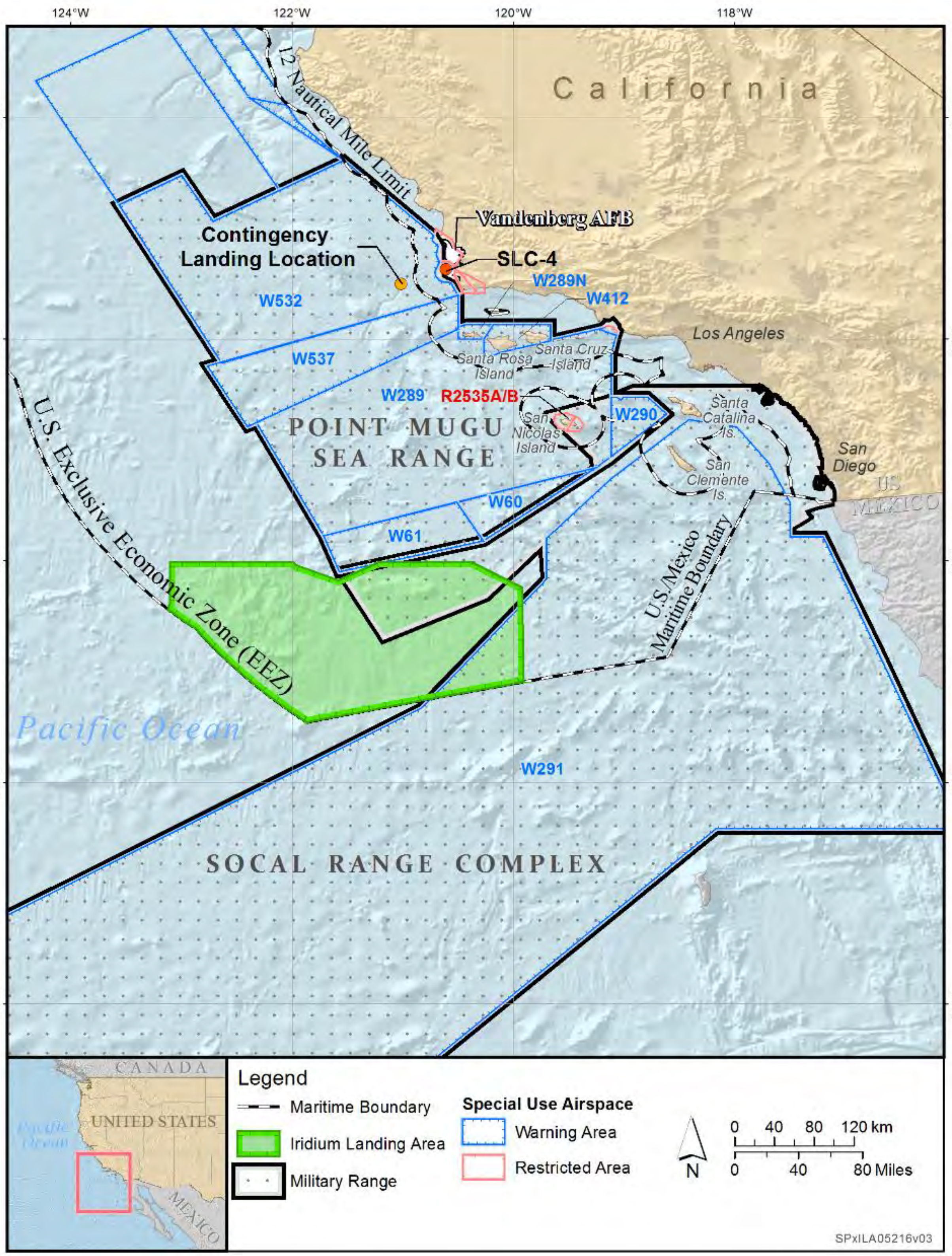


Figure 1-3. Proposed Contingency Landing Areas and Vicinity

1.2 Proposed Action

SpaceX proposes to return the Falcon 9 First Stage booster to SLC-4 for potential reuse up to 12 times per year. This includes performing boost-back maneuvers (in-air) and landings of the Falcon 9 First Stage on the pad at SLC-4W or at two contingency landing options should it not be feasible to land the First Stage at SLC-4W. The first contingency landing option is on a barge located at least 27 nautical miles (nm) (50 km) offshore of VAFB. The second contingency landing option is on a barge within the Iridium Landing Area. The Iridium Landing Area is an approximately 33,153 square kilometers (km^2) area that is located approximately 122 nm (225 km) southwest of San Nicolas Island's coastal waters and 133 nm (245 km) southwest of San Clemente Island's coastal waters. It extends as far north as 32nd parallel north (32°N), as far east as the Patton Escarpment, and as far south and west as the U.S. Pacific Coast Region Exclusive Economic Zone (Figure 1-3). Table 1-1 depicts the current SpaceX launch schedule from SLC-4 and the anticipated landing areas (Note that this schedule is subject to unanticipated changes).

Table 1-1. Notional Falcon 9 Launch Schedule from SLC-4

Date	Booster	Payload	Customer	Landing Location
November 2017	Falcon 9	Iridium NEXT	Iridium Communications	Iridium Landing Area
December 2017	Falcon 9	Paz	Hisdesat	SLC-4W
December 2017	Falcon 9	Iridium NEXT	Iridium Communications	Iridium Landing Area
Early 2018	Falcon 9	SSO-A with SHERPA	Spaceflight Industries	SLC-4W
January 2018	Falcon 9	Iridium NEXT	Iridium Communications	Iridium Landing Area
March 2018	Falcon 9	Iridium NEXT	Iridium Communications	Iridium Landing Area
May 2018	Falcon 9	Iridium NEXT	Iridium Communications	Iridium Landing Area
2018	Falcon 9	SAOCOM	CONAE	SLC-4W
2018	Falcon 9	SARah 1	Bundeswehr	SLC-4W
2018	Falon 9	SARah 2/3	Bundeswehr	SLC-4W
2018	Falcon 9	RADARSAT Constellation	Canadian Space Agency	SLC-4W

1.2.1 Falcon 9 Boost-back and Landing at SLC-4W

SpaceX proposes to return the Falcon 9 First Stage booster to SLC-4W at VAFB for potential reuse up to 12 times per year. The Falcon 9 First Stage is 12 ft. in diameter and 160 ft. in height, including the interstage that would remain attached during landing.

Figure 1-4 provides a graphical depiction of the boost-back and landing sequence. Figure 1-5 shows an example of the boost-back trajectory of the First Stage (depicted by the green path) and the second stage trajectory (depicted by the yellow path). After the First Stage engine cutoff, concurrent to the second stage ignition and delivery of the payload to orbit, exoatmospheric cold gas thrusters would be initiated to flip the First Stage into position for a “retrograde burn.” Three of the nine First Stage Merlin engines would be restarted to conduct the retrograde burn in order to reduce the velocity of the First Stage and to place the First Stage in the correct angle to land. Once the First Stage is in position and approaching its landing target, the three engines would cut off to end the boost-back burn. The First Stage would then perform a controlled descent using atmospheric resistance to slow the stage down and guide it to the landing pad target. The First Stage is outfitted with grid fins that allow cross range corrections as needed. The landing legs on the First Stage would then deploy in preparation for a final single engine burn that would slow the First Stage to a velocity of zero before landing on the landing pad at SLC-4W.

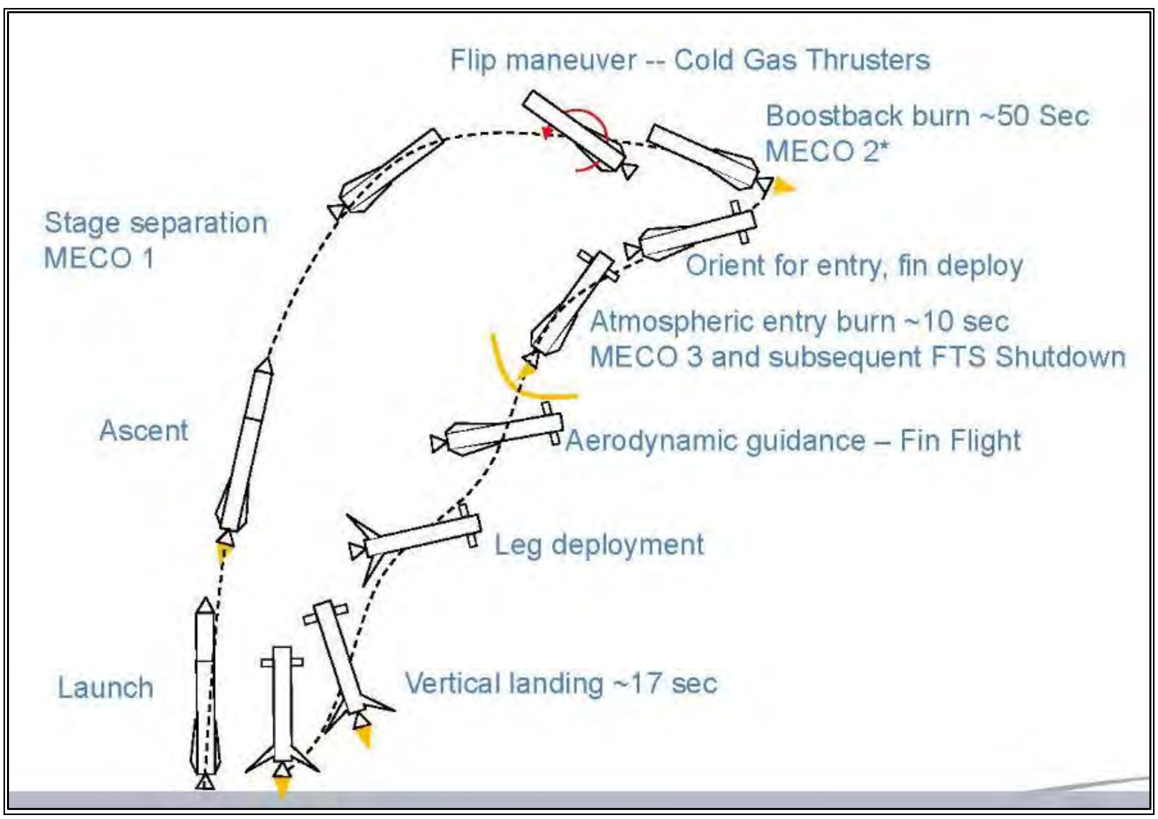


Figure 1-4. Stages of Boost-Back and Propulsive Landing
(Notes: MECO = Main Engine Cut Off; FTS = Flight Termination System)

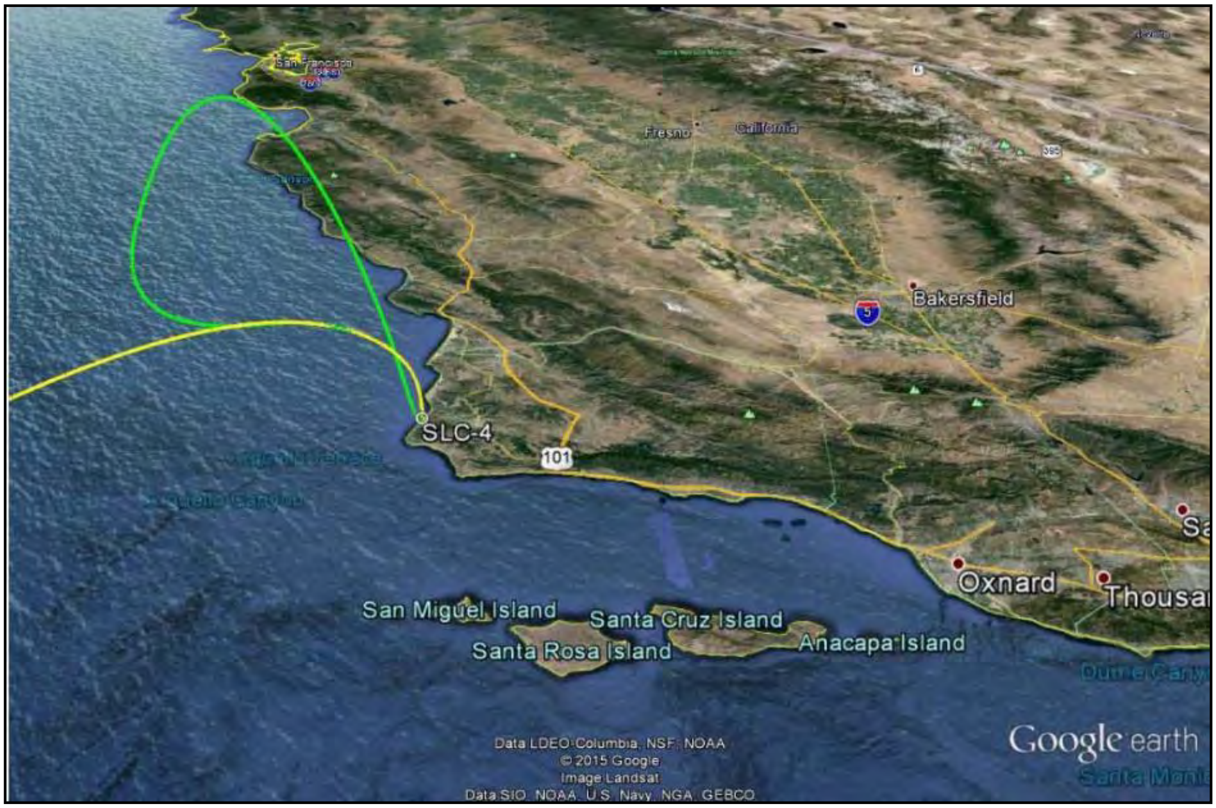


Figure 1-5. Example Trajectories for the Falcon 9's First Stage Return Path (green line) and Second Stage Path (yellow line) for a landing at SLC-4W on VAFB

1.2.2 Contingency Barge Landing

As a contingency action to landing the Falcon 9 First Stage on the SLC-4W pad at VAFB, SpaceX proposes to return the Falcon 9 First Stage booster to a barge in the Pacific Ocean (Figure 1-6). The barge is specifically designed to be used as a First Stage landing platform and would be located at least 27 nm (50 km) offshore of VAFB (Figure 1-7) or within the Iridium Landing Area (Figure 1-8). These contingency landing locations would be used when landing at SLC-4W would not be feasible. The maneuvering and landing process described above for a pad landing would be the same for a barge landing. Three vessels would be required for a barge landing:

1. Barge/Landing Platform – approximately 300 ft. long and 150 ft. wide;
2. Support Vessel – approximately 165 ft. long research vessel; and
3. Ocean Tug – 120 ft. long open water commercial tug.

The support vessels would originate from Long Beach Harbor and be positioned to support contingency landings. The tug and support vessel would be staged 5 to 7 mi. away from the landing location. The barge to be used as the landing platform was originally a McDonough Marine Deck Barge with dimensions of 300 ft. by 100 ft. The barge has an operational displacement of 24,000,000 pounds (lb.) and is classified as an American Bureau of Shipping Class-A1 Ocean barge. The Barge was modified to accommodate the First Stage landing by increasing its width to 150 ft. and installing a dynamic positioning system and a redundant communications and command and control system. The barge has been inspected by the U.S. Coast Guard, and SpaceX has obtained a Certificate of Inspection for its operation under the service of Research Vessel.

Figure 1-6. Barge Landing Platform

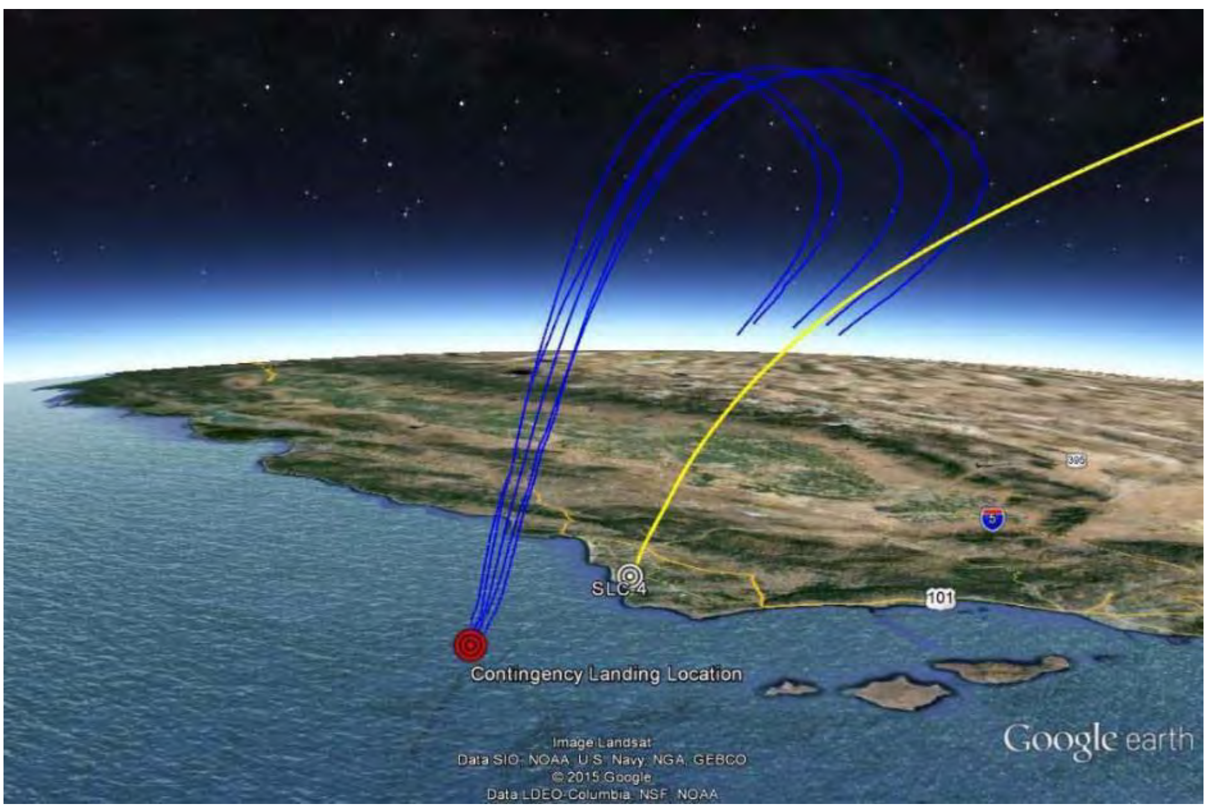


Figure 1-7. Trajectories for Variations of the Contingency First Stage Return Path to a Barge Landing at the Contingency Landing Location (blue lines) and Second Stage Path (yellow line)

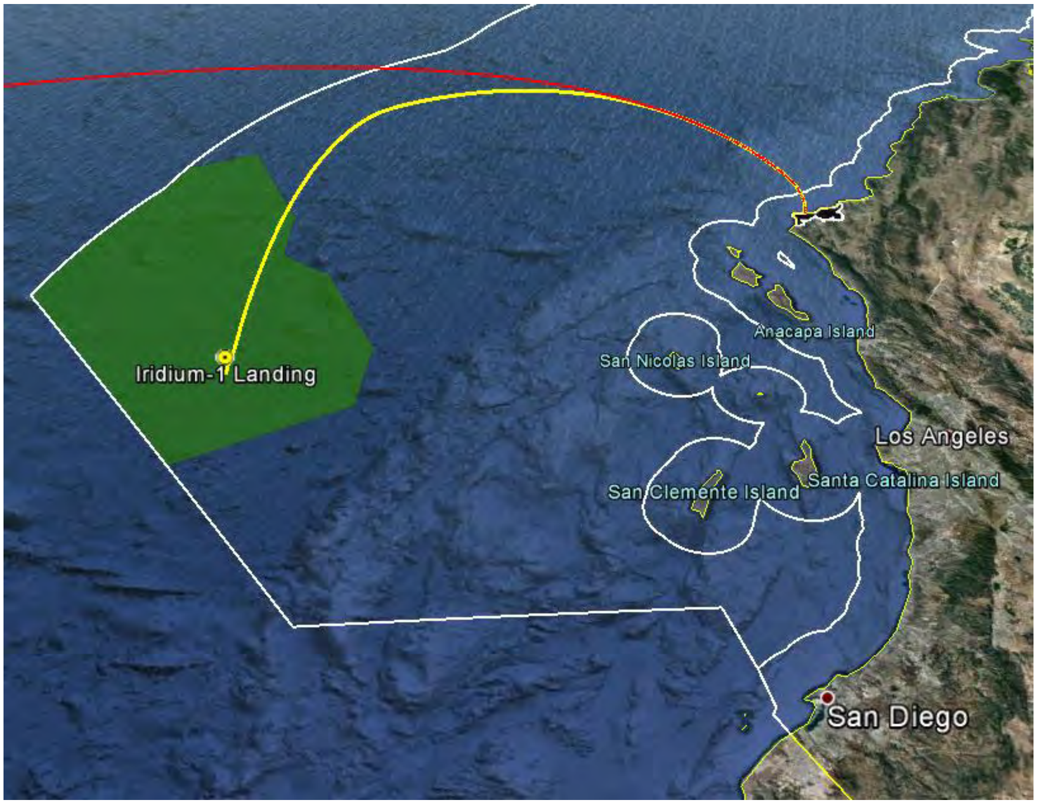


Figure 1-8. Trajectories for Variations of the Contingency First Stage Return Path to a Barge Landing within the Iridium Landing Area (yellow line)

The Support Vessel is a 165 ft. long research vessel that is capable of housing the crew, instrumentation and communication equipment, and supporting debris recovery efforts, if necessary. The U.S. Coast Guard would have the opportunity to have a representative on this vessel during the operation and a representative in the Launch and Landing Control on VAFB to coordinate required clearances and approve access back to the barge after the landing after the landing as they deem required.

The Tug is a 120 ft. open-water commercial ocean vessel. The primary operation of the tug is to tow the barge into position at the landing site and tow the barge and rocket back to Long Beach Harbor. After landing, the First Stage would be secured onto the barge and transported to the Long Beach Harbor for off-loading hazardous materials and transport to a SpaceX testing facility in McGregor, Texas, to complete acceptance testing again before re-flight. Once testing is completed, the First Stage would be transported back to the SLC-4W pad or another SpaceX launch facility for reuse.

1.2.2.1 Concept of Operation for Barge Landing

The following outlines the concept of operation for a barge landing. All times are correlated to a launch time of T-0:

T-12 Hours	Barge/landing platform on-station and crew begins system activations
T-6 Hours	Tow line is released and the barge is holding position via the dynamic positioning system
T-4 Hours	The crew transfers from the barge to the support vessel
T-2 Hours	The support vessel departs the area to a pre-determined staging area, and VAFB Range Safety is notified
T-1 Hour	The support vessel is at the staging area and Range Safety has been notified
T+8 minutes	Landing occurs
T+10 minutes	Range Safety confirms it is safe for the support vessel and tug to return to the landing site and conveys permission to reenter area
T+60 minutes	The support vessel and tug are back at the landing site
T+2 hours	The barge/landing platform is secured to the towline for towing to Long Beach Harbor.

T- = time to scheduled launch, T+ = time after launch

2 Duration and Location of Activities

SpaceX would perform up to twelve boost-back and landing events per year during all times of the year. A sonic boom (overpressure of high-energy impulsive sound) and landing noise would be generated during each boost-back event and are therefore expected parts of the Proposed Action that helps define the geographic area of impact. During an unsuccessful barge landing, the Falcon 9 First Stage would likely explode, creating an impulsive in-air noise. These acoustic stressors, as well as other potential stressors, would have different geographic regions of influence and are described below.

2.1 Launches

SpaceX launches the Falcon 9 at SLC-4E. During launch events, the Falcon 9 would emit a combustible light source (flame) as engines ignite. These light emissions would be more visible during nighttime operations. The launch noise is estimate to be up to approximately 110 A-weighted decibels (dBA) at the landing pad (Figure 2-1). This noise would attenuate below 70 dBA approximately 11 mi. from SLC-4E. From the launch pad, the trajectory of the Falcon 9 First Stage would be either westward or southward from SLC-4E depending on the payload's orbital mission.

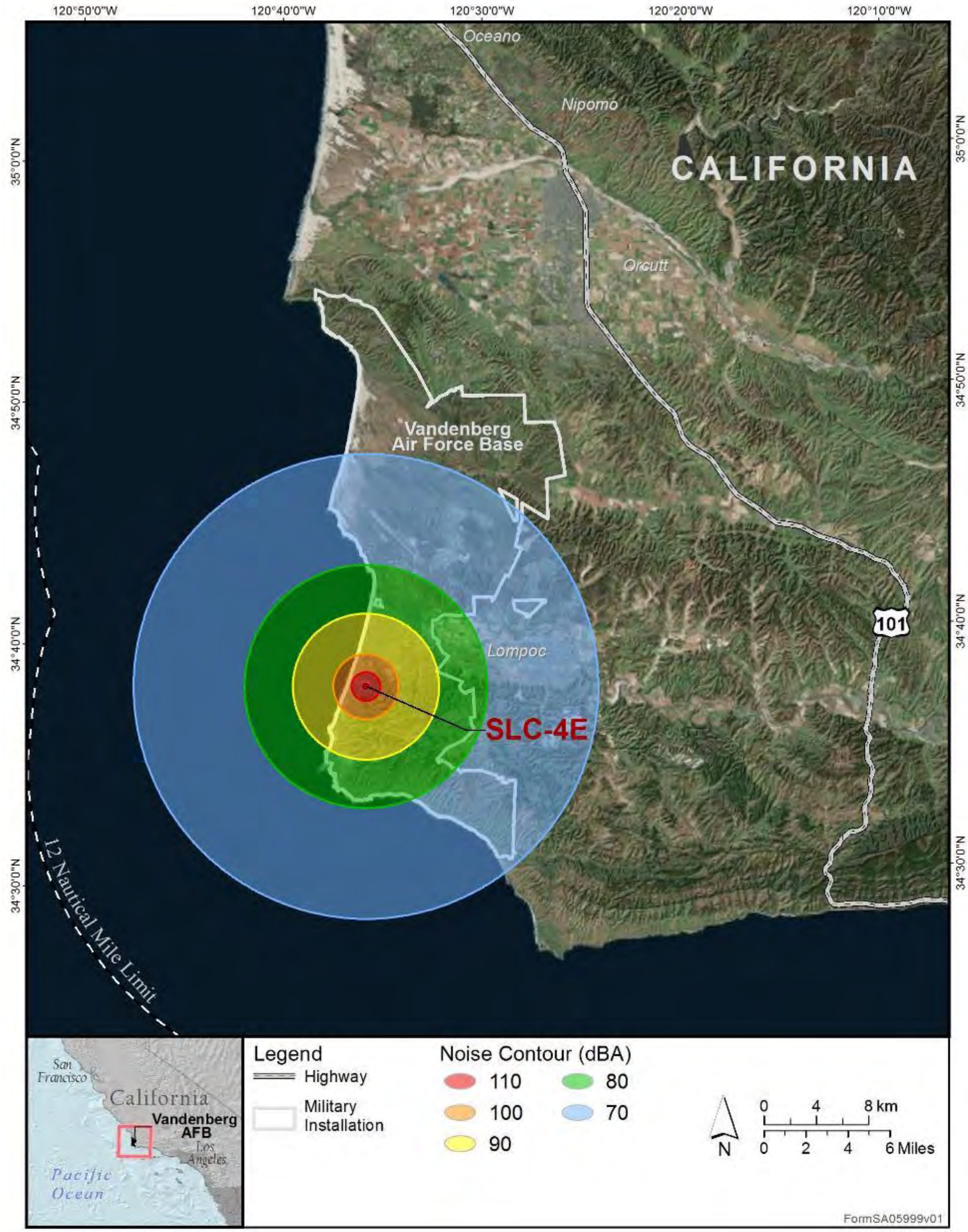


Figure 2-1. Estimated Launch Noise of Falcon 9 First Stage at SLC-4E

2.2 Sonic Boom

During descent, when the First Stage is supersonic, a sonic boom (overpressure of high-energy impulsive sound) would be generated. Sonic booms would occur in proximity to the landing areas and may be heard during or briefly after the boost-back and landing, depending on the location of the observer. Previous acoustic modeling determined these overpressures would reach as high as 2.0 pounds per square feet (psf) at the landing area and up to 3.1 psf south of the landing areas. Recent observations show that these early models underestimated the near-field overpressures. Therefore, SpaceX and the U.S. Air Force (USAF) have developed new estimates for near-field overpressures based on actual observations from past Falcon 9 First Stage boost-back and landing events.

The USAF predicts that a boost-back and landing of the Falcon 9 First Stage at SLC-4W would produce a sonic boom with overpressures as high as 8.5 psf at SLC-4W, which would attenuate to levels below 1.0 psf at approximately 15.90 mi. (25.59 km) from the landing area (Figure 2-2). This estimate is based, in part, on actual observations from Falcon 9 boost-backs and landings at Cape Canaveral. Wyle predicted that a boost-back and landing of the Falcon 9 First Stage at SLC-4W would produce a sonic boom with overpressures up to 3.1 psf in the North Channel Islands (San Miguel Island, Santa Rosa Island, and Santa Cruz Island) (Figure 2-5 and Figure 2-5). In addition, Blue Ridge Research Consultation predicts that a boost-back and landing of the Falcon 9 First Stage at SLC-4W would produce sonic boom with overpressures between 0.5 and 2 psf near the Northern Channel Islands (James, et al., 2017) (Figure 2-3). The Wyle and Blue Ridge Research Corporation models provide a more accurate representation of likely far-field effects from a sonic boom (i.e., overpressures at the North Channel Islands) than Figure 2-2.

During a contingency barge-landing event, sonic boom overpressure would be directed at the ocean surface while the first-stage booster is supersonic. The Wyle model is used to show potential far-field effects from First Stage landings offshore of VAFB or within the Iridium Landing Area. It is anticipated that the Northern Channel Islands would experience overpressures of less than 1 psf from a First Stage barge landing off the coast of VAFB (Figure 2-6 and Figure 2-7). First Stage boost-backs and landings within the Iridium Landing Area would not likely produce measurable overpressures at any land surface (Figure 2-8 and Figure 2-9).

2.3 Landing Noise

Previously, SpaceX proposed to use a single engine burn during landing. SpaceX now proposes to use a three-engine burn during landing. This engine burn, lasting approximately 17 seconds, would generate between 70 and 110 decibels (dB) of noise centered on SLC-4W, but affecting an area up to 15 nm (27.8 km) offshore of VAFB (Figure 2-10). Engine noise would also be produced during the barge landing of the Falcon 9 First Stage, which was estimated by extrapolating the landing noise profile from a SLC-4W landing. Engine noise during the barge landing is expected to be between 70 and 110 dB non-pulse, in-air noise affecting a radial area up to 15 nm (27.8 km) around the contingency landing location (Figure 2-11) and the Iridium Landing Area (Figure 2-12).

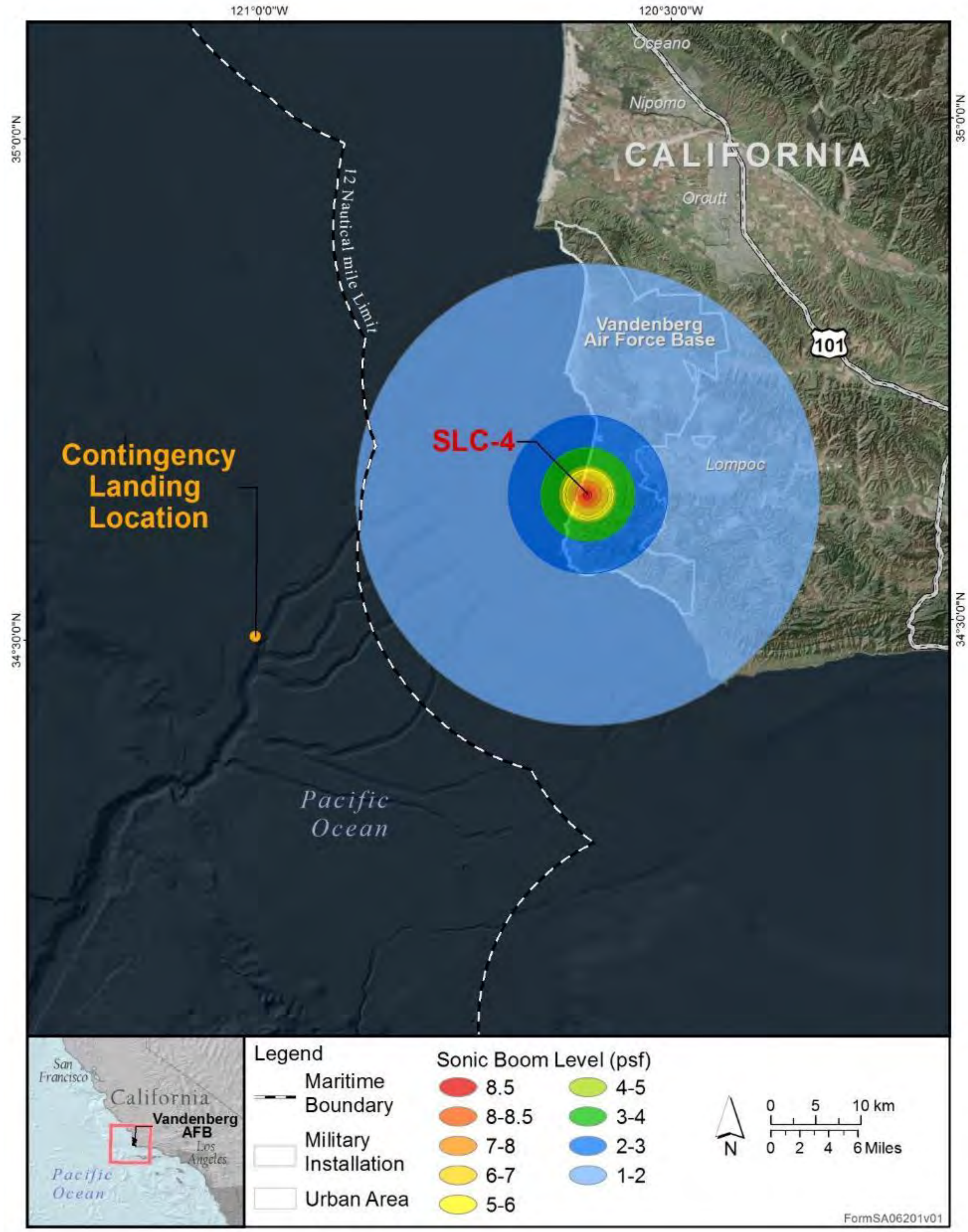


Figure 2-2. Estimated Near-Field Sonic Boom Contours for Falcon 9 First Stage Landing at SLC-4W (USAF Model)

Figure 2-3. Estimated Far-Field Sonic Boom Contours for Falcon 9 First Stage Landing at SLC-4W (Blue Ridge Research Corporation Model)

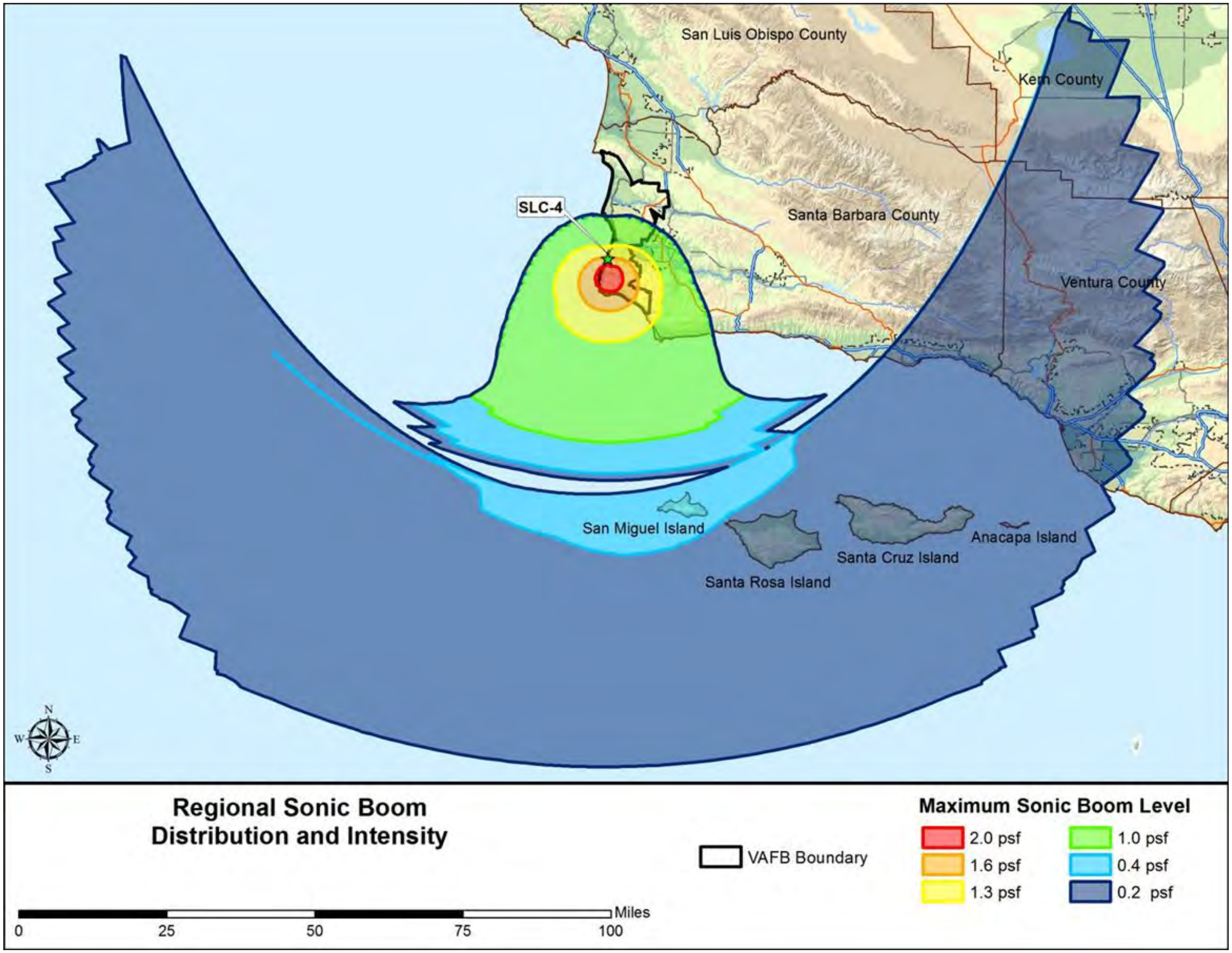


Figure 2-4. Estimated Far-Field Sonic Boom Contours for Falcon 9 First Stage Landing at SLC-4W with an Incoming Trajectory for a Light Payload (Wyle Model)

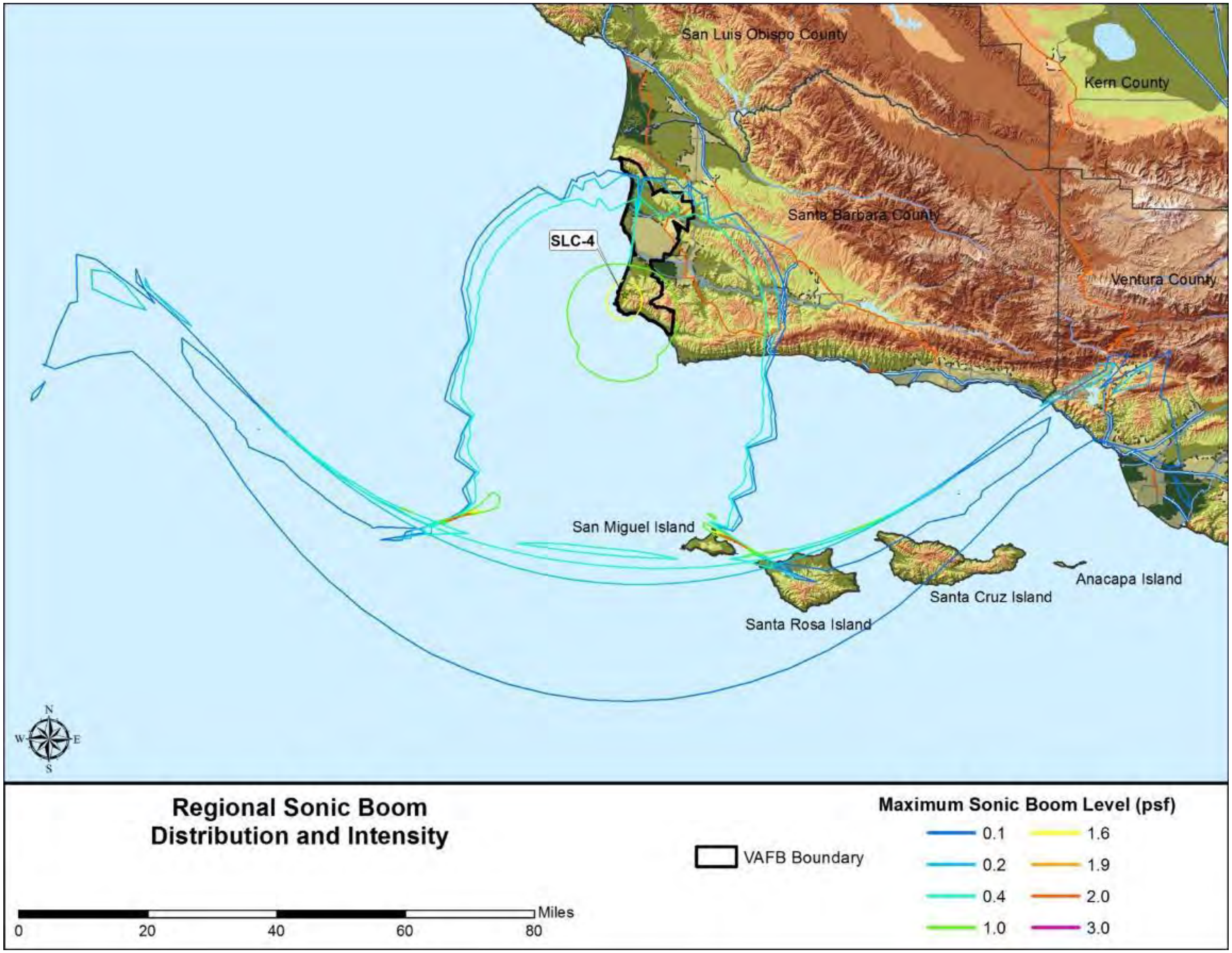


Figure 2-5. Estimated Far-Field Sonic Boom Contours for Falcon 9 First Stage Landing at SLC-4W with an Incoming Trajectory for a Heavy Payload (Wyle Model)

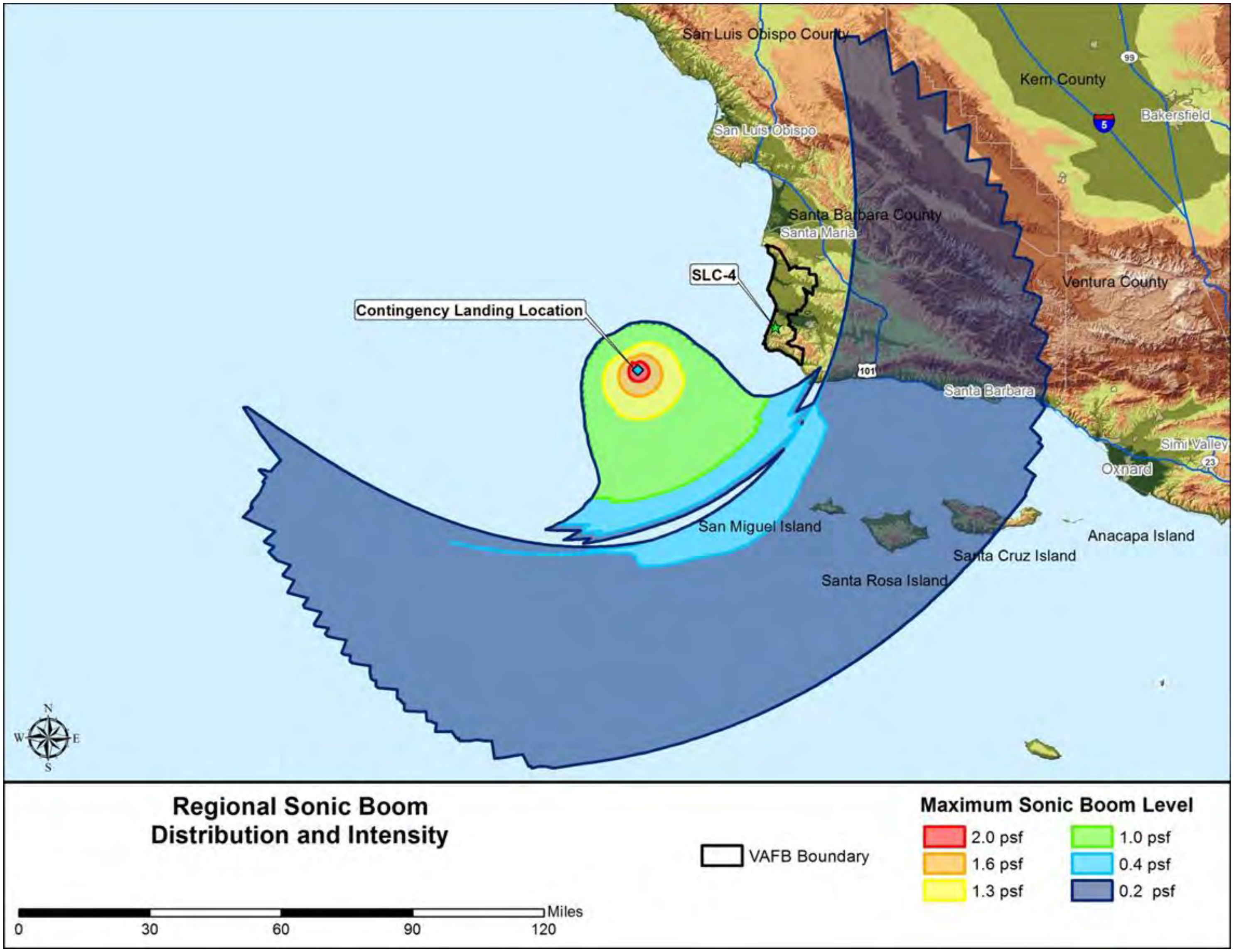
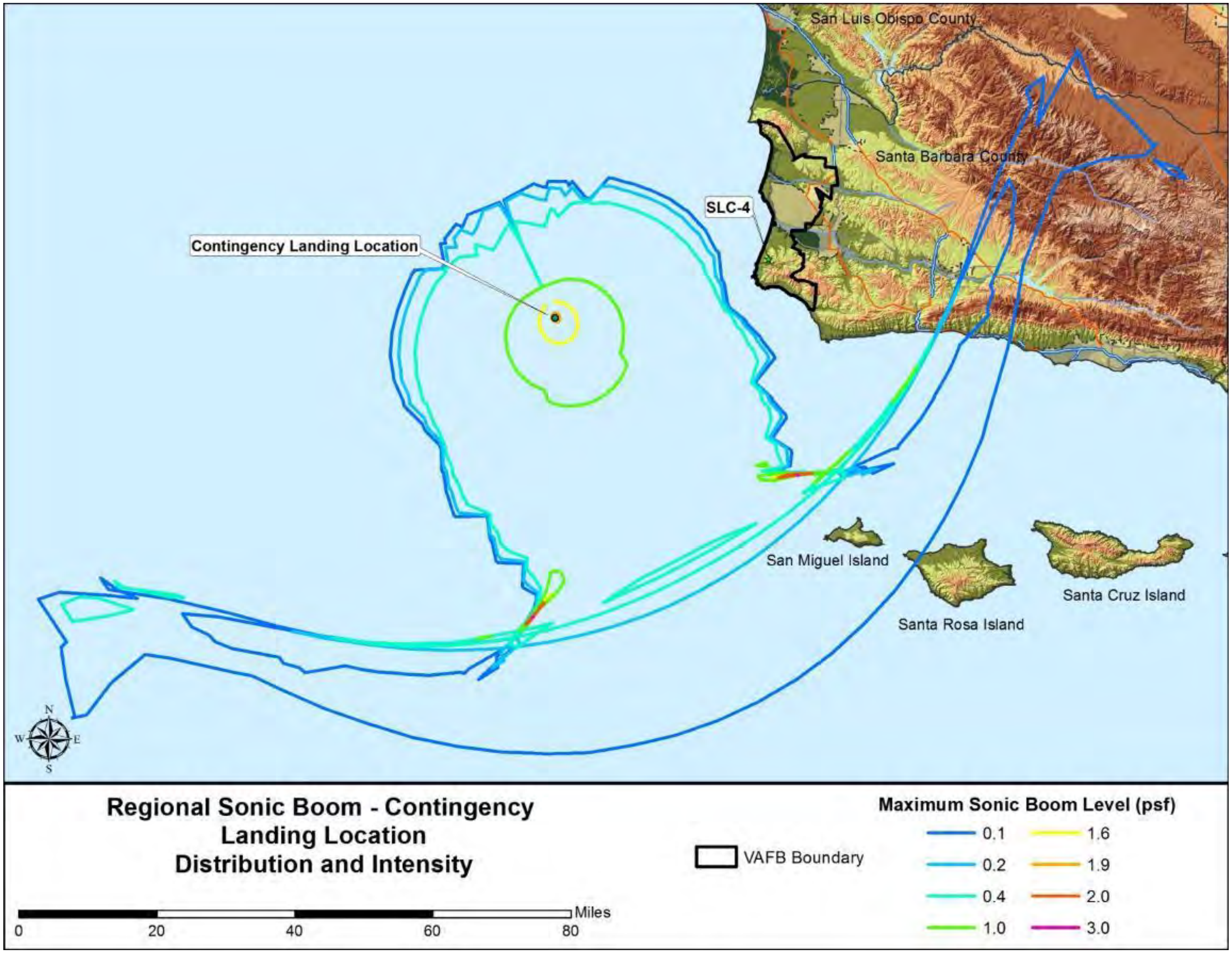


Figure 2-6. Hypothetical Far-field Sonic Boom Overpressure for Contingency Action of Drone Ship Landing Offshore of VAFB with an Incoming Trajectory for a Light Payload (Wyle Model)



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2 Figure 2-7. Hypothetical Far-field Sonic Boom Overpressure for Contingency Action of Drone Ship Landing Offshore of VAFB with
3 an Incoming Trajectory for a Heavy Payload (Wyle Model)

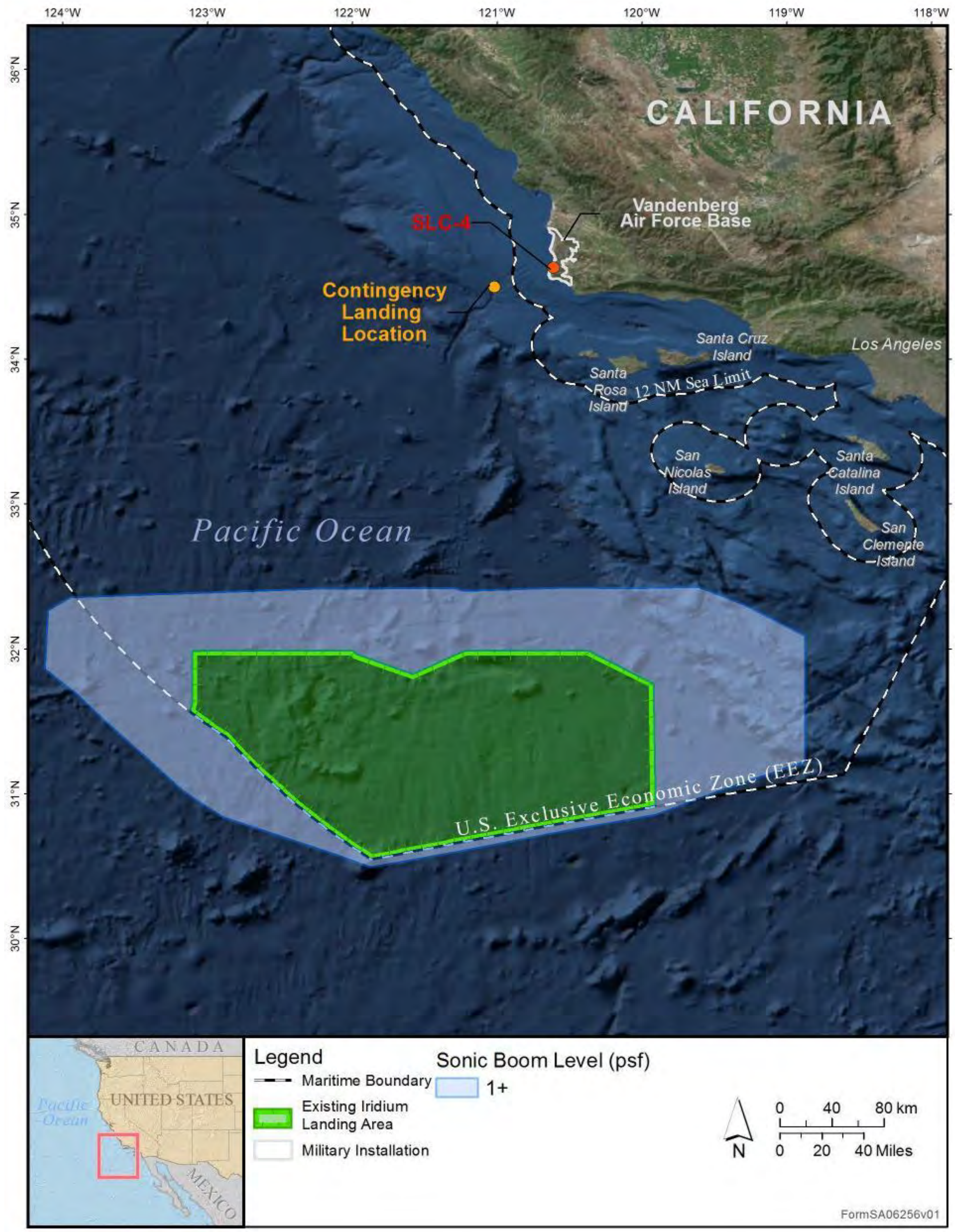
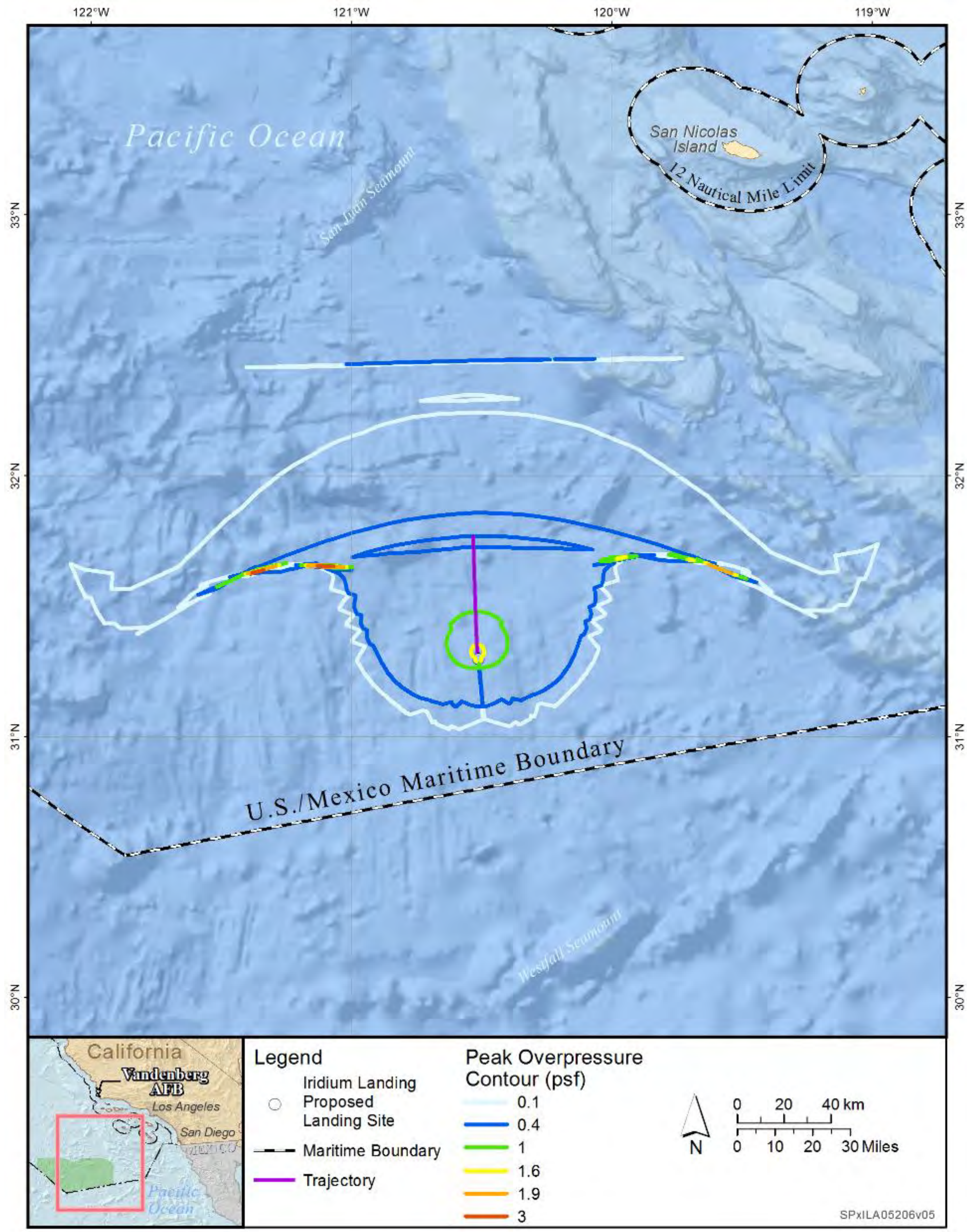
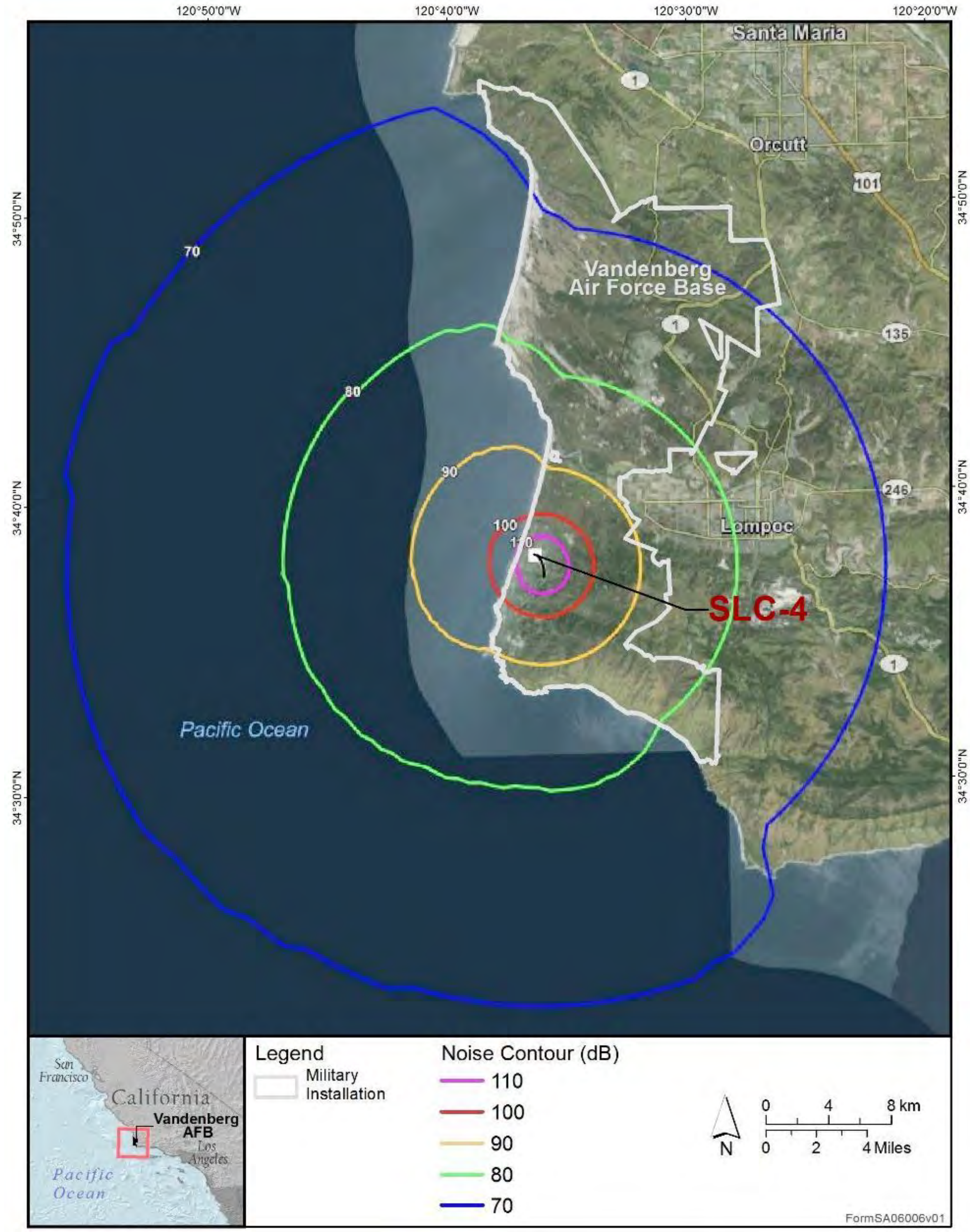


Figure 2-8. Estimated Far-Field Sonic Boom Contours for Falcon 9 First Stage Landing within the Iridium Landing Area



Source: (Bradley, 2016b)

Figure 2-9. Example Sonic Boom within the Iridium Landing Area (Wyle Model)



Source: (Bradley, 2016a)

Figure 2-10. Estimated Landing Noise of Falcon 9 First Stage at SLC-4

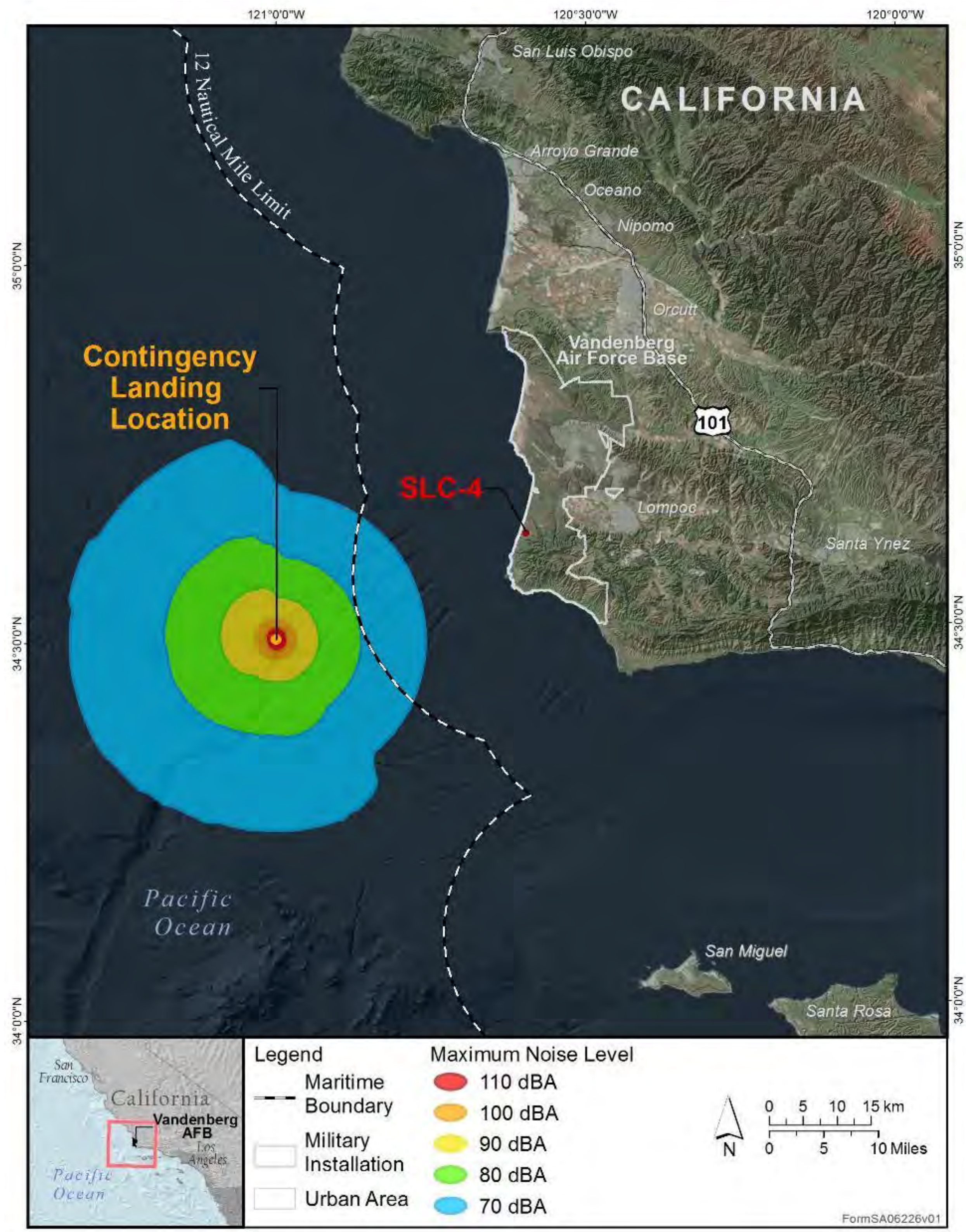


Figure 2-11. Estimated Landing Noise of Falcon 9 First Stage at the Contingency Landing Location

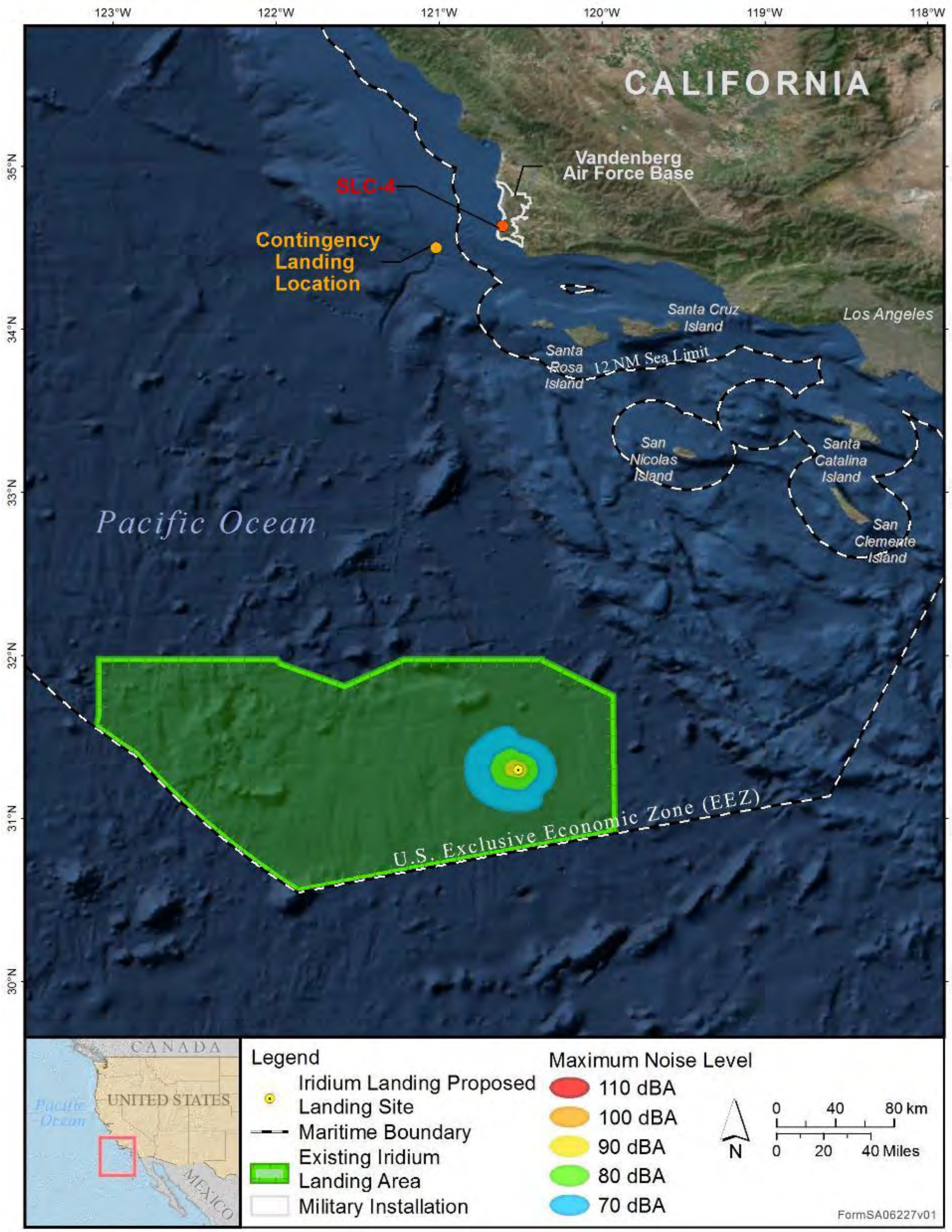


Figure 2-12. Example Landing Noise of Falcon 9 First Stage within the Iridium Landing Area

3 Species and Numbers of Marine Mammals

Six pinnipeds (seals and sea lions) and 29 cetaceans (whales and dolphins) may be present in the areas potentially impacted by boost-back and landing at either SLC-4W or the contingency landing locations. Table 3-1 summarizes the population status and abundance of each of these species, while Section 4 contains detailed life history information.

The estimated at-sea density for the following species is assumed to be zero in the affected area: Hawaiian monk seal (*Monachus schauinslandi*), pygmy killer whale (*Feresa attenuata*), false killer whale (*Pseudorca crassidens*), Longman's beaked whale (*Indopacetus pacificus*), Fraser's dolphin (*Lagenodelphis hosei*), spinner dolphin (*Stenella longirostris*), pantropical spotted dolphin (*Stenella attenuata*), rough-toothed dolphin (*Steno bredanensis*), and melon-headed whale (*Peponocephala electra*). Because these species are very unlikely to occur or are not known to occur in the region (U.S. Department of the Navy, 2016), these species are not considered further in this Application.

In 2015, the National Marine Fisheries Service (NMFS) identified areas where select cetaceans are known to concentrate at certain times of the year to engage in activities considered biologically important (e.g., feeding and migrating) (Calambokidis, et al., 2015). These areas, which are referred to as biologically important areas (BIAs), do not receive any additional regulatory protection, nor do they represent the totality of important habitat throughout a marine mammal's full range, which for many species extends well beyond the BIAs. The goal of identifying these BIAs was to synthesize existing biological information for use during the planning and design of anthropogenic activities. Figure 3-1 depicts the location of BIAs in relation to the project area. These BIAs were considered in the preparation of this application.

Table 3-1. Marine Mammal Species Status, Habitat Use, Stock Abundance, and Seasonality

Species	ESA Listing Status	MMPA Depletion Status	Occurrence within Project Area	Habitat Use in Project Area	Stock Abundance[1]	Seasonality
California Sea Lion *Zalophus californianus*	NL	N	Common	Rocks and beach haul-outs, nearshore, open ocean	296,750 (U.S.)	Year round
Pacific Harbor Seal *Phoca vitulina richardsi*	NL	N	Common	Rocks and beach haul-outs, nearshore, open ocean	30,968 (California)	Year round
Northern Elephant Seal *Mirounga angustirostris*	NL	N	Common	Beach haul-outs, nearshore, open ocean	179,000 (California breeding)	Year round, peak occurrence during winter breeding (Dec-Mar)
Steller Sea Lion *Eumetopias jubatus*	DL	D	Rare, but increasing	Rocks and beach haul-outs, nearshore, open ocean	2,781[2] (California)	Year round, rare
Northern Fur Seal *Callorhinus ursinus*	NL	N	Common	Rocks and beach haul-outs, nearshore, open ocean	14,050 (California)	Year round
Guadalupe Fur Seal *Arctocephalus townsendi*	T	D/S	Rare	Open ocean	7,408 (Mexico to California)	Slightly more common in summer and fall
Humpback whale *Megaptera novaeangliae*	E	D/S	Common Seasonal	Open ocean and coastal waters	1,918 (California, Oregon, Washington)	Summer feeding ground, peak occurrence is Dec – Jun[3]
Blue whale *Balaenoptera musculus*	E	D/S	Common Seasonal	Open ocean and coastal waters	1,647 (Eastern North Pacific)	Most common in summer and fall months
Fin whale *Balaenoptera physalus*	E	D/S	Common year-round	Offshore waters, open ocean	3,051 (California, Oregon, Washington)	Most common in summer and fall months
Sei whale *Balaenoptera borealis*	E	D/S	Rare	Offshore waters, open ocean	126 (Eastern North Pacific)	Primarily are encountered there during July to September and leave California waters by mid-October
Bryde's whale *Balaenoptera brydei/edeni*	NL	N	Rare	Open ocean	798 (Hawaii)	Year round, rare
Minke whale *Balaenoptera acutorostrata*	NL	N	Common	Nearshore and offshore	478 (California, Oregon, Washington)	Less common in summer; small numbers around northern Channel Islands
Gray whale *Eschrichtius robustus*	E	N	Seasonal	Nearshore and offshore	20,990 (Eastern North Pacific)	Most abundant Jan through Apr
Sperm whale *Physeter microcephalus*	E	D/S	Common year-round	Nearshore and offshore	2,106 (California, Oregon, Washington)	Widely distributed year-round; More likely in waters > 1,000 m depth, most often > 2,000 m
Pygmy sperm whale *Kogia breviceps*	NL	N	Potential	Nearshore and open ocean	579 (California, Oregon, Washington)	Year round, rare
Dwarf sperm whale *Kogia sima*	NL	N	Potential	Open ocean	Unknown	Year round, rare

Species	ESA Listing Status	MMPA Depletion Status	Occurrence within Project Area	Habitat Use in Project Area	Stock Abundance[1]	Seasonality
Killer whale *Orcinus orca*	NL	N	Uncommon	Nearshore and open ocean	240 (Eastern North Pacific) 82 (Eastern North Pacific Southern Resident)	Most common in summer and fall months
Short-finned pilot whale *Globicephala macrorhynchus*	NL	S	Uncommon	Offshore, open ocean	760 (California, Oregon, Washington)	Year round, rare
Long-beaked common dolphin *Delphinus capensis*	NL	N	Common	Nearshore (within 57.5 miles [92.5 km])	107,016 (California)	Most abundant during May to Oct
Short-beaked common dolphin *Delphinus delphis*	NL	N	Common	Nearshore and open ocean	411,211 (California, Oregon, Washington	One of the most abundant CA dolphins; higher summer densities
Common bottlenose dolphin *Tursiops truncates*	NL	N	Common	Coastal and offshore	1,006 (California offshore) 323 (California Coastal)	Year round
Striped dolphin *Stenella coeruleoalba*	NL	N	Uncommon	Offshore	10,908 (California, Oregon, Washington)	More abundant in summer/fall
Pacific white-sided dolphin *Lagenorhynchus obliquidens*	NL	N	Common	Open ocean and offshore	26,930 (California, Oregon, Washington)	More abundant Nov-Apr
Northern right whale dolphin *Lissodelphis borealis*	NL	N	Common	Open ocean	8,334 (California, Oregon, Washington)	Higher densities Nov-Apr
Risso's dolphin *Grampus griseus*	NL	N	Common	Nearshore and offshore	6,272 (California, Oregon, Washington)	Higher densities Nov-Apr
Dall's Porpoise *Phocoenoides dalli*	NL	N	Common	Inshore/offshore	42,000 (California, Oregon, Washington)	Higher densities Nov-Apr
Harbor Porpoise *Phocoena phocoena*	NL	N	Common	Nearshore and offshore	2,917 (Morro Bay Stock)	Year round
Cuvier's beaked whale *Ziphius cavirostris*	NL	S	Potential	Open ocean	6,590 (California, Oregon, Washington)	Possible year-round occurrence but difficult to detect due to diving behavior
Baird's beaked whale *Berardius bairdii*	NL	N	Potential	Open ocean	847 (California, Oregon, Washington)	Primarily along continental slope from late spring to early fall

Species	ESA Listing Status	MMPA Depletion Status	Occurrence within Project Area	Habitat Use in Project Area	Stock Abundance[1]	Seasonality
Mesoplodont Beaked Whales (Blainville's beaked whale *Mesoplodon densirostris*; Ginkgo-toothed beaked whale *Mesoplodon ginkgodens*; Perrin's beaked whale *Mesoplodon perrini*; Stejneger's beaked whale; *Mesoplodon stejnegeri*; Hubbs' beaked whale *Mesoplodon carlhubbsi*; Pygmy beaked whale *Mesoplodon peruvianus)*	NL	S	Rare/Potential	Open ocean	694	Year round, rare

[1] Carretta, et al., 2016
[2] Allen and Angliss, 2014
[3] Calambokidis et al., 2001
Notes: ESA = Endangered Species Act, E = Federal Endangered Species, T = Federal Threatened Species, C = Federal Candidate Species, DL = Federally De-listed Species, NL = Not Federally listed under the ESA, D = MMPA Depleted Stock, S= MMPA Strategic Stock

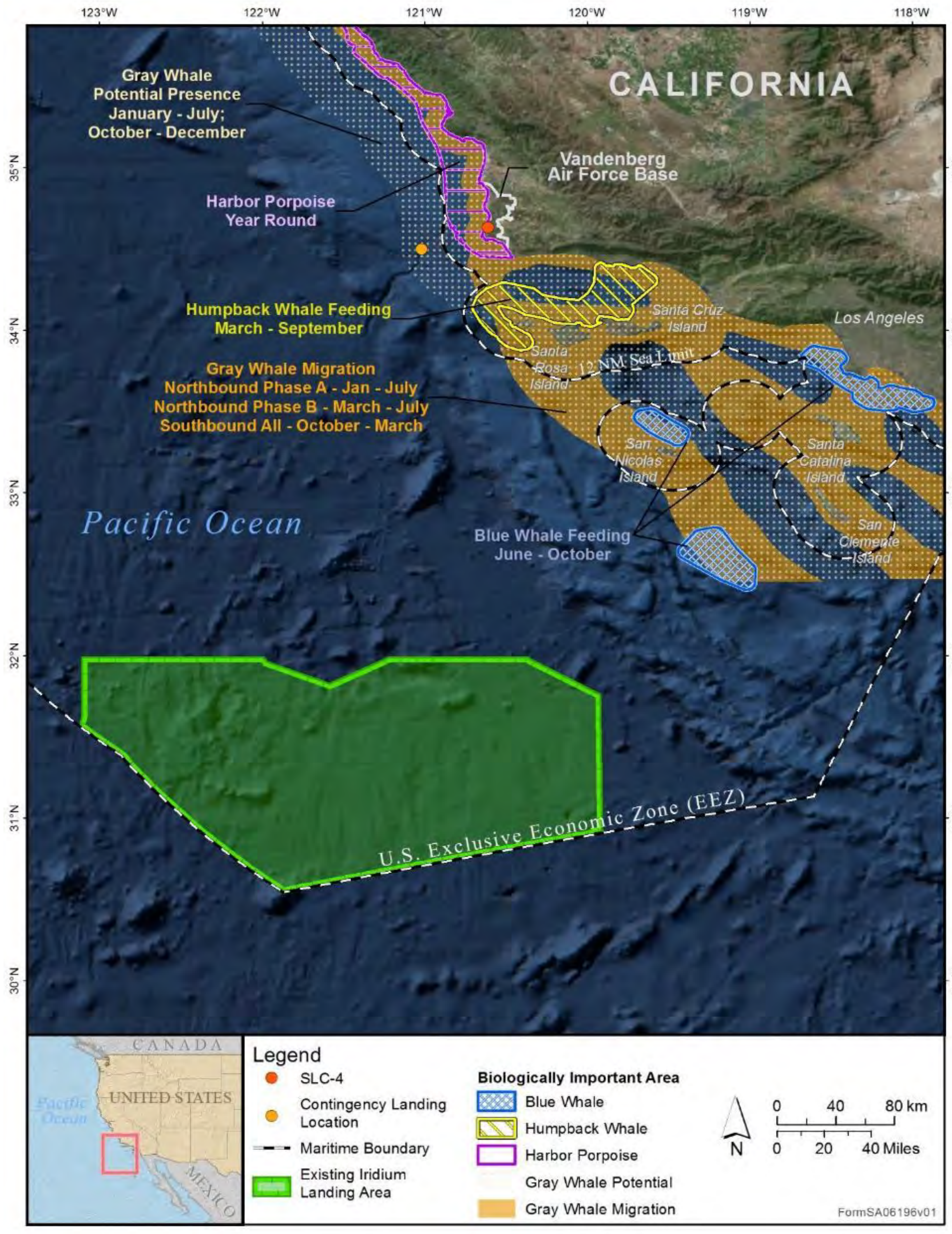


Figure 3-1. Biologically Important Areas in Relation to VAFB and the Landing Areas

4 Affected Species Status and Distribution

The following 6 pinnipeds and 29 cetaceans may be present in the affected area during boost-back and landing events. With the exception of the pacific harbor porpoise, density estimates reported below were extrapolated from raw data from the U.S. Department of the Navy (2016). These estimates are estimated as the highest at-sea seasonal and geographic densities reported within approximately 15 mi. of each landing area (i.e., "affected area," those areas that are conservatively estimated to receive greater than a 1 psf sonic boom).

4.1 California Sea Lion (*Zalophus californianus*)

California sea lions are common offshore of VAFB and haul out sporadically on rocks and beaches along the coastline of VAFB. In 2014, counts of California sea lions at haulouts on VAFB increased substantially, ranging from 47 to 416 during monthly counts (ManTech SRS Technologies, Inc., 2015). However, California sea lions rarely pup on the VAFB coastline: no pups were observed in 2013 or 2014 (ManTech SRS Technologies, Inc., 2014, 2015) and one pup was observed in 2015 (VAFB, unpubl. data). California sea lions are the most abundant pinniped species in the Channel Islands (Lowry et al., 2017b). San Miguel Island is the northern extent of the species breeding range; and, along with San Nicolas Island, it contains one of the largest breeding colonies of the species in the Channel Islands (Melin et al., 2010; Lowry et al., 2017a). Pupping occurs in large numbers on San Miguel Island at the rookeries found at Point Bennett on the west end of the island and at Cardwell Point on the east end of the island. During aerial surveys of the Northern Channel Islands conducted by NOAA Fisheries in February 2010, 21,192 total California sea lions (14,802 pups) were observed at haulouts on San Miguel Island and 8,237 total (5,712 pups) at Santa Rosa Island (M. Lowry, NOAA Fisheries, unpubl. data). During aerial surveys in July 2012, 65,660 total California sea lions (28,289 pups) were recorded at haulouts on San Miguel Island, 1,584 total (3 pups) at Santa Rosa Island, and 1,571 total (zero pups) at Santa Cruz Island (M. Lowry, NOAA Fisheries, unpubl. data). The at-sea estimated density for California sea lions is assumed to be 0.0596 individuals per km^2 in the affected areas (U.S. Department of the Navy, 2016).

4.2 Pacific Harbor Seal (*Phoca vitulina richardsi*)

Pacific harbor seals congregate on multiple rocky haul-out sites along the VAFB coastline. Most haul-out sites are located between the Boat House and South Rocky Point, where most of the pupping on VAFB occurs. Pups are generally present in the region from March through July. Within the affected area on VAFB, up to 332 adults and 34 pups have been recorded in monthly counts from 2013 to 2015 (ManTech SRS Technologies, Inc., 2014, 2015; VAFB, unpublished data). During aerial pinniped surveys of haulouts located in the Point Conception area by NOAA Fisheries in May 2002 and May and June of 2004, between 488 to 516 harbor seals were recorded (M. Lowry, NOAA Fisheries, unpubl. data). Data on pup numbers were not provided. Harbor seals also haul out, breed, and pup in isolated beaches and coves throughout the coast of San Miguel Island. During aerial surveys conducted by NOAA Fisheries in May 2002 and May and June of 2004, between 521 and 1,004 harbors seals were recorded at San Miguel Island, between 605 and 972 at Santa Rosa Island, and between 599 and 1,102 Santa Cruz Island (M. Lowry, NOAA Fisheries, unpubl. data). Again, data on pup numbers were not provided. Lowry et al. (2017b) counted 1,367 Pacific harbor seals at the Channel Islands in July 2015. The at-sea estimated density for harbor seals is assumed to be 0.0183 individuals per km^2 in the affected areas (U.S. Department of the Navy, 2016).

4.3 Northern Elephant Seal (*Mirounga angustirostris*)

Northern elephant seals haul-out sporadically on rocks and beaches along the coastline of VAFB and observations of young of the year seals from May through November have represented individuals dispersing later in the year from other parts of the California coastline where breeding and birthing occur. Eleven northern elephant seals were observed during aerial surveys of the Point Conception area by NOAA Fisheries in February of 2010 (M. Lowry, NOAA Fisheries, unpubl. data). Northern elephant seals breed and pup at the rookeries found at Point Bennett on the west end of San Miguel Island and at Cardwell Point on the east end of the island (Lowry, 2002). Northern elephant seals are abundant in the Channel Islands from December to March (Lowry et al., 2017b). During aerial surveys of the Northern Channel Islands conducted by NOAA Fisheries in February 2010, 21,192 total northern elephant seals (14,802 pups) were recorded at haulouts on San Miguel Island and 8,237 total (5,712 pups) were observed at Santa Rosa Island (M. Lowry, NOAA Fisheries, unpubl. data). None were observed at Santa Cruz Island (M. Lowry, NOAA Fisheries, unpubl. data). Lowry (2017b) stated that aerial surveys found 16,208 pups in San Miguel Island, 10,882 pups at San Nicolas Island, and 5,946 pups at Santa Rosa Island. The at-sea estimated density for northern elephant seals is assumed to be 0.076 individuals per km^2 in the affected areas (U.S. Department of the Navy, 2016).

4.4 Steller Sea Lion (*Eumetopias jubatus*)

North Rocky Point was used in April and May 2012 by Steller sea lions (Marine Mammal Consulting Group and Science Applications International Corporation [MMCG and SAIC], 2012). This observation was the first time this species had been reported at VAFB during launch monitoring and monthly surveys conducted over the past two decades. Since 2012, Steller sea lions have been observed frequently in routine monthly surveys, with as many as 16 individuals recorded. In 2014, up to five Steller sea lions were observed in the affected area during monthly marine mammal counts (ManTech SRS Technologies, Inc., 2015) and a maximum of 12 individuals were observed during monthly counts in 2015 (VAFB, unpublished data). However, up to 16 individuals were observed in 2012 (MMCG and SAIC, 2012). Steller sea lions once had two small rookeries on San Miguel Island, but these were abandoned after the 1982-1983 El Niño event (DeLong and Melin, 2000; Lowry, 2002); however occasional juvenile and adult males have been detected since then. These rookeries were once the southernmost colonies of the eastern stock of this species. The Eastern Distinct Population Segment of this species, which includes the California coastline as part of its range, was de-listed from the federal Endangered Species Act in November 2013. The at-sea estimate density for Steller sea lion is assumed to be 0.0001 individuals per km^2 in the affected areas; however the species is not expected to occur in the Iridium Landing Area (U.S. Department of the Navy, 2015; U.S. Department of the Navy, 2016).

4.5 Northern Fur Seal (*Callorhinus ursinus*)

Northern fur seal occur from Southern California to Japan. Within California approximately 1 percent of the population occurs on San Miguel Island off southern California and 0.3 percent occurs on the Farallon Islands off the coast of central California. Males tend to be ashore for three months during the breeding season, whereas females may occur ashore for as long as six months (June to November) (Carretta, et al., 2016). Peak pupping is in early July. The pups are weaned at three to four months. Some juveniles are present year-round, but most juveniles and adults head for the open ocean and a pelagic existence until the next year. Animals found offshore of VAFB are most likely from the San Miguel Island stock, which remain in the area around San Miguel Island throughout the year (Koski et al., 1998).

Comprehensive count data for northern fur seals on San Miguel Island were not available during preparation of this application. However, based on prior harassment authorizations, it is estimated that approximately 5,000 norther fur seals may be hauled out on San Miguel Island. Northern fur seals have not been observed to haul out along the mainland coast of Santa Barbara County; however, one fur seal stranding has been reported at VAFB which involved a seal that came ashore at Surf Beach in 2012. The at-sea estimated density for northern fur seals is assumed to be is assumed to be 0.021 individuals per km^2 in the affected areas (U.S. Department of the Navy, 2016).

4.6 Guadalupe Fur Seal (*Arctocephalus townsendi*)

The Guadalupe fur seal is typically found on shores with abundant large rocks, often at the base of large cliffs. They are also known to inhabit caves, which provide protection and cooler temperatures, especially during the warm breeding season (Belcher and Lee, 2002). They are rare in southern California, only found occasionally visiting the northern Channel Islands, as they mainly breed on Guadalupe Islands, Mexico, in the months of May-July. On San Miguel Island, one to several Guadalupe fur seals were observed annually between 1969 and 2000 (DeLong and Melin, 2000) and an adult female with a pup was observed in 1997 (Melin and Delong, 1999). Over the past five years, two to three pups have been observed annually on San Miguel Island and 13 individuals and two pups were observed in 2015 (J. Harris, NOAA Fisheries, pers. comm.). Guadalupe fur seals can be found in deeper waters of the California Current Large Marine Ecosystem (Hanni et al., 1997; Jefferson et al., 2008). Guadalupe fur seals have not been observed hauling out on the mainland coast of Santa Barbara County. Adult males, juveniles, and nonbreeding females may live at sea during some seasons or for part of a season (Reeves et al., 1992). The movements of Guadalupe fur seals at sea are generally unknown, but strandings have been reported in northern California and as far north as Washington (Etnier, 2002). A 1993 population estimate of all age classes in Mexico was 7,408 (Carretta et al., 2016). The at-sea estimated density for northern Guadalupe fur seals is assumed to be 0.0278 individuals per km^2 in the affected areas (U.S. Department of the Navy, 2016).

4.7 Humpback Whale (*Megaptera novaeangliae*)

Humpback whales are listed as depleted under the MMPA. The California, Oregon, and Washington stock of humpback whales use the waters offshore of Southern California as a summer feeding ground. Peak occurrence occurs in Southern California waters from December through June (Calambokidis et al., 2001). During late summer, more humpback whales are sighted north of the Channel Islands, and limited occurrence is expected south of the northern Channel Islands (San Miguel, Santa Rosa, Santa Cruz) (Carretta et al., 2010). The at-sea estimated density for humpback whales is assumed to be 0.017539 individuals per km^2 in the affected areas for SLC-4, 0.016099 individuals per km^2 in the affected area for the Conditional Landing Location, and 0.000276 individuals per km^2 in the affected area for the Iridium Landing Area (U.S. Department of the Navy, 2016).

4.8 Blue Whale (*Balaenoptera musculus*)

The blue whale is listed as depleted under the MMPA. The blue whale inhabits all oceans and typically occurs near the coast, over the continental shelf, though it is also found in oceanic waters.

Their range includes the California Current system (Ferguson, 2005; Stafford et al., 2004). The U.S. Pacific coast is known to be a feeding area for this species during summer and fall (barlow et al., 2009; Carretta et al., 2010). This species has frequently been observed in Southern California waters (Carretta et al., 2000; U.S. Department of the Navy, 2011), and in the Southern California Bight, the highest densities of blue whales occurred along the 200 m. isobath in waters with high surface chlorophyll concentrations (Redfern et al., in review). The at-sea estimated density for blue whales is assumed to be 0.10006 individuals per km^2 in the affected area for SLC-4W, 0.007651 individuals per km^2 in the affected area for the Contingency Landing Location, and 0.002476 individuals per km^2 in the affected area the Iridium Landing Area (U.S. Department of the Navy, 2016).

4.9 Fin Whale (*Balaenoptera physalus*)

The fin whale is listed as depleted under the MMPA. This species has been documented from 60° N to 23° N, and they have frequently been recorded in offshore waters within the Southern California current system (Carretta et al., 2010, Mizroch et al., 2009). Aerial surveys conducted in October and November 2008 within Southern California offshore waters resulted in the sighting of 22 fin whales (Oleson and Hill, 2009, Acevedo-Gutiérrez et al., 2002). Navy-sponsored monitoring in the Southern California Range Complex for the 2009–2010 period also recorded the presence of fin whales (U.S. Department of the Navy, 2010). Moore and Barlow (2011) indicate that, since 1991, there is strong evidence of increasing fin whale abundance in the California Current area; they predict continued increases in fin whale numbers over the next decade. The at-sea estimated density for fin whales is assumed to be 0.017677 individuals per km^2 in the affected area for SLC-4W, and 0.02548 individuals per km^2 for the Conditional Landing Location, and 0.1752 individuals per km^2 in the affected areas for the Iridium Landing Area (U.S. Department of the Navy, 2016).

4.10 Sei Whale (*Balaenoptera borealis*)

The sei whale is listed as depleted under the MMPA. Sei whales are rare in offshore waters of Southern California (Carretta et al., 2010). They are generally found feeding along the California Current (Perry et al., 1999). There are records of sightings in California waters as early as May and June, but primarily are encountered there during July to September and leave California waters by mid-October. The at-sea estimated density for sei whales assumed to be 0.000050 individuals per km^2 in the affected areas (U.S. Department of the Navy, 2016).

4.11 Bryde's Whale (*Balaenoptera brydei/edeni*)

Bryde's whales are only occasionally sighted in the California Current Large Marine Ecosystems (Carretta et al., 2010, Jefferson et al., 2008). Aerial surveys conducted in October and November 2008 off the Southern California coast resulted in the sighting of one Bryde's whale (Smultea et al., 2012). This was the first sighting in this area since 1991 when a Bryde's whale was sighted within 345 mi. (555 km) of the California coast (Barlow, 1995). The at-sea estimated density for bryde's whales is assumed to be 0.000020 individuals per km^2 in the affected areas (U.S. Department of the Navy, 2016).

4.12 Minke Whale (*Balaenoptera acutorostrata*)

Minke whales are present in summer and fall in Southern California waters (Carretta et al., 2009). They often use both nearshore and offshore waters as habitats for feeding and migration to wintering areas. The at-sea estimated density for minke whales is assumed to be 0.00068 individuals per km^2 in the affected areas (U.S. Department of the Navy, 2016).

4.13 Gray Whale (*Eschrichtius robustus*)

There are two North Pacific populations of gray whales: the Western subpopulation and the Eastern subpopulation. Both populations (stocks) could be present in Southern California waters during their northward and southward migration (Sumich and Show, 2011). The Western North Pacific stock is listed as depleted under the MMPA. Eastern gray whales are frequently observed in Southern California waters (Carretta et al., 2000; Forney et al., 1995, Henkel and Harvey 2008, Hobbs et al., 2004). During aerial surveys off San Clemente Island, California, eastern gray whales were the most abundant cetacean from January through April, a period that covers both the northward and southward migrations (Carretta et al., 2000; Forney et al., 1995). The at-sea estimated density for gray whales is assumed to be 0.17910 individuals per km^2 in the affected area for SLC-4W, and 0.01066 individuals per km^2 in the affected area for the Contingency Landing Location. This species is not known to occur in the Iridium Landing Area (U.S. Department of the Navy, 2016).

4.14 Sperm Whale (*Physeter microcephalus*)

The sperm whale is listed as depleted under the MMPA. Sperm whales are found year round in California waters (Barlow 1995; Forney and Barlow 1993). Sperm whales are known to reach peak abundance from April through mid-June and from the end of August through mid-November (Carretta et al., 2010). The at-sea estimated density for sperm whales is assumed to be 0.003380 individuals per km^2 in the affected areas for SLC-4 and the Conditional Landing Location, and 0.008503 individuals per km^2 in the affected areas for the Iridium Landing Area (U.S. Department of the Navy, 2016).

4.15 Pygmy Sperm Whale (*Kogia breviceps*)

Pygmy sperm whales apparently occur close to shore, sometimes over the outer continental shelf. However, several studies have suggested that this species generally occurs beyond the continental shelf edge (Bloodworth and Odell, 2008; MacLeod et al., 2004). A total of two sightings of this species have been made in offshore waters along the California coast during previous surveys (Carretta et al., 2010). The at-sea estimated density for *Kogia spp.* is assumed to be 0.00159 individuals per km^2 in the affected area for SLC-4W and the Contingency Landing Location, and 0.003660 individuals per km^2 in the Iridium Landing Area (U.S. Department of the Navy, 2016).

4.16 Dwarf Sperm Whale (*Kogia sima*)

Along the U.S. Pacific coast, no reported sightings of this species have been confirmed as dwarf sperm whales. This may be somewhat due to their pelagic distribution, cryptic behavior (i.e., “hidden” because they are not very active at the surface and do not have a conspicuous blow), and physical similarity to the pygmy sperm whale (Jefferson et al., 2008; McAlpine, 2009). However, the presence of dwarf sperm whales off the coast of California has been demonstrated by at least five dwarf sperm whale strandings in California between 1967 and 2000 (Carretta et al., 2010). The at-sea estimated density for *Kogia spp.* is assumed to be 0.00159 individuals per km^2 in the affected area for SLC-4W and the Contingency Landing Location and 0.003660 individuals per km^2 in the Iridium Landing Area (U.S. Department of the Navy, 2016).

4.17 Killer Whale (*Orcinus orca*)

Along the Pacific coast of North America, killer whales are known to occur (from stranding records and acoustic detection) along the outer coasts of Washington, Oregon, and California (Calambokidis and Barlow, 2004, Dahlheim et al., 2008, Ford and Ellis, 1999, Forney et al., 1995). Although they are not commonly observed in Southern California coastal areas, killer whales are found year round off the coast of Baja California (Carretta et al., 2010; Forney et al., 1995). The at-sea estimated density for killer whales is assumed to be 0.000250 individuals per km^2 in the affected areas (U.S. Department of the Navy, 2016).

4.18 Short-finned Pilot Whale (*Globicephala macrorhynchus*)

Along the U.S. Pacific coast, short-finned pilot whales are most abundant south of Point Conception (Carretta et al., 2010; Reilly and Shane, 1986) in deep offshore waters over the continental shelf break, in slope waters, and in areas of high topographic relief (Olson, 2009). A few hundred pilot whales are believed to group each winter at Santa Catalina Island (Carretta et al., 2010; Reilly and Shane, 1986), although these animals are not seen as regularly as in previous years. The at-sea estimated density for short-finned pilot whales is assumed to be 0.001260 individuals per km^2 in the affected areas (U.S. Department of the Navy, 2016).

4.19 Long-beaked Common Dolphin (*Delphinus capensis*)

The long-beaked common dolphin's range within California Current waters is considered to be within about 57.5 mi. (92.5 km) of the coast, from Baja California north through central California. Stranding data and sighting records suggest that the abundance of this species fluctuates seasonally and from year to year off California (Carretta et al., 2010; Zagzebski et al., 2006). It is found off Southern California year round, but it may be more abundant there during the warm-water months (May to October) (Bearzi, 2005; Carretta et al., 2010). The long-beaked common dolphin is not a migratory species, but seasonal shifts in abundance (mainly inshore/offshore) are known for some regions of its range. The at-sea estimated density for long-beaked common dolphins is assumed to be 2.507585 individuals per km^2 in the affected area for SLC-4, 1.713031 individuals per km^2 in the affected area for the Conditional Landing, and 0.000337 individuals per km^2 in the affected area for the Iridium Landing Area (U.S. Department of the Navy, 2016).

4.20 Short-beaked Common Dolphin (*Delphinus delphis*)

Along the U.S. Pacific coast, short-beaked common dolphin distribution overlaps with that of the long-beaked common dolphin. Short-beaked common dolphins are found in California Current waters throughout the year, distributed between the coast and at least 345 mi. (555 km) from shore (Carretta et al., 2010; Forney and Barlow, 1998). Although they are not truly migratory, the abundance of the short-beaked common dolphin off California varies, with seasonal and year-to-year changes in oceanographic conditions; movements may be north-south or inshore-offshore (Barlow, 1995; Carretta et al., 2010; Forney and Barlow, 1998). The at-sea estimated density for short-beaked common dolphins is assumed to be 0.947400 individuals per km^2 in the affected areas for SLC-4W and the Contingency Landing Location, and 1.079803 individuals per km^2 in the affected area for the Iridium Landing Area (U.S. Department of the Navy, 2016).

4.21 Common Bottlenose Dolphin (*Tursiops truncates*)

During surveys off California, offshore bottlenose dolphins were generally found at distances greater than 1.9 mi. (3.06 km) from the coast and throughout the southern portion of California Current waters (Bearzi et al., 2009; Carretta et al., 2010). Sighting records off California and Baja

California suggest continuous distribution of offshore bottlenose dolphins in these regions. Aerial surveys during winter/spring 1991–1992 and shipboard surveys in summer/fall 1991 indicated no seasonality in distribution (Barlow, 1995; Carretta et al., 2010; Forney et al., 1995). In the North Pacific, common bottlenose dolphins have been documented in offshore waters as far north as about 41° N (Carretta et al., 2010). The at-sea estimated density for common bottlenose dolphins is assumed to be 0.06386 individuals per km^2 in the affected areas. The California coastal stock is assumed to have an estimated density of 0.535291 individuals per km^2 in the affected areas for SLC-4 but would not occur at the Contingency Landing Location or the Iridium Landing Area (U.S. Department of the Navy, 2016).

4.22 Striped Dolphin (*Stenella coeruleoalba*)

In and near California waters, striped dolphins are found mostly offshore and are much more common during the warm-water period (summer/fall), although they are found there throughout the year. During summer/fall surveys, striped dolphins were sighted primarily from 115 to 345 mi. (185 to 555 km) offshore of the California coast. Based on sighting records, striped dolphins appear to have a continuous distribution in offshore waters from California to Mexico (Carretta et al., 2010). The at-sea estimated density for striped dolphins is assumed to be .000063 individuals per km^2 in the affected area for SLC-4W, 0.000551 individuals per km^2 in the affected area for the Contingency Landing Location, and 0.138230 individuals per km^2 in the affected area for the Iridium Landing Area (U.S. Department of the Navy, 2016).

4.23 Pacific White-sided Dolphin (*Lagenorhynchus obliquidens*)

Primary habitat includes the cold temperate waters of the North Pacific Ocean and deep ocean regions. They range as far south as the mouth of the Gulf of California, northward to the southern Bering Sea and coastal areas of southern Alaska (Leatherwood et al., 1984; Jefferson et al., 2008). Off California, Forney and Barlow (1998) found significant north/south shifts in the seasonal distribution of Pacific white-sided dolphin, with the animals moving north into Oregon and Washington waters during the summer, and showing increased abundance in the Southern California Bight in the winter. Off California, the species is found mostly at the outer edge of the continental shelf and slope and does not frequently move into shallow coastal waters. Although Pacific white-sided dolphins do not migrate, seasonal shifts have been documented as noted above. From November to April, Pacific white-sided dolphins can be found in shelf waters off the coast of Southern California. The at-sea estimated density for Pacific white-sided is assumed to be 1.70129 individuals per km^2 in the affected area for SLC-4W, 0.220652 individuals per km^2 in the affected area for the Contingency Landing Location, and 0.010258 individuals per km^2 in the affected area for the Iridium Landing Area (U.S. Department of the Navy, 2016).

4.24 Northern Right Whale Dolphin (*Lissodelphis borealis*)

This species is known to occur year round off California, but abundance and distribution vary seasonally. This species is most abundant off central and northern California in relatively nearshore waters in winter (Dohl et al., 1983). In the cool water period, the peak abundance of northern right whale dolphins in Southern California waters corresponds closely with the peak abundance of squid (Forney and Barlow, 1998). In the warm water period, the northern right whale dolphin is not as abundant in Southern California waters due to shifting distributions north into Oregon and Washington, as water temperatures increase (Barlow, 1995; Carretta et al., 2015; Forney and Barlow, 1998; Leatherwood and Walker, 1979).The at-sea estimated density for northern right whale dolphins is assumed to be 0.137820 individuals per km^2 in the affected area for SLC-4W and the Contingency Landing Location, and 0.139480 individuals per km^2 in the affected area for the Iridium Landing Area (U.S. Department of the Navy, 2016).

4.25 Risso's Dolphin (*Grampus griseus*)

Off California, they are commonly seen over the slope and in offshore waters (Carretta et al., 2010; Forney et al., 1995; Jefferson et al., 2008). This species is frequently observed in the waters surrounding San Clemente Island, California. They are generally present year round in Southern California, but are more abundant in the cold-water months, suggesting a possible seasonal shift in distribution (Carretta et al., 2000; Soldevilla, 2008). Several stranding records have been documented for this species in central and Southern California between 1977 and 2002 (Zagzebski et al., 2006). The at-sea estimated density for Risso's dolphins is assumed to be 0.202440 individuals per km^2 in the affected area for SLC-4W and the Contingency Landing Location, and 0.025717 individuals per km^2 in the affected area for the Iridium Landing Area (U.S. Department of the Navy, 2016).

4.26 Dall's Porpoise (*Phocoenoides dalli*)

In Southern California waters, Dall's porpoises are sighted seasonally, mostly during the winter (Carretta et al., 2010). Inshore/offshore movements off Southern California have been reported, with individuals remaining inshore in fall and moving offshore in the late spring (Houck and Jefferson, 1999). The at-sea estimated density for Dall's porpoises is assumed to be 0.069206 individuals per km^2 in the affected area for SLC-4W and the Contingency Landing Location, and 0.055840 individuals per km^2 in the affected area for the Iridium Landing Area (U.S. Department of the Navy, 2016).

4.27 Harbor Porpoise (*Phocoena phocoena*)

In the Pacific Ocean, the Harbor Porpoise can be found from Point Conception, California, to Alaska and as far west as Kamchatka and Japan. Individuals found between Point Conception and the Russian River are treated as a separate stock, which is referred to as the Morro Bay Stock. Unlike its Atlantic counterpart, harbor porpoises in the Pacific are not panmictic or migratory (Carretta, et al., 2016). The maximum at-sea estimated density for harbor porpoises is assumed to be 0.9591 individuals per km^2 in the affected areas for SLC-4W and the Contingency Landing Location. The Iridium Landing Area is outside the species' known range (U.S. Department of the Navy, 2015).

4.28 Cuvier's Beaked Whale (*Ziphius cavirostris*)

Cuvier's beaked whale is the most commonly encountered beaked whale off the eastern North Pacific Coast. There are no apparent seasonal changes in distribution, and this species is found from Alaska to Baja California, Mexico (Carretta et al., 2010; Mead 1989; Pitman et al., 1988). However, Mitchell (1968) reported strandings from Alaska to Baja California to be most abundant between February and September. Repeated sightings of the same individuals have been reported off San Clemente Island in Southern California, which indicates some level of site fidelity (Falcone et al., 2009). The at-sea estimated density for Cuvier's beaked whales is assumed to be 0.001538 individuals per km^2 in the affected area for SLC-4W, 0.004687 individuals per km^2 in the affected areas for the Contingency Landing Location, and 0.019156 individuals per km^2 in the affected areas for the Iridium Landing Area (U.S. Department of the Navy, 2016).

4.29 Baird's Beaked Whale (*Berardius bairdii*)

The continental shelf margins from the California coast to 125° West (W) longitude were recently identified as key areas for beaked whales (MacLeod and D'Amico, 2006). Baird's beaked whale is found mainly north of 28° N in the eastern Pacific (Kasuya and Miyashita, 1997; Reeves et al., 2003). Along the West Coast, Baird's beaked whales are seen primarily along the continental slope, from late spring to early fall (Carretta et al., 2010; Green et al., 1992). Baird's beaked whales are sighted less frequently and are presumed to be farther offshore during the colder water months of November through April (Carretta et al., 2010). The at-sea estimated density for Baird's beaked whales is assumed to be 0.000381 individuals per km^2 in the affected area for SLC-4W, and 0.001825 individuals per km^2 in the affected area for the Contingency Landing Location, and 0.012094 individuals per km^2 in the affected area for the Iridium Landing Area (U.S. Department of the Navy, 2016).

4.30 Mesoplodont Beaked Whales (*Mesoplodon spp.*)

The following six Mesoplodont species are known to occur in the region: Blainville's beaked whale (*M. densirostris*), Perrin's beaked whale (*M. perrini*), Lesser beaked whale (*M. peruvianus*), Stejneger's beaked whale (*M. stejnegeri*), Gingko-toothed beaked whale (*M. gingkodens*), and Hubbs' beaked whale (*M. carlhubbsi*). These species are distributed throughout deep waters and along the continental slope in the region. The at-sea estimated density for Cuvier's beaked whales is assumed to be 0.001538 individuals per km^2 in the affected area for SLC-4W, 0.004687 individuals per km^2 in the affected areas for the Contingency Landing Location, and 0.019156 individuals per km^2 in the affected areas for the Iridium Landing Area (U.S. Department of the Navy, 2016).

5 Type of Incidental Taking Authorization Requested

In this Application, SpaceX requests an IHA for the take of marine mammals incidental to the boost-back and landing of the Falcon 9 First Stage at SLC-4W and within the contingency landing locations described in Sections 1 and 2 for one year following the date of issuance. The term "take," as defined in Section 3 of the MMPA, means "to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal" (16 U.S.C. § 1362[13]). "Harassment" was further defined in the 1994 amendments to the MMPA, which provided two levels of "harassment," Level A (potential injury) and Level B (potential disturbance).

Under the MMPA, the 30th Space Wing at VAFB was issued a 5-year LOA to take, by Level B harassment only, Pacific harbor seals, California sea lions, northern elephant seals, Steller sea lions, and northern fur seals incidental to launches, aircraft and helicopter operations, and harbor activities related to vehicles from VAFB from 26 March 2014 to 26 March 2019 (NOAA Fisheries, 2014). This LOA authorizes Level B harassment to these species resulting from sonic boom and engine noise generated during the launch of the Falcon 9 First Stage at SLC-4E (M. DeAngelis, NOAA Fisheries, pers. comm.).

SpaceX received an IHA for the take, Level B harassment only, of a small number of marine mammals incidental to the Falcon 9 First Stage recovery activities in California and the Pacific Ocean. This IHA is valid from June 30, 2016 through June 29, 2017. SpaceX notified NOAA Fisheries of the propose use of the Iridium Landing Area for recovery activities in August 2016, who concurred that a take of marine mammals would not likely occur from this change and a revision to the IHA was not warranted at that time.

The Incidental Take Authorization requested herein is for the authorization of Level B harassment to marine mammals protected under the MMPA that are identified in Chapter 6 as a result of boost-back and landing at SLC-4W on VAFB and boost-back and contingency landing on a barge 27 nm (50 km) offshore of VAFB. A boost-back and landing on a barge within the Iridium Landing Area would not result in an incidental take of a marine mammal.

The specific activities outlined in Section 1 that are analyzed in Section 6 for potential impacts to marine mammals are listed below with associated stressors that were considered.

1) Boost-back and landing of the Falcon 9 First Stage at SLC-4W.
   a. Sonic boom (in-air impulsive noise).
   b. Landing noise (in-air non-pulse noise) and visual stimuli.

2) Boost-back and landing of the Falcon 9 First Stage on a barge at the contingency landing location 27 nm (50 km) offshore
   a. Sonic boom (in-air impulsive noise).
   b. Landing noise (in-air non-pulse noise) and visual stimuli.

Of these, the following stressors were determined to have discountable or no effect on one or both marine mammal groups (see Section 6):

1) Boost-back and landing of the Falcon 9 First Stage at SLC-4W
   a. Sonic boom (in-air impulsive noise) – no effect on cetaceans
   b. Landing noise (in-air non-pulse noise) and visual stimuli – no effect on cetaceans or pinnipeds

2) Boost-back and landing of the Falcon 9 First Stage on a barge at the contingency landing location 27 nm (50 km) offshore.
   a. Sonic boom (in-air impulsive noise) – no effect on cetaceans or pinnipeds
   b. Landing noise (in-air non-pulse noise) and visual stimuli – no effect on cetaceans or pinnipeds.
   c. Vessel noise (in-water non-pulse noise) – no effect on pinnipeds or cetaceans

Therefore, SpaceX requests the issuance of an IHA pursuant to Section 101(a)(5) of the MMPA for incidental take of six pinniped species listed in Section 4 by Level B harassment during the boost-back and landing of the Falcon 9 First Stage during a one-year period from date of issuance for the following. Note that all potential stressors are determined to have no effect or a discountable effect on cetaceans):

1) Boost-back and landing of the Falcon 9 First Stage at SLC-4W
   a. Sonic boom (in-air impulsive noise) – may cause behavioral disturbance (Level B harassment) to six pinniped species listed in Section 4.

Note that all potential stressors are determined to have no effect or a discountable effect on cetaceans. In addition, the boost-back and landing of the Falcon 9 at any of the identified contingency landing locations would have no effect or a discountable effect on pinnipeds.

6 Take Estimates for Marine Mammals

There are 35 marine mammal species known to exist in the study area, as presented in Table 3-1. The methods for estimating the number of takes for each activity and associated stressors are described in the sections below.

6.1 Acoustic Impact Thresholds

NOAA Fisheries developed interim sound threshold guidance for received sound pressure levels from broadband sound that may cause behavioral disturbance and injury in the context of the MMPA (NOAA Fisheries, 2015). Table 6-1 provides thresholds for temporary threshold shifts (TTS; Level B Harassment) for pinnipeds based on this interim guidance. These thresholds were used to determine the potential geographic area where in-air acoustic impacts to pinnipeds from the boost-back and landing actions would be possible. Currently, there is no guidance for a permanent threshold shift (PTS; Level A Harassment) from in-air sound for marine mammals.

Table 6-1. NOAA Fisheries Interim Sound Threshold Guidance

Criterion	Criterion Definition	Threshold
In-Air Acoustic Thresholds		
Level A	PTS (injury) conservatively based on TTS	None established
Level B	Behavioral disruption for harbor seals	90 dB_{rms}
Level B	Behavioral disruption for non-harbor seal pinnipeds	100 dB_{rms}

Source: NOAA Fisheries, 2015

Notes: PTS = permanent threshold shift in hearing sensitivity (i.e., loss of hearing); TTS = temporary threshold shift in hearing sensitivity (behavioral disruption); dB_{rms} = root mean square value of decibels, obtained by squaring the amplitude at each instant, obtaining the average of the squared values over the interval of interest, and then taking the square root of this average

NOAA Fisheries (2016) provided final guidance for underwater thresholds in July 2016. This guidance groups cetaceans into low-frequency cetaceans, mid-frequency cetaceans, and high frequency cetaceans and pinnipeds into phocid and otariid (Table 6-2). These thresholds are provided in

Table 6-3.

Table 6-2. Marine Mammal Hearing Groups

Hearing Group	Generalized Hearing Range
Low-frequency (LF) cetaceans (baleen whales)	7 Hz to 35 kHz
Mid-frequency (MF) cetaceans (dolphins, toothed whales, beaked whales, bottlenose whales)	150 Hz to 160 kHz
High-frequency (HF) cetaceans (true porpoises, Kogia, river dolphins, *cephalorhynchid, Lagenorhynchus cruciger and L. australis*)	275 Hz to 160 kHz
Phocid pinnipeds (PW) (underwater) (true seals)	50 Hz to 86 kHz
Otariid pinnipeds (OW) (underwater) (sea lions and fur seals)	60 Hz to 39 kHz

Source: NOAA Fisheries, 2016

Table 6-3. Disturbance Thresholds for Underwater Impulsive and Non-Impulsive Noise

Group	Hearing Threshold	Non-impulsive		Impulse			
		TTS (threshold)	PTS (threshold)	TTS (threshold)		PTS (threshold)	
	SPL	SEL (weighted)	SEL (weighted)	SEL (weighted)	Peak SPL (unweighted)	SEL (weighted)	Peak SPL (unweighted)
LF	54 dB	179 dB	199 dB	168 dB	213 dB	183 dB	219 dB
MF	54 dB	178 dB	198 dB	170 dB	224 dB	185 dB	230 dB
HF	48 dB	153 dB	173 dB	140 dB	196 dB	155 dB	202 dB
OW	67 dB	199 dB	219 dB	188 dB	226 dB	203 dB	232 dB
PW	53 dB	181 dB	201 dB	170 dB	212 dB	185 dB	218 dB

Sources: NOAA Fisheries (2016); Finneran (2016)
Notes: SEL = sound exposure level, SPL = sound pressure level, TTS = temporary threshold shift, PTS = permanent threshold shift, dB = decibel(s), LF = low frequency, MF = mid-frequency, HF = high frequency, OW = Otariid pinnipeds, PW = phocid pinnipeds

After estimating the geographic areas of potential impact for each acoustic stressor, marine mammal density data (U.S. Department of the Navy, 2016), haulout data (ManTech SRS Technologies, Inc., 2014, 2015; VAFB, unpubl. data; M. Lowry, NOAA Fisheries, unpubl. data), and stock assessments (Carretta et al., 2015) were used to estimate the potential number of exposures for each species. In a conservative manner, the highest values were used for each marine species (see species descriptions in Section 4) when estimating potential impacts. Below, each potential acoustic stressor is analyzed for potential impacts to marine mammals and, where take is predicted, take estimates are presented for each species under the associated acoustic stressor.

6.2 In-Air Acoustic Impacts

Cetaceans spend their entire lives in the water and spend most of their time (>90 percent for most species) entirely submerged below the surface. Additionally, when at the surface, cetacean bodies are almost entirely below the water's surface, with only the blowhole exposed to allow breathing. This minimizes in-air noise exposure, both natural and anthropogenic, essentially 100 percent of the time because their ears are nearly always below the water's surface. As a result, in-air noise caused by sonic boom and landing engine noise during landing would not have an effect on cetacean species.

Pinnipeds spend significant amounts of time out of the water during breeding, molting, and hauling out periods. In the water, pinnipeds spend varying amounts of time underwater. NOAA Fisheries does not currently believe that in-air noise is likely to result in behavioral harassment of animals at sea (J. Carduner, NOAA Fisheries, pers. comm.). The MMPA defines Level B harassment as any act of pursuit, torment or annoyance which has the potential to disturb a marine mammal stock in the wild by causing disruption of behavioral patterns, including but not limited to migration, breathing, nursing, breeding, feeding, or sheltering. NOAA Fisheries believes the potential for such disruption, from in-air noise, is extremely unlikely for animals that are at sea. As such, it is not necessary for SpaceX to seek MMPA authorization for the incidental take of marine mammals at sea as a result of in-air noise. The proposed action, however, would create in-air noise that may impact marine mammals that are hauled out and these potential impacts are analyzed below.

6.2.1 Sonic Boom

Sonic booms would disturb pinnipeds that may be at the surface in the area of exposure, depending on the strength of the overpressure. This impulsive in-air noise is expected to cause variable levels of disturbance to pinnipeds that may be hauled out within the area of exposure depending on the species exposed and the level of the sonic boom. The USAF has monitored pinnipeds during launch-related sonic booms on the Northern Channel Islands during numerous launches over the past two decades and determined that there are generally no significant behavioral disruptions caused to pinnipeds by sonic booms less than 1.0 psf (see Chapter 7 for further discussion). Furthermore, past pinniped monitoring of sonic booms on San Miguel Island by the USAF has shown that certain species, including northern elephant seal and northern fur seal tend not to respond or respond only mildly (e.g., head raise alert) to any sonic booms, whereas harbor seal, California sea lion, and Steller sea lion tend to be more reactive. Guadalupe fur seal also tends to be non-responsive to auditory stimuli (J. Harris, NOAA Fisheries, pers. comm.).

For a SLC-4W landing, haulouts are included from the areas of Point Arguello and Point Conception (Figure 2-2 and Figure 6-1). Only haulouts along northeastern San Miguel Island, northern and northwestern Santa Rosa Island, and northwestern Santa Cruz Island would experience overpressures greater than 1 psf during a boost-back and landing at SLC-4W (Figure 2-3, Figure 2-4, Figure 2-5, and Figure 6-2). For a contingency landing event, sonic booms are sufficiently offshore so that no haulouts would be exposed to a 1.0 psf or greater sonic boom (Figure 2-6 and Figure 2-7). In addition, a boost-back and landing event in the Iridium Landing Area would not overlap any marine mammal haulout areas (Figure 2-8). Therefore, landing at these areas would not result in any annual takes.

The annual take estimate assumes 12 landing events per year at either SLC-4W (

Table 6-4, page 45). Where sufficient data exists, SpaceX used the average number of individuals of each species from multiple count data for haulouts within the geographic area of potential impact to calculate take estimates. For California sea lion and northern elephant seal, the number of individuals hauled out at different times of the year can vary exponentially within the project area, depending on breeding behaviors and dispersal activity. Lowry (2017) was used to identify the maximum number of California sea lion, northern elephant seals, and Pacific harbor seals at haulouts that could be affected by a 1+ psf sonic boom in the North Channel Islands and Point Conception. These estimates are also consistent with VAFB's take estimates for sonic booms on the Northern Channel Islands that are caused by similar VAFB launch activities (VAFB, 2013).

SpaceX conservatively estimates that the entire population of California sea lions, harbor seals, northern elephant seals, steller sea lions, northern fur seals, and Guadalupe fur seals at or near VAFB and Point Conception would experience a behavioral disruption from a sonic boom of between 1 and 8.5 psf at SLC-4W. This estimate conservatively overestimates that all individual marine mammals are hauled out at the time of the sonic boom. Haulout areas within the North Channel Island would receive a sonic boom between 1 and 3.1 psf. SpaceX conservatively estimates that 5 percent of northern elephant seals, northern fur seals, and Guadalupe fur seals and 100 percent of California sea lions, harbor seals, and steller sea lions would have a behavioral reaction to a sonic boom of this magnitude on the North Channel Islands.

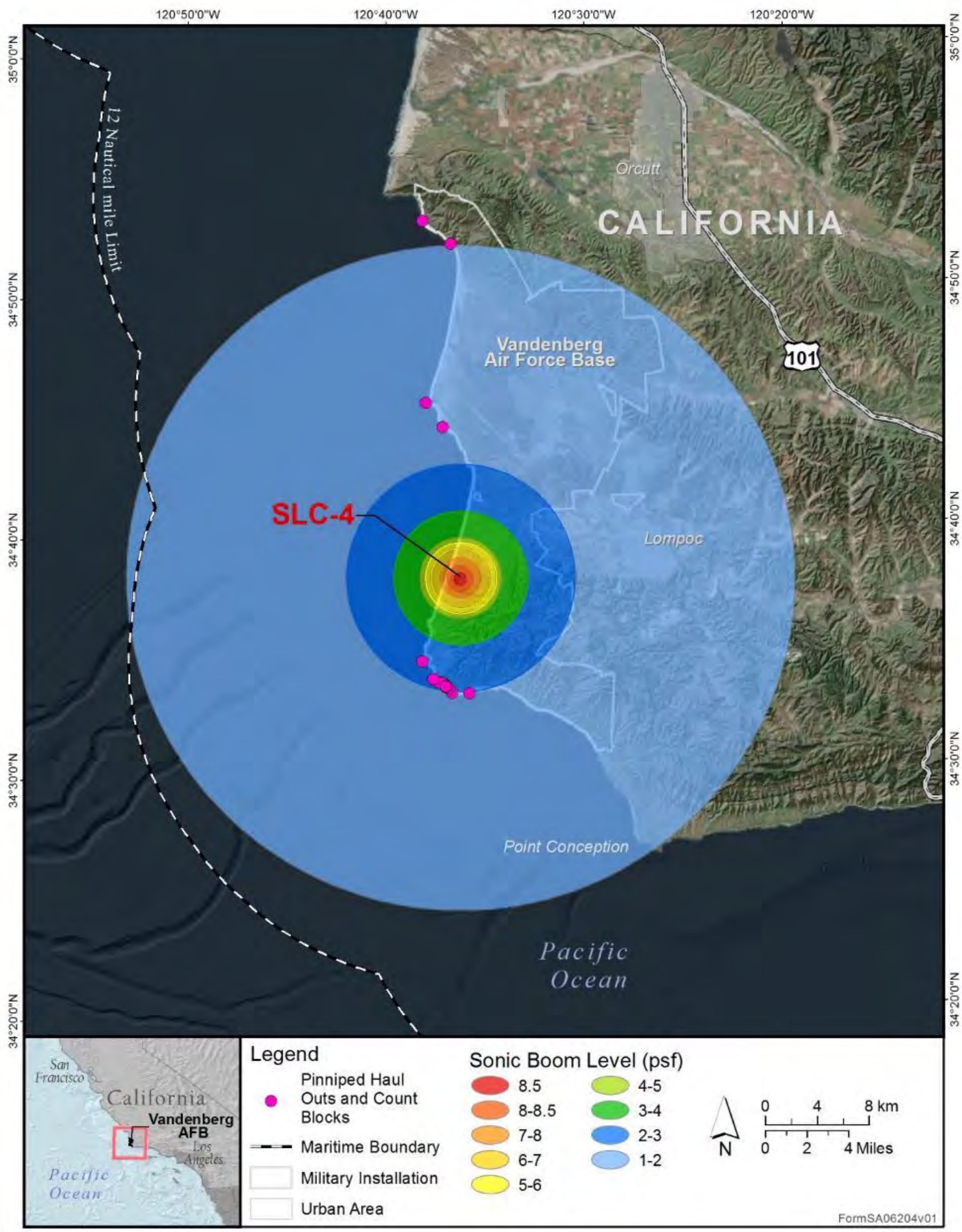


Figure 6-1. Marine Mammal Haulouts at VAFB

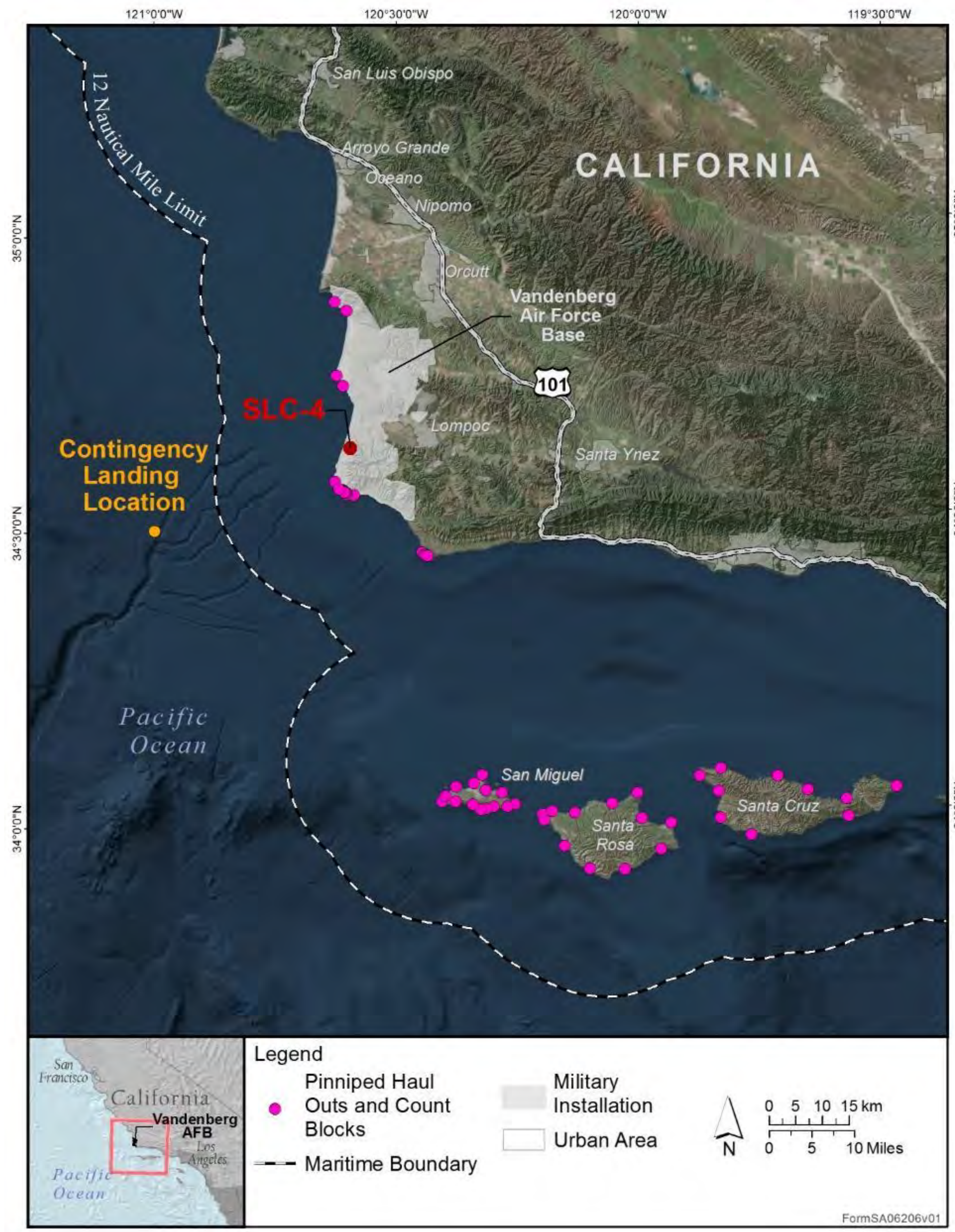


Figure 6-2. Marine Mammal Haulouts at North Channel Islands

Table 6-4. SLC-4W landing – Level B harassment take estimates per year (twelve events)

Species	Geographic Location	Estimated # of Marine Mammals at Haulouts in 1.0+ psf Area	Estimated # Individuals in 1.0+ psf Exposure Area per Event	Level B Harassment: Estimated # Individuals in 1.0+ psf Exposure Area per Year ^
Pacific Harbor Seal	VAFB[a]	366	1,384	16,608
	Pt. Conception[b]	516		
	San Miguel Island[b]	310		
	Santa Rosa Island[b]	192		
	Santa Cruz Island[b]	0		
California Sea Lion	VAFB[a]	416	4,561	54,732
	Pt. Conception	N/A		
	San Miguel Island[b]	2,134		
	Santa Rosa Island[b]	1,200		
	Santa Cruz Island[b]	811		
Northern Elephant Seal	VAFB[a]	190	227	2,724
	Pt. Conception[b]	11		
	San Miguel Island[b]	18*		
	Santa Rosa Island[b]	8*		
	Santa Cruz Island[b]	0		
Steller Sea Lion	VAFB[a]	16	20	240
	Pt. Conception	N/A		
	San Miguel Island	4		
	Santa Rosa Island	N/A		
	Santa Cruz Island	N/A		
Northern Fur Seal	VAFB	N/A	250	3,000
	Pt. Conception	N/A		
	San Miguel Island[c]	250*		
	Santa Rosa Island	N/A		
	Santa Cruz Island	N/A		
Guadalupe Fur Seal	VAFB	N/A	1	12
	Pt. Conception	N/A		
	San Miguel Island[e]	13*		
	Santa Rosa Island	N/A		
	Santa Cruz Island	N/A		

[a] VAFB monthly marine mammal survey data 2013-2015 (ManTech SRS Technologies, Inc., 2014, 2015; USAF, 2017).
[b] Lowry (2017b).
[c] Testa (2013); USAF (2013); pers. comm., T. Orr, NMFS NMML, to J. Carduner, NMFS, Feb 27, 2016.
[d] NOAA Fisheries aerial survey data February 2010 (M. Lowry, NOAA Fisheries, unpubl. data).
[e] DeLong and Melin (2000); J. Harris, NOAA Fisheries, pers. comm.
^ Based on twelve SLC-4W landing events per year.
*5 percent of animals exposed to sonic booms above 1.0 psf are assumed to experience Level B exposure.

6.2.2 Landing Noise

The Falcon 9 First Stage would generate non-pulse engine noise up to 110 dB re 20 uPa while landing on the landing pad or barge. This landing noise event would be of short duration (approximately 17 seconds). Although, during a landing event at SLC-4W, landing noises between 70 and 90 dB would overlap pinniped haulout areas at and near Point Arguello and Purisima Point, no pinniped haulouts would experience landing noises of 90 dB or greater (Figure 2-10, Figure

2-11, and

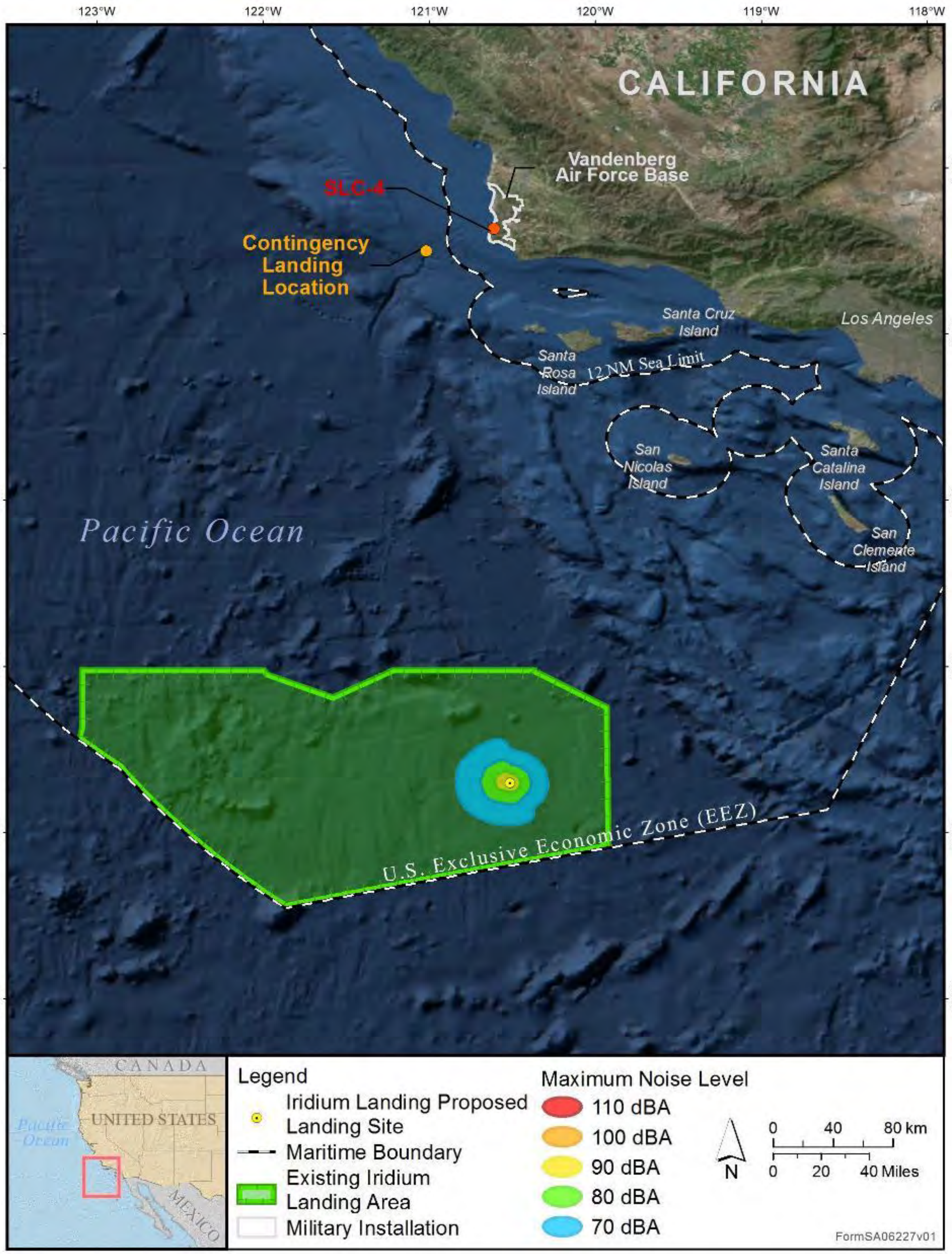


Figure 2-12).

In addition, the trajectory of the return flight includes a nearly vertical descent (Figure 1-7 and Figure 1-8), as such, there would be no significant visual disturbance to marine mammals. The First Stage would either be shielded by coastal bluffs or too far away to cause significant stimuli to marine mammals. Therefore, landing noise and visual disturbance associated with the Falcon 9 First Stage boost-back would not result in Level B harassment of marine mammals.

7 Anticipated Impact of the Activity

The activities and associated stressors analyzed in Section 6 that were determined to have no effect or a discountable effect on marine mammals are not carried forward. Below is a discussion of the biological context and consequences of the in-air sonic boom on hauled out pinnipeds, identified in Section 6 as the only stressor that may result in Level B harassment to pinnipeds.

7.1 Sonic Boom

Pinnipeds would be taken only by incidental Level B harassment from noise or visual disturbances associated with the boost-back and landing of the Falcon 9 First Stage. Reactions of pinnipeds to sonic booms range from no response to heads-up alerts, from startle responses to some movements on land, and from some movements into the water to occasional stampedes, especially involving California sea lions at the Northern Channel Islands. Sonic booms generated during the return flight of the Falcon 9 First Stage may elicit an alerting, avoidance, or other short-term behavioral reaction, including diving or fleeing to the water if hauled out. The number of individuals impacted are based on conservative estimates of the size of the exposure areas and the numbers of individuals that would be exposed and react to a sonic boom over 1.0 psf. In reality, the density for each pinniped species would fluctuate throughout the year and not be uniform throughout the exposure area. As a result, a realistic number of individuals exposed to sonic boom is likely to be less than the densities assumed herein for some or all of the events.

In addition, behavioral reactions to noise can depend on relevance and association to other stimuli. A behavioral decision is made when an animal detects increased background noise, or possibly, when an animal recognizes a biologically relevant sound. An animal's past experience with the sound-producing activity or similar acoustic stimuli can affect its choice of behavior. Competing and reinforcing stimuli may also affect its decision. Other stimuli present in the environment can influence an animal's behavior decision. These stimuli can be other acoustic stimuli not directly related to the sound-producing activity; they can be visual, olfactory, or tactile stimuli; the stimuli can be conspecifics or predators in the area; or the stimuli can be the strong drive to engage in a natural behavior.

Competing stimuli tend to suppress behavioral reactions. For example, an animal involved in mating or foraging may not react with the same degree of severity to acoustic stimuli as it may have otherwise. Reinforcing stimuli reinforce the behavioral reaction caused by acoustic stimuli. For example, awareness of a predator in the area coupled with the acoustic stimuli may illicit a stronger reaction than the acoustic stimuli itself otherwise would have. The visual stimulus of the Falcon 9 First Stage would not be coupled with the sonic boom, since the First Stage will be at significant altitude when the overpressure is produced. This would decrease the likelihood and severity of a behavioral response. It is difficult to separate the stimulus of the sound from the stimulus of source creating the sound. The sound may act as a cue, or as one stimulus of many that the animal is considering when deciding how to react.

In addition, data from launch monitoring by the USAF on the Northern Channel Islands has shown that pinniped's reaction to sonic booms is correlated to the level of the sonic boom. Low energy sonic booms (< 1.0 psf) have resulted in little to no behavioral responses, including head raising and briefly alerting but returning to normal behavior shortly after the stimulus. Sonic booms that are more powerful have flushed animals from haulouts but not resulted in any mortality or sustained decreased in numbers after the stimulus.

Table 7-1 presents a summary of monitoring efforts on from 1999 to 2011. The associated reports have been previously submitted to NOAA Fisheries but are available upon request. These data show that reactions to sonic booms tend to be insignificant below 1.0 psf, and that even above 1.0 psf, only a portion of the animals present react to a sonic boom. Reactions between species are also different, as harbor seals and California sea lions tend to be more sensitive to disturbance than northern elephant seals.

Table 7-1. Summary of Responses of Pinnipeds on San Miguel Island to Sonic Booms Resulting from VAFB Launches

Launch Event	**Sonic Boom Level (psf)**	**Species and Associated Reaction**
Athena II (27 April 1999)	1.0	*Z. californianus* – 866 alerted; 232 flushed into water *M. angustirostris* and *C. ursinus* – alerted but did not flush
Athena II (24 September 1999)	0.95	*Z. californianus* – 600 alerted; 12 flushed into water *M. angustirostris* and *C. ursinus* – alerted but did not flush
Delta II 20 (November 2000)	0.4	*Z. californianus* – 60 flushed into water; no reaction from rest *M. angustirostris* – no reaction
Atlas II (8 September 2001)	0.75	*Z. californianus* and *M. angustirostris* – no reaction *P. vitulina* – 2 of 4 flushed into water
Delta II (11 February 2002)	0.64	*Z. californianus, C. ursinus,* and M. *angustirostris* – no reaction
Atlas II (2 December 2003)	0.88	*Z. californianus* – 40 percent alerted; several flushed to water *M. angustirostris* – no reaction
Delta II (15 July 2004)	1.34	*Z. californianus* – 10 percent alerted
Atlas V (13 March 2008)	1.24	*M. angustirostris* – no reaction
Delta II (5 May 2009)	0.76	*Z. californianus* – no reaction
Atlas V (14 April 2011)	1.01	*M. angustirostris* – no reaction
Atlas V (3 April 2014)	0.74	*P. vitulina* – 1 of ~25 flushed into water; no reaction from rest
Atlas V (12 December 2014)	1.16	*Z. californianus* – 5 of ~225 alerted; none flushed

With the conservative estimates for density and the assumption that all animals present would be exposed to and react to the sonic boom, the number of individuals estimated to experience behavioral disruption resulting from sonic boom would likely be even lower than the estimated values shown in

Table 6-4. Additionally, the sonic boom events would be infrequent (up to twelve times annually) and therefore unlikely to result in any permanent avoidance of the area. Finally, since the sonic boom is decoupled from biologically relevant stimuli there would likely be less reaction, or no reaction, to the sonic boom, depending on intensity.

8 Impacts on Subsistence Use

Potential impacts resulting from the Proposed Action would be limited to individuals of marine mammal species located in areas that have no subsistence requirements. Therefore, no impacts on the availability of species or stocks for subsistence use are considered.

9 Anticipated Impacts on Habitat

The Proposed Action would not result in in-water acoustic sound that would cause significant injury or mortality to prey species and would not create barriers to movement of marine mammals or prey. Behavioral disturbance caused by in-air acoustic impacts may result in marine mammals temporarily moving away from or avoiding the exposure area but are not expected to have long term impacts, as supported by over two decades of launch monitoring studies on the Northern Channel Islands by the U.S. Air Force (MMCG and SAIC, 2012).

10 Anticipated Effect of Habitat Impacts on Marine Mammals

Since the acoustic impacts associated with the boost-back and landing of the Falcon 9 First Stage are of short duration and infrequent (up to twelve events annually), the associated behavioral responses in marine mammals are expected to be temporary. Therefore, the Proposed Action is unlikely to result in long term or permanent avoidance of the exposure areas or loss of habitat, as supported by over two decades of launch monitoring studies on the Northern Channel Islands by the USAF (MMCG and SAIC, 2012).

11 Mitigation Measures

It would not be feasible to stop or divert an inbound First Stage booster if a marine mammal was identified within the exposure area of one of the activities, and thereby attempt to avoid impact. Once the boost-back and landing sequence is underway, there would be no way to change the trajectory to avoid impacts to marine mammals. Thus, SpaceX does not propose any mitigation measures associated with the boost-back and landing of the Falcon 9 First Stage. However, SpaceX would continue to implement the following mitigation measure:

(a) Unless constrained by other factors including human safety or national security concerns, launches would be scheduled to avoid, whenever possible, boost-backs and landings during the harbor seal pupping season of March through June.

12 Arctic Subsistence Plan of Cooperation

Potential impacts resulting from the Proposed Action would be limited to individuals of marine mammal species located in areas that have no subsistence requirements. Therefore, an arctic subsistence plan of cooperation is not applicable.

13 Monitoring and Reporting

Implementation of the monitoring measures outlined below would allow SpaceX to better quantify the characteristics of the various stressors analyzed here and document impacts to marine mammals as a result of the Proposed Action. Implementation of all measures would be overseen by qualified SpaceX personnel or contractor staff. The following measures would be implemented to monitor potential impacts to offshore marine mammals and the offshore marine environment:

13.1 Sonic Boom Modeling

Sonic boom modeling would be performed prior to all boost-back events. PCBoom, a commercially available modeling program, or an acceptable substitute, would be used to model sonic booms. Launch parameters specific to each launch would be incorporated into each model. These include direction and trajectory, weight, length, engine thrust, engine plume drag, position versus time from initiating boost-back to additional engine burns, among other aspects. Various weather scenarios would be analyzed from NOAA weather records for the region, then run through the model. Among other factors, these would include the presence or absence of the jet stream, and if present, its direction, altitude and velocity. The type, altitude, and density of clouds would also be considered. From these data, the models would predict peak amplitudes and impact locations.

13.2 Pinniped Monitoring

(a) SpaceX would 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;

(b) To conduct monitoring of Falcon 9 First Stage recovery activities, SpaceX would designate qualified, on-site individuals approved in advance by NMFS;

(c) Should model results indicate that a peak overpressure of 1 psf or greater is likely to impact VAFB, then acoustic and biological monitoring at VAFB would be implemented;

(d) If sonic boom model results indicate that a peak overpressure of 1.0 psf or greater is predicted to impact the Channel Islands between March 1 and June 30, greater than 1.5 psf between July 1 and September 30, and greater than 2.0 psf between October 1 and February 28, monitoring of haulout sites on the Channel Islands would be implemented. Monitoring would be conducted at the haulout site closest to the predicted sonic boom impact area;

(e) Monitoring would be conducted at the haulout site closest to the predicted sonic boom impact area. Monitoring locations would be selected based on what species have pups at the haul outs and which of those would be the most reactive. Predictions of the areas likely to receive the greatest sonic boom and the current haulout locations and distribution of pinniped species as well as the geography, wind exposure, and accessibility of a location would be considered when selecting monitoring locations. Rookeries are highly preferred if accessible;

(f) Monitoring would be conducted for at least 72 hours prior to any planned Falcon 9 First Stage recovery and continue until at least 48 hours after the event;

(g) Monitors would conduct hourly counts for 6 hours per day centered around the scheduled launch time to the extent possible. The monitors would be at the monitoring location continuously for 6 hours per day and would take a count every hour during this period;

(h) For daytime events, counts would be centered around the launch time so there are observations for 2-3 hours before and after the event. For nighttime events, counts would be conducted from daybreak to 6 hours after daybreak and observers would go to the monitoring location approximately one hour before launch to set up recording equipment and record the boom. The monitors would observe pinniped reactions with night vision binoculars to the best extent possible. Monitors would remain at the location until pinniped behavior is observed to return to normal.

(i) New northern elephant seal pupping location(s) at VAFB would be prioritized for monitoring when landings occur at SLC-4W during northern elephant seal pupping season (January through February) when practicable;

(j) For launches during the harbor seal pupping season (March through June), follow-up surveys would be conducted within 2 weeks of the Falcon 9 First Stage recovery to monitor for any long-term adverse effects on marine mammals;

(k) If Falcon 9 First Stage recovery is scheduled during daylight, time-lapse photography or video recording would be used to document the behavior of marine mammals during Falcon 9 First Stage recovery activities;

(l) Monitoring would include multiple surveys each day that record the species, number of animals, general behavior, presence of pups, age class, gender and reaction to noise associated with Falcon 9 First Stage recovery, sonic booms or other natural or human caused disturbances, in addition to recording environmental conditions such as tide, wind speed, air temperature, and swell; and

(m) Acoustic measurements of the sonic boom created during boost-back at the monitoring location would be recorded to determine the overpressure level.

(n) Monitors would use the "3-Point Scale" depicted in Figure 13-1 to assess whether harassment has occurred. Level 1 is not considered harassment, while Level 2 and 3 would be considered harassment.

Figure 13-1. National Marine Fisheries Service "3-Point Scale" for Harassment

Level	Type of Response	Definition
1	Alert	Seal head orientation or brief movement in response to disturbance, which may include turning head towards the disturbance, craning head and neck while holding the body rigid in a u-shaped position, changing from a lying to a sitting position, or brief movement of less than twice the animal's body length.
2	Movement	Movements away from the source of disturbance, ranging from short withdrawals at least twice the animal's body length to longer retreats over the beach, or if already moving a change of direction of greater than 90 degrees.
3	Flush	All retreats (flushes) to the water.

13.3 Reporting

(a) Submit a report to the Office of Protected Resources, NMFS, and the West Coast Regional Administrator, NMFS, within 60 days after each Falcon 9 First Stage recovery action. This report would contain the following information:

1. Date(s) and time(s) of the Falcon 9 First Stage recovery action;
2. Design of the monitoring program; and
3. Results of the monitoring program, including, but not necessarily limited to the following:
    a. Numbers of pinnipeds present on the haulout prior to the Falcon 9 First Stage recovery;
    b. Numbers of pinnipeds that may have been harassed as noted by the number of pinnipeds estimated to have moved more than one meter or entered the water as a result of Falcon 9 First Stage recovery activities;
    c. For pinnipeds estimated to have entered the water as a result of Falcon 9 First Stage recovery noise, the length of time pinnipeds remained off the haulout or rookery;
    d. Any other observed behavioral modifications by pinnipeds that were likely the result of Falcon 9 First Stage recovery activities, including sonic boom; and
    e. Results of acoustic monitoring including comparisons of modeled sonic booms with actual acoustic recordings of sonic booms.

(b) Submit an annual report on all monitoring conducted under the IHA. A draft of the annual report would be submitted within 90 calendar days of the expiration of the IHA, or, within 45 calendar days of the renewal of the IHA (if applicable). A final annual report would be prepared and submitted within 30 days following resolution of comments on the draft report from NMFS. The annual report would summarize the information from the 60-day post-activity reports, including but not necessarily limited to the following:

1. Date(s) and time(s) of the Falcon 9 First Stage recovery action;
2. Design of the monitoring program; and
3. Results of the monitoring program, including, but not necessarily limited to the requirements in section 13.3(a) of this application as well as
    a. Any cumulative impacts on marine mammals as a result of the activities, such as long term reductions in the number of pinnipeds at haulouts as a result of the activities.

(c) Reporting injured or dead marine mammals:

1. In the unanticipated event that the specified activity clearly causes the take of a marine mammal in a manner prohibited by this IHA (as determined by the lead marine mammal observer), such as an injury (Level A harassment), serious injury, or mortality, SpaceX would immediately cease the specified activities and report the incident to the Office of Protected Resources, NMFS, and the West Coast Regional Stranding Coordinator, NMFS. The report must include the following information:
    a. Time and date of the incident;
    b. Description of the incident;
    c. Status of all Falcon 9 First Stage recovery activities in the 48 hours preceding the incident;
    d. Description of all marine mammal observations in the 48 hours preceding the incident;

e. Environmental conditions (e.g., wind speed and direction, Beaufort sea state, cloud cover, and visibility);
f. Species identification or description of the animal(s) involved;
g. Fate of the animal(s); and
h. Photographs or video footage of the animal(s).

Activities would not resume until NMFS is able to review the circumstances of the prohibited take. NMFS would work with SpaceX to determine what measures are necessary to minimize the likelihood of further prohibited take and ensure MMPA compliance. SpaceX may not resume their activities until notified by NMFS via letter, email, or telephone.

2. In the event that SpaceX discovers an injured or dead marine mammal, and the lead observer determines that the cause of the injury or death is unknown and the death is relatively recent (e.g., in less than a moderate state of decomposition), SpaceX would immediately report the incident to the Office of Protected Resources, NMFS, and the West Coast Regional Stranding Coordinator, NMFS. The report would include the same information identified in section 13.3(a) of this application. Activities may continue while NMFS reviews the circumstances of the incident and makes a final determination on the cause of the reported injury or death. NMFS would work with SpaceX to determine whether additional mitigation measures or modifications to the activities are appropriate.

3. In the event that SpaceX discovers an injured or dead marine mammal, and the lead observer determines that the injury or death is not associated with or related to the activities authorized in the IHA (e.g., previously wounded animal, carcass with moderate to advanced decomposition, scavenger damage), SpaceX would report the incident to the Office of Protected Resources, NMFS, and the West Coast Regional Stranding Coordinator, NMFS, within 24 hours of the discovery. SpaceX would provide photographs or video footage or other documentation of the stranded animal sighting to NMFS. The cause of injury or death may be subject to review and a final determination by NMFS.

14 Suggested Means of Coordination

SpaceX would share biologically relevant data related to the potential stressors identified herein, including data collected on their acoustic characteristics in the field and observed impacts to marine mammal species as described in section 13 of this application.

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1 JANUARY 2016 TO 31 DECEMBER 2016

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