# 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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*Prepared for:*

Space Explorations Technologies Corporation
1 Rocket Road
Hawthorne, CA 920250

*Prepared by:*

ManTech SRS Technologies, Inc.
102 East Ocean Ave.
Lompoc, CA 93436

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# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| $^{o}C$ | degrees Celsius |
| $^{o}F$ | degrees Fahrenheit |
| COPV | Carbon Over Pressure Vessel |
| dB | decibel |
| $dB_{RMS}$ | root mean square value of decibel |
| E | East |
| EPM | Environmental Protection Measure |
| ESA | Endangered Species Act |
| FE | federally endangered |
| ft. | foot or feet |
| FT | federally threatened |
| FTS | Flight System Termination |
| km | kilometer |
| $km^2$ | square kilometer(s) |
| L | liter |
| $LC_{50}$ | lethal concentration level |
| lb. | pound(s) |
| LOA | Letter of Authorization |
| LOX | liquid oxygen |
| m | meter |
| MECO | Main Engine Cut Off |
| mg | milligram |
| $mi^2$ | square miles |
| MMPA | Marine Mammal Protection Act |
| MSRS | ManTech SRS Technologies, Inc. |
| NASA | National Aeronautics and Space Administration |
| NOAA Fisheries | National Oceanic and Atmospheric Administration, National Marine Fisheries Service |
| psf | pounds per square foot |
| PTS | permanent threshold shift |
| RMS | root mean squared |
| RP-1 | Rocket Propellant-1 |
| SLC | Space Launch Complex |
| SpaceX | Space Exploration Technologies Corporation |
| TTS | temporary threshold shift |
| U.S. | United States |
| U.S.C. | United States Code |
| USAF | United States Air Force |
| USFWS | United States Fish and Wildlife Service |
| VAFB | Vandenberg Air Force Base |
| W | west |

# 1 Description of Activity

## 1.1 Introduction

Space Exploration Technologies Corporation (SpaceX) is currently operating the Falcon Launch Vehicle Program at Space Launch Complex 4E (SLC-4E) on Vandenberg Air Force Base (VAFB). SpaceX proposes regular employment of first stage recovery (boost-back and landing) by returning the Falcon 9 First Stage to SLC-4 West (SLC-4W) at Vandenberg Air Force Base (VAFB) for potential reuse up to six times per year. The reuse of the Falcon 9 First Stage will enable SpaceX to efficiently conduct lower cost launch missions from VAFB in support of commercial and government clients.

VAFB occupies approximately 99,100 acres (ac.) (400 square kilometers [$km^2$]) of central Santa Barbara County, California (Figure 1-1), approximately halfway between San Diego and San Francisco. The Santa Ynez River and State Highway 246 divide VAFB into two distinct parts: North Base and South Base. SLC-4W is located on South Base, approximately 0.5 miles (0.8 kilometers [km]) inland from the Pacific Ocean (Figure 1-2). SLC-4E is the launch facility for the Falcon 9 program, which is located approximately 1,400 feet (ft.) (427 meters [m]) to the east of SLC-4W, the proposed landing site for the Falcon 9 First Stage (Figure 1-2, inset). Although SLC-4W is the preferred landing location, SpaceX has identified the need for a contingency landing action that would only be exercised if there were critical assets on South VAFB that would not permit an over-flight of the First Stage or other reasons (eg. fuel constraints) that would not permit landing at SLC-4W. The contingency action is to land the First Stage on a barge in the Pacific Ocean at a landing location 31 miles (50 km) offshore of VAFB (Figure 1-5).


**Figure 1-1.** Regional Location of VAFB

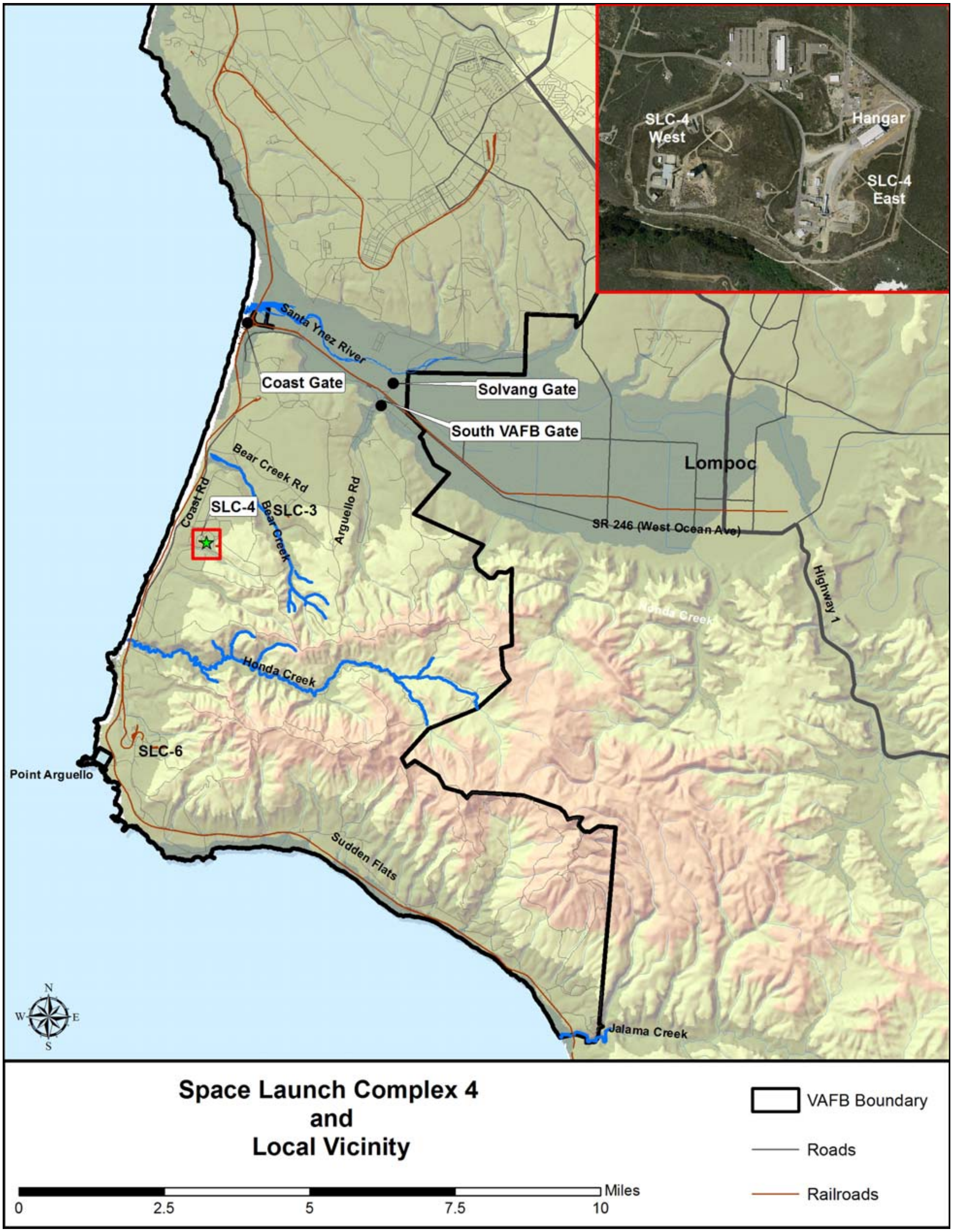


**Figure 1-2.** Proposed Project Area and Vicinity

## 1.2 Proposed Action

The Proposed Action includes (1) constructing a new concrete landing pad at SLC-4W and (2) the boost-back maneuver (in-air) and landing of the Falcon 9 First Stage on the new pad at SLC-4W. In addition, the Proposed Action includes a contingency action should landing on the pad at SLC-4W be infeasible during a launch: the boost-back and landing of the Falcon 9 First Stage on a barge specifically designed for the landing located at least 31 miles (50 km) offshore of VAFB. For this Incidental Harassment Authorization application, SpaceX determined that the boost-back and landing actions have the potential to rise to the level of harassment as defined under Marine Mammal Protection Act of 1972 (MMPA), as amended, and are therefore considered in this application. SpaceX would conduct up to six boost-back and landing events per year.

### 1.2.1 Falcon 9 Boost-back and Landing

SpaceX proposes to return the Falcon 9 First Stage booster to SLC-4W at VAFB for potential reuse. The Falcon 9 First Stage is 12 ft. in diameter and 160 ft. in height, including the interstage that would remain attached during landing. 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 1-3 provides a graphical depiction of the boost-back and landing sequence. Figure 1-4 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).

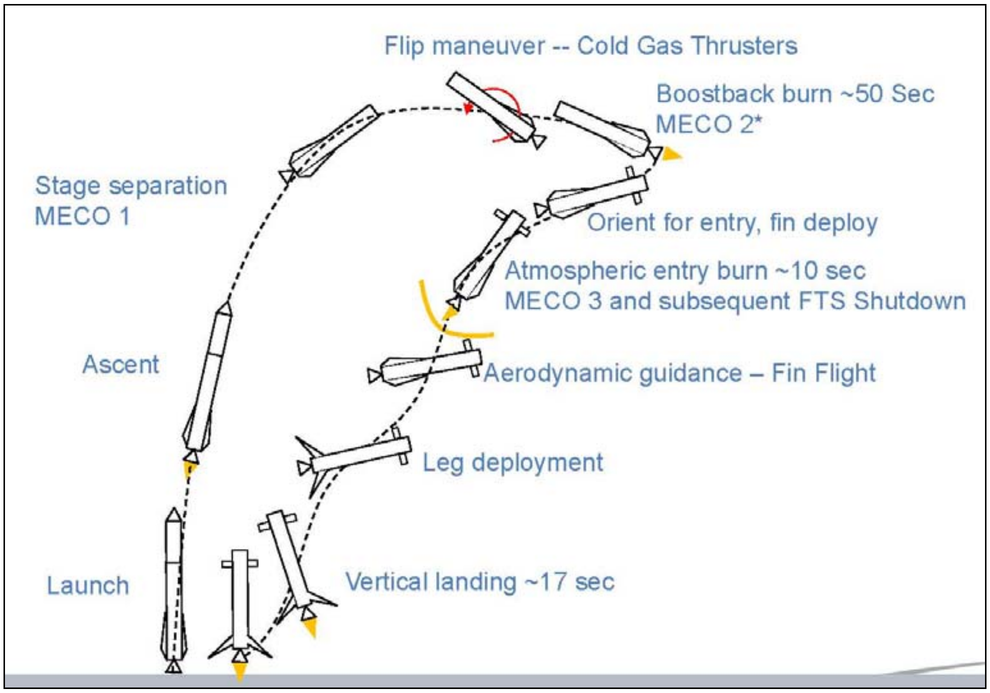


**Figure 1-3.** Stages of Boost-Back and Propulsive Landing (Notes: MECO = Main Engine Cut Off; FTS = Flight Termination System)

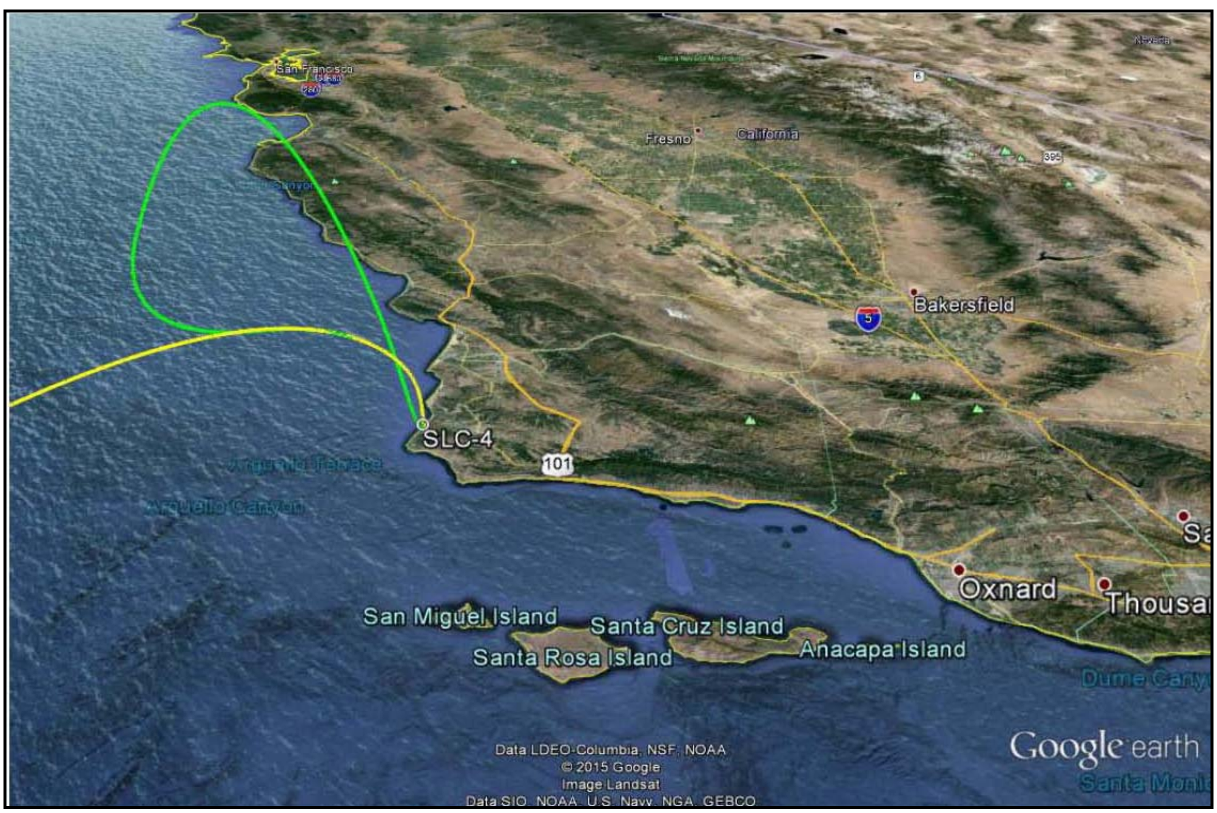


**Figure 1-4.** Trajectories for the First Stage Return Path (green line) and Second Stage Path (yellow line) of the Falcon 9 for a landing at SLC-4W on VAFB

### 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. The barge is specifically designed to be used as a First Stage landing platform and will be located at least 31 miles (50 km) off VAFB's shore (Figure 1-5). The contingency landing location would be used if conditions prevented a landing at SLC-4W.

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 miles 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. (Figure 1-6). 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.

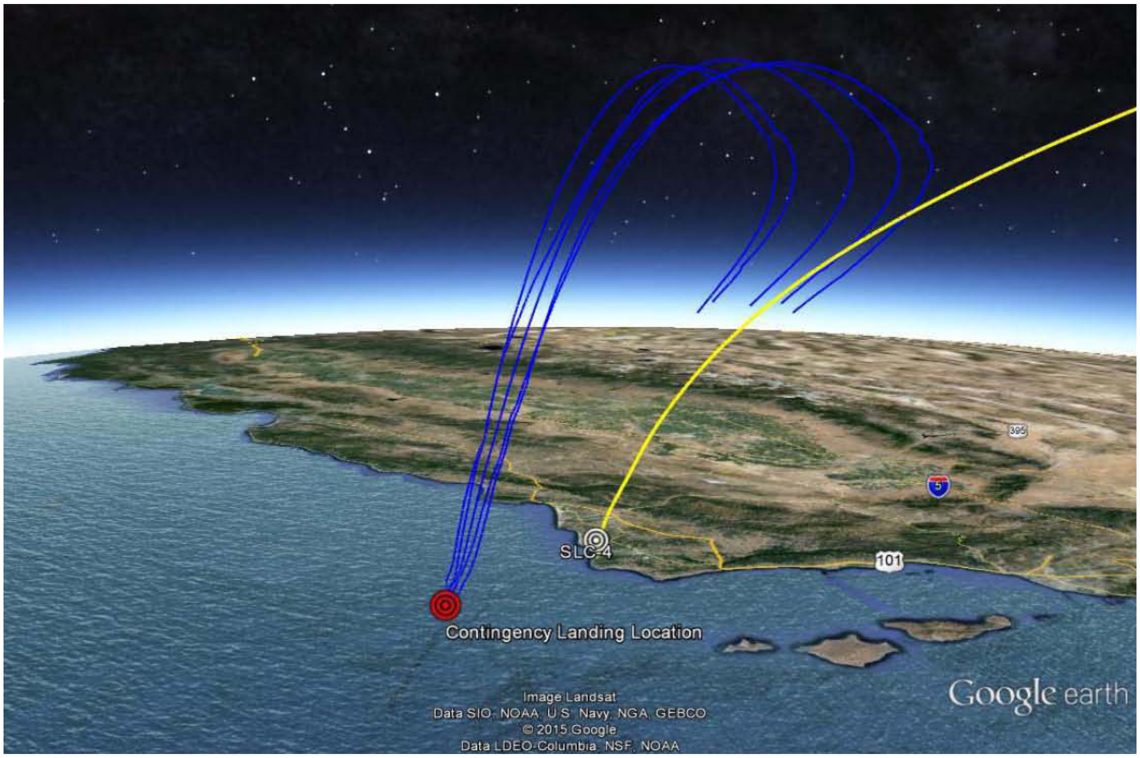


**Figure 1-5.** Trajectories for Variations of the Contingency First Stage Return Path to a Barge Landing Location 31 miles (50 km) off VAFB (blue lines) and Second Stage Path (yellow line)


**Figure 1-6**. Barge Landing Platform

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 will 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 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 and transport to a SpaceX testing facility in McGregor, Texas to complete acceptance testing again before re-flight. Once testing is completed, it 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 tow line for towing to Long Beach Harbor. |

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

### 1.2.2.2 In the Event of an Unsuccessful Barge Landing Attempt

SpaceX has twice attempted barge landings off Florida's coast (Figure 1-7). Both attempts were unsuccessful and resulted in the First Stage impacting the barge and exploding. A photograph of the barge after one of the unsuccessful landing attempts is shown in Figure 1-8. If a barge landing is unsuccessful, the First Stage would likely explode upon barge impact. The explosive equivalence of the First Stage with maximum fuel and oxidizer is 503 pounds of trinitrotoluene (TNT). This amount of TNT would be capable of generating a maximum projectile range of 1,250 ft. (381 m) from the point of impact.

SpaceX has experience performing recovery operations after unsuccessful Falcon 9 First Stage landing attempts. This experience, in addition to the debris catalog, indicates that after an unsuccessful barge landing approximately 25 pieces of debris will remain floating after. The surface area potentially impacted with debris would be less than 114 acres (0.46 $km^2$), and almost all floating debris would be recovered. All other debris would sink to the bottom of the ocean.

These 25 pieces of floating debris are primarily made up of Carbon Overwrapped Pressure Vessels (COPVs), the LOX fill line, and carbon fiber constructed landing legs. Following previous unsuccessful landing attempts SpaceX has successfully recovered all of these floating items. An unsuccessful barge landing off VAFB’s coast would result in a very small debris field, making recovery of debris relatively straightforward and efficient. All debris recovered offshore would be transported back to Long Beach Harbor.

**Figure 1-7**. Barge Landing Attempt

**Figure 1-8**. Barge Landing Platform after an Unsuccessful Landing Attempt

Upon impact with the landing barge, the First Stage would contain at most 400 gallons of Rocket Propellant-1 (RP-1), a highly refined form of kerosene, similar to jet fuel. If the landing is unsuccessful, most of this fuel would be consumed during the subsequent explosion; residual fuel (estimated to be between 50 and 150 gallons) would be released onto the barge deck at the impact location and may be released into the ocean. For analyses of potential impacts, it assumed that a maximum of 50 to 150 gallons of RP-1 would be released into the ocean. Final volumes of fuel remaining in the First Stage upon landing may vary but we anticipate they will be below this high range estimate.

Very light oils, including RP-1, are highly volatile, which means they evaporate quickly when exposed to the air, and are usually completely dissipated within 1–2 days after a spill. Following a spill of very light oil on water, clean-up is usually not possible, particularly with such a small quantity of oil (U.S. Fish and Wildlife Service 1998). Therefore, if any RP-1 is released directly into the ocean no attempt would be made to boom or recover RP-1. Any RP-1 remaining on the barge deck from an unsuccessful landing would be recovered, contained, and handled per federal, state, and local agency requirements.

# 2 Duration and Location of Activities

SpaceX would perform up to six 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 will likely explode, creating an impulsive in-air noise. These acoustic stressors, as well as other potential stressors during landing, will have different geographic regions of influence and are described below.

## 2.1 Sonic Boom

During descent when the First Stage is supersonic, a sonic boom (overpressure of high-energy impulsive sound) would be generated. During a landing event at SLC-4W, the sonic boom would be directed at the coastal area south of SLC-4 (Figure 2-1). Acoustic modeling was performed to estimate the area of expected impact and overpressure levels that would be created during the return flight of the Falcon 9 First Stage (Wyle, Inc. 2015). The boom footprint was computed using PCBoom (Plotkin and Grandi 2002; Page et al. 2010). The vehicle is a cylinder generally aligned with the velocity vector, descending engines first (Figure 1-3). It was modeled via PCBoom's drag-dominated blunt body mode (Tiegerman 1975), which has been validated for entry vehicles (Plotkin et al. 2006). Drag is determined by vehicle weight and the kinematics of the trajectory. Kinematics include the effect of the retro burn. The model results predict that sonic overpressures would reach up to 2.0 pounds per square foot (psf) in the immediate area around SLC-4 (Figures 2-1 and 2-2) and an overpressure between 1.0 and 2.0 psf would impact the coastline of VAFB from approximately 5 miles (8 km) north of SLC-4 to approximately 11 miles (18 km) southeast of SLC-4 (Figures 2-1 and 2-2). A significantly larger area, including the mainland, the Pacific Ocean, and the Northern Channel Islands would experience an overpressure between 0.1 and 1.0 psf (Figure 2-1). In addition, San Miguel Island and Santa Rosa Island may experience an overpressure up to 3.1 psf and the west end of Santa Cruz Island may experience an overpressure up to 1.0 psf (Figures 2-1 and 2-3).

During a contingency barge landing event, an overpressure would also be generated while the first-stage booster is supersonic. The overpressure would be directed at the ocean surface no less than 31 miles (50 km) off the coast of VAFB. The SLC-4W pad-based landing overpressure modeling was roughly extrapolated to show potential noise impacts for landing 31 miles (50 km) to the west of VAFB (Figure 2-4). An overpressure of up to 2.0 psf would impact the Pacific Ocean at the contingency landing location approximately 31 miles (50 km) offshore of VAFB. San Miguel Island and Santa Rosa Island would experience a sonic boom between 0.1 and 0.2 psf. Sonic boom overpressures on the mainland would be between 0.2 and 0.4 psf.

## 2.2 Landing Noise

A final engine burn, lasting approximately 17 seconds, would generate between 70 and 110 decibels (dB) of noise centered on SLC-4W, but affecting and area up to 14 miles (22.5 km) offshore of VAFB (Figure 2-5). Engine noise would also be produced during the barge landing of the Falcon 9 First Stage; similar to the sonic boom intensity estimation, the potential area of influence was estimated by extrapolating the landing noise profile from a SLC-4W landing (Figure 2-5). 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 14 miles (22.5 km) around the contingency landing location (Figure 2-6).

## 2.3 First Stage Explosion (Unsuccessful Barge Landing)

In the event of an unsuccessful barge landing, the First Stage will likely explode upon barge impact. The explosion would generate an in-air impulsive noise that would propagate in a radial fashion away from the barge. Based on the size of the anticipated explosion, Sadovsky equations were used to calculate peak received pressures (received levels are a function of charge weight and distance from source) at sound pressure contour lines. Since the sound pressure levels were peak levels, the approximate root mean squared (RMS) values were estimated by converting peak to RMS (peak pressure value * 0.707). Then, these values were converted into dB re 20 uPa to determine distances to defined contour levels and in-air threshold levels. To generate realistic sound pressure contour lines, atmospheric attenuation was included in the model. Calculations for atmospheric attenuation included the following assumptions: the explosion was assumed to be 250 hertz of less, relative humidity was assumed to be 30%, and air temperature was assumed to be 50 degrees Fahrenheit ($^{o}$F) (10 degrees Celcius [$^{o}$C]).

Figure 2-7 shows dB contours from the source level (180 dB) to 16.5 miles (26.5 km) at which point the blast wave would deteriorate to 90 dB. This model does not take into account additional factors that would attenuate the blast wave further, including: sea surface roughness, changes in atmospheric pressure, frontal systems, precipitation, clouds, and degradation when encountering other sound pressure waves. Thus, the area of exposure is conservatively overestimated.

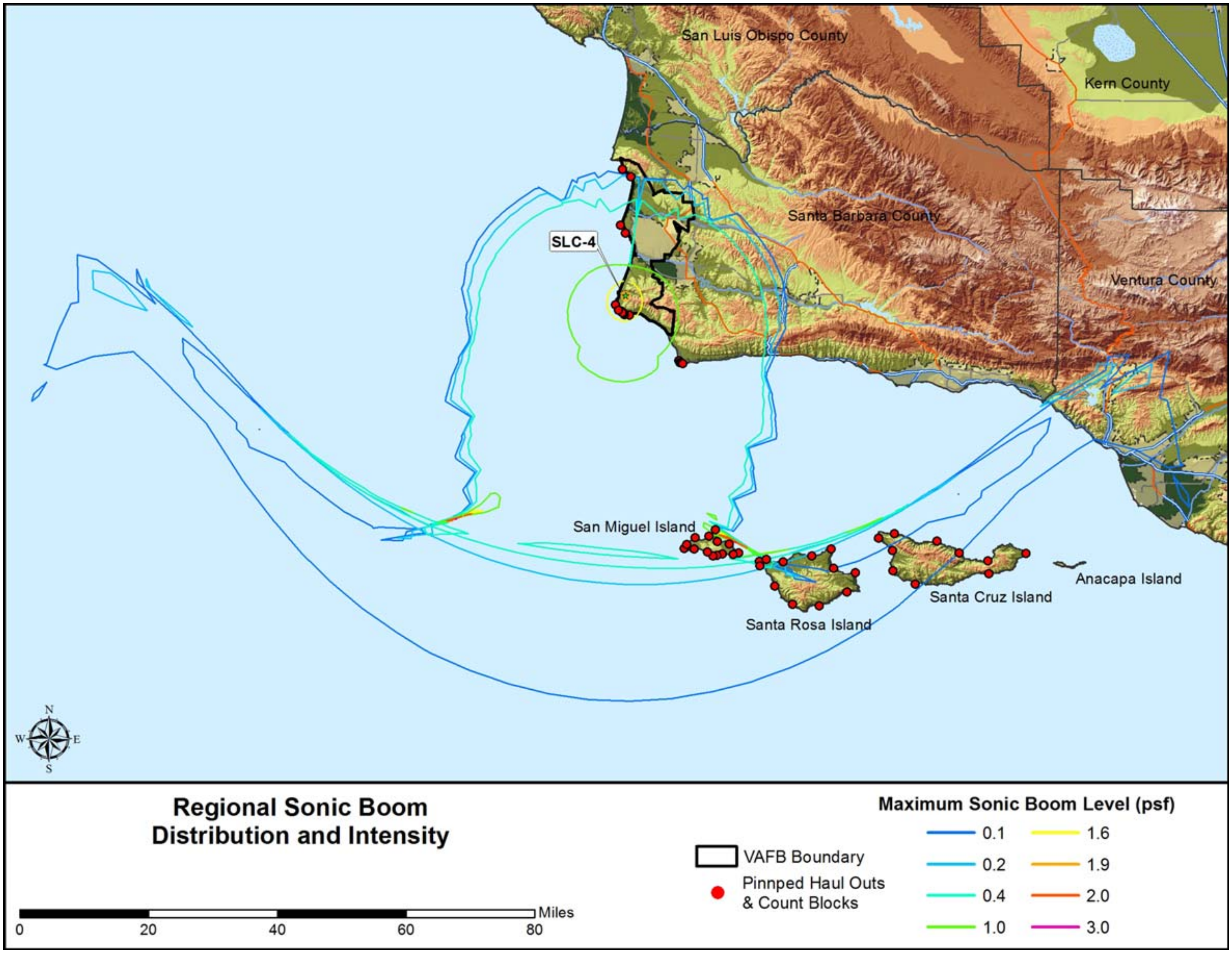


**Figure 2-1.** Regional Sonic Boom Distribution and Intensity for Pad Landing at SLC-4 on VAFB

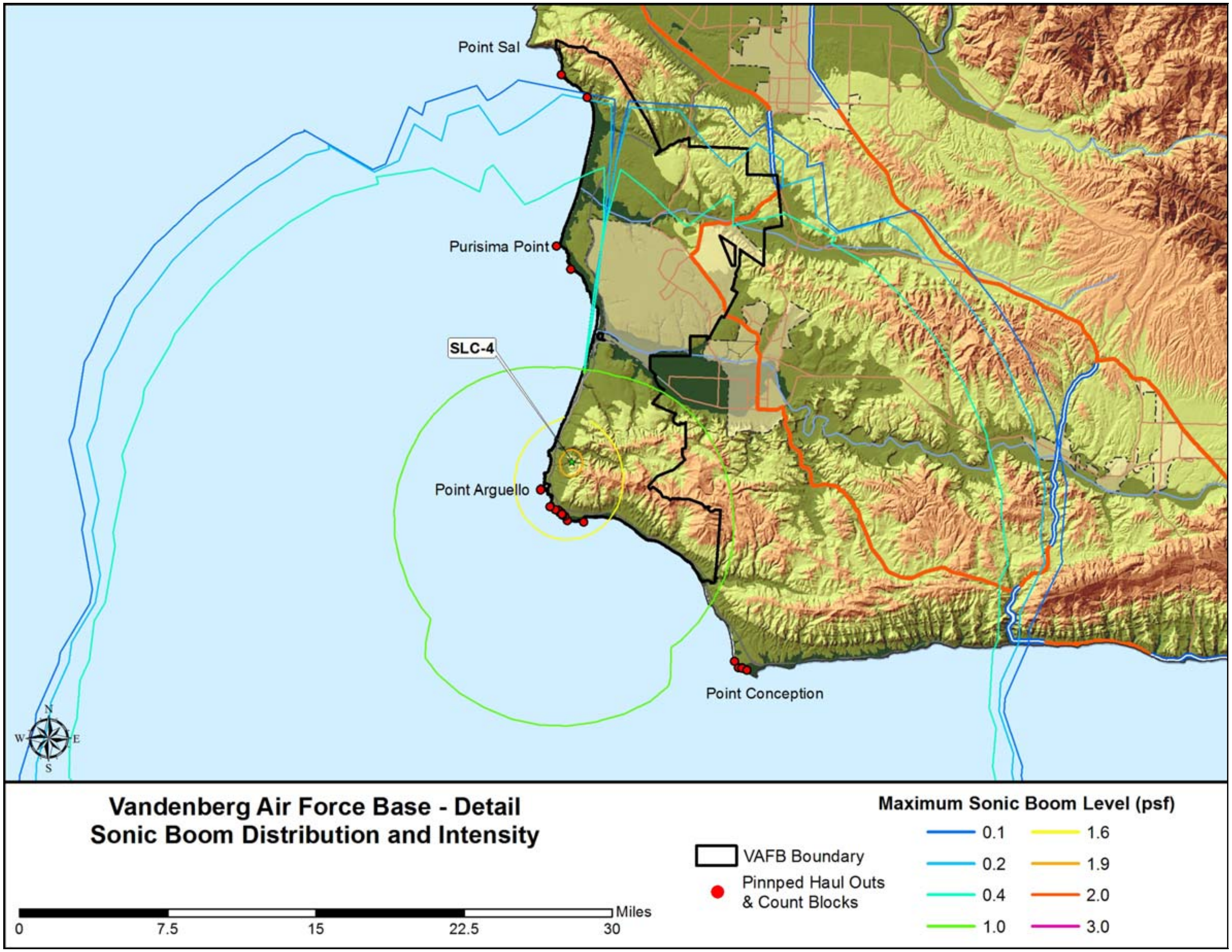


**Figure 2-2.** VAFB Detail of Sonic Boom Distribution and Intensity for Pad Landing at SLC-4 on VAFB

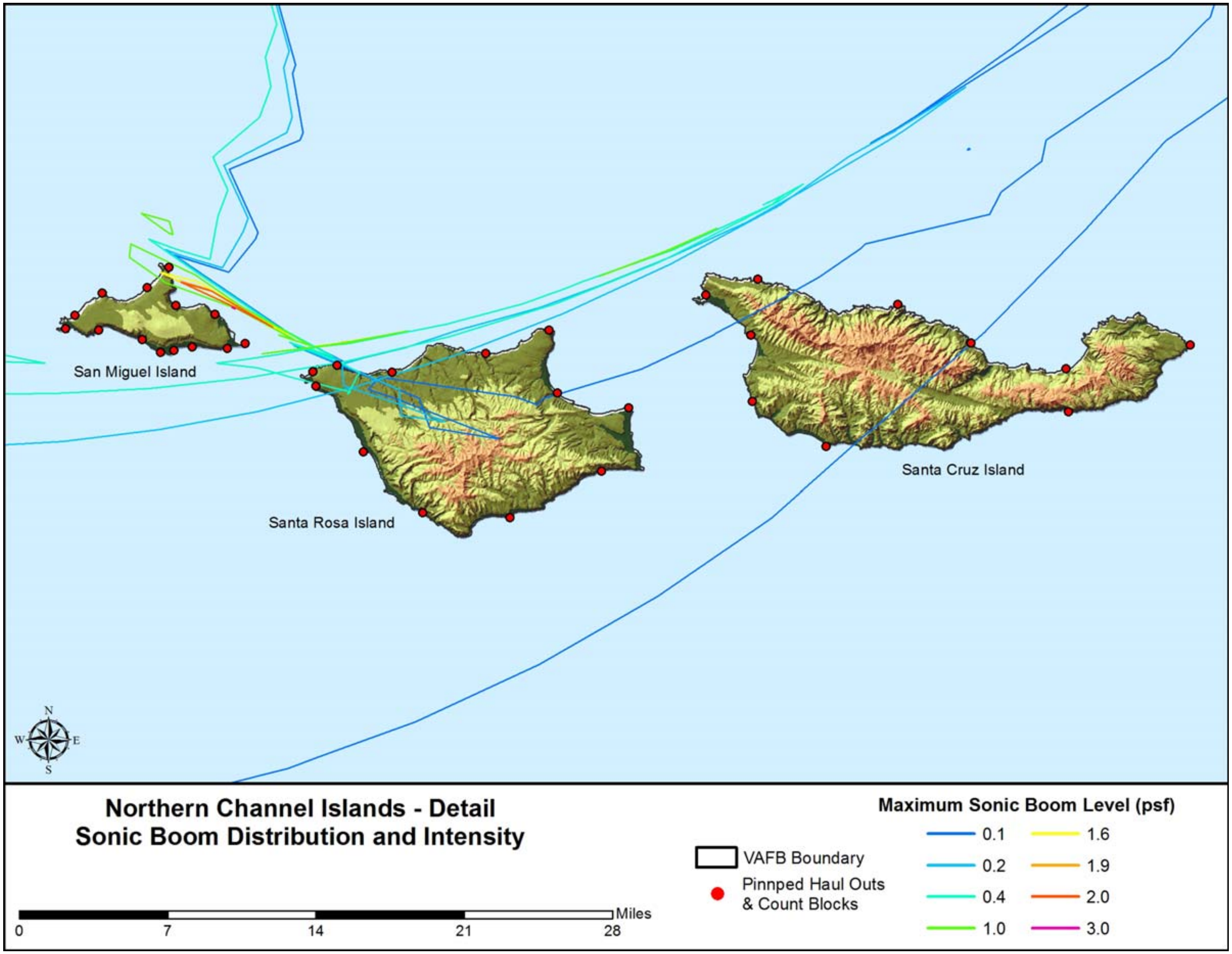


**Figure 2-3.** Northern Channel Islands Sonic Boom Distribution and Intensity for Pad Landing at SLC-4W on VAFB

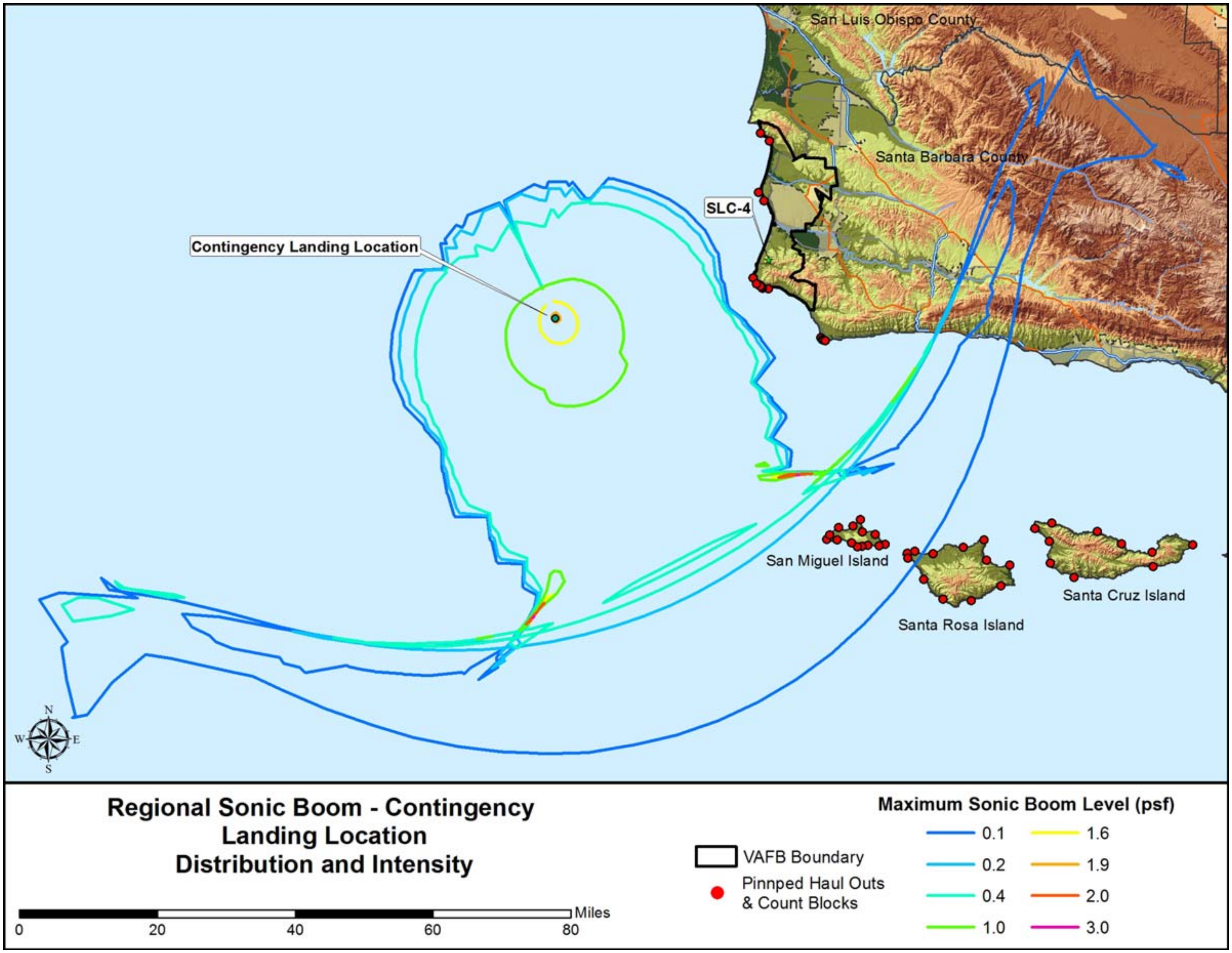


**Figure 2-4.** Hypothetical Sonic Boom Overpressure for Contingency Actions of Barge Landing 31 miles (50 km) Offshore of VAFB

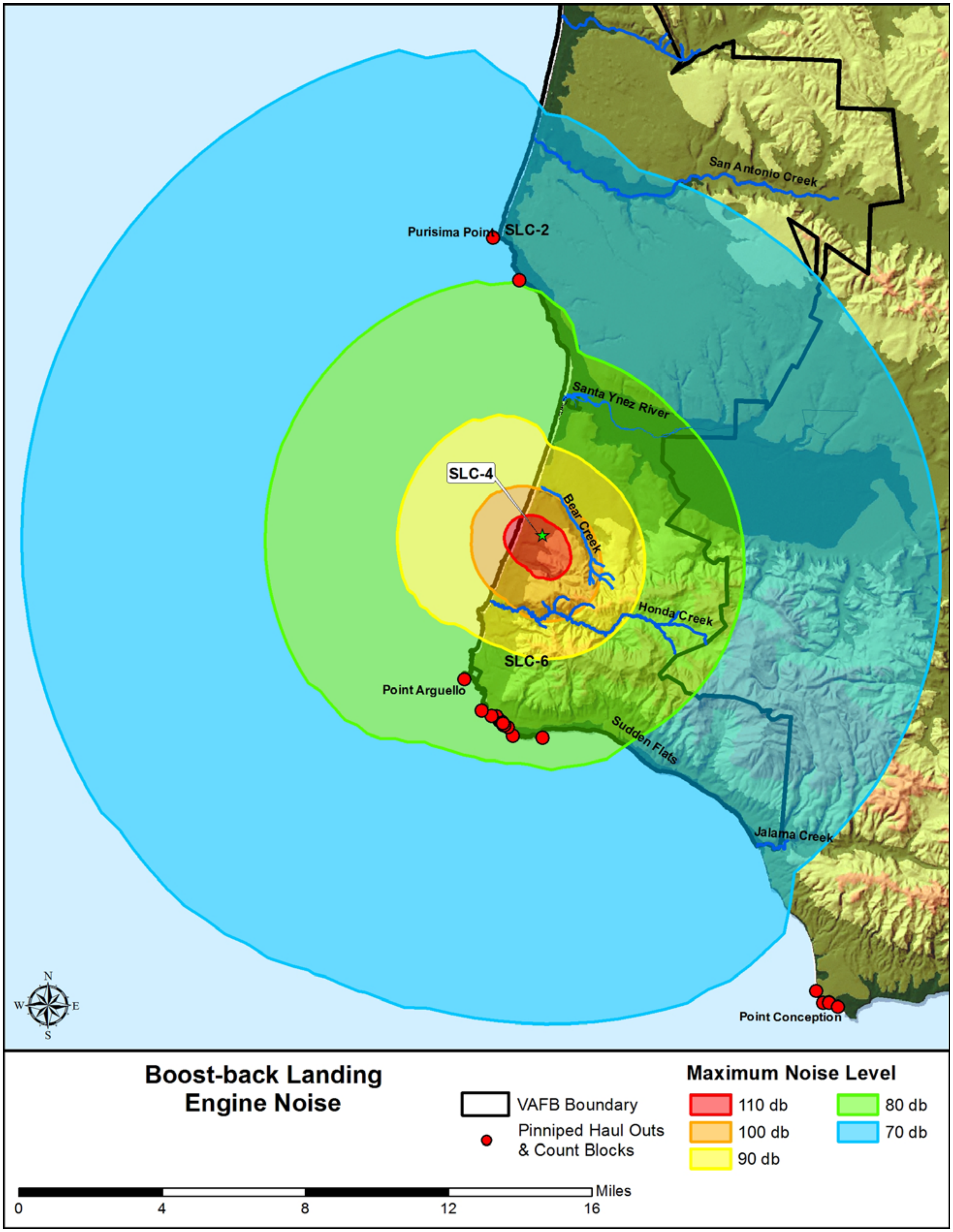


**Figure 2-5.** Regional Landing Noise Intensity Map for Pad Landing at SLC-4W on VAFB

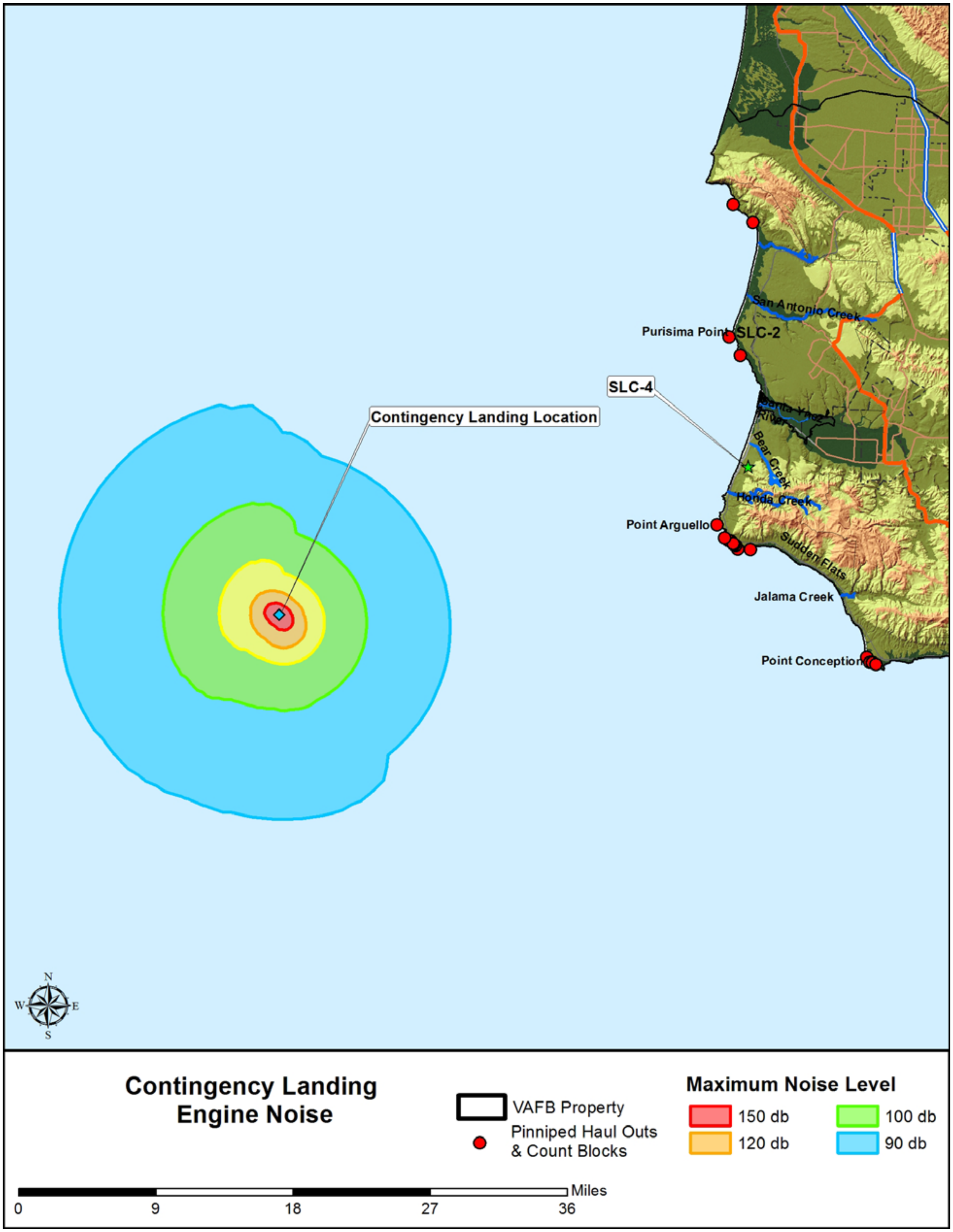


**Figure 2-6.** Approximate Regional Landing Noise Intensity Map for Contingency Actions of Barge Landing 31 miles (50 km) off VAFB

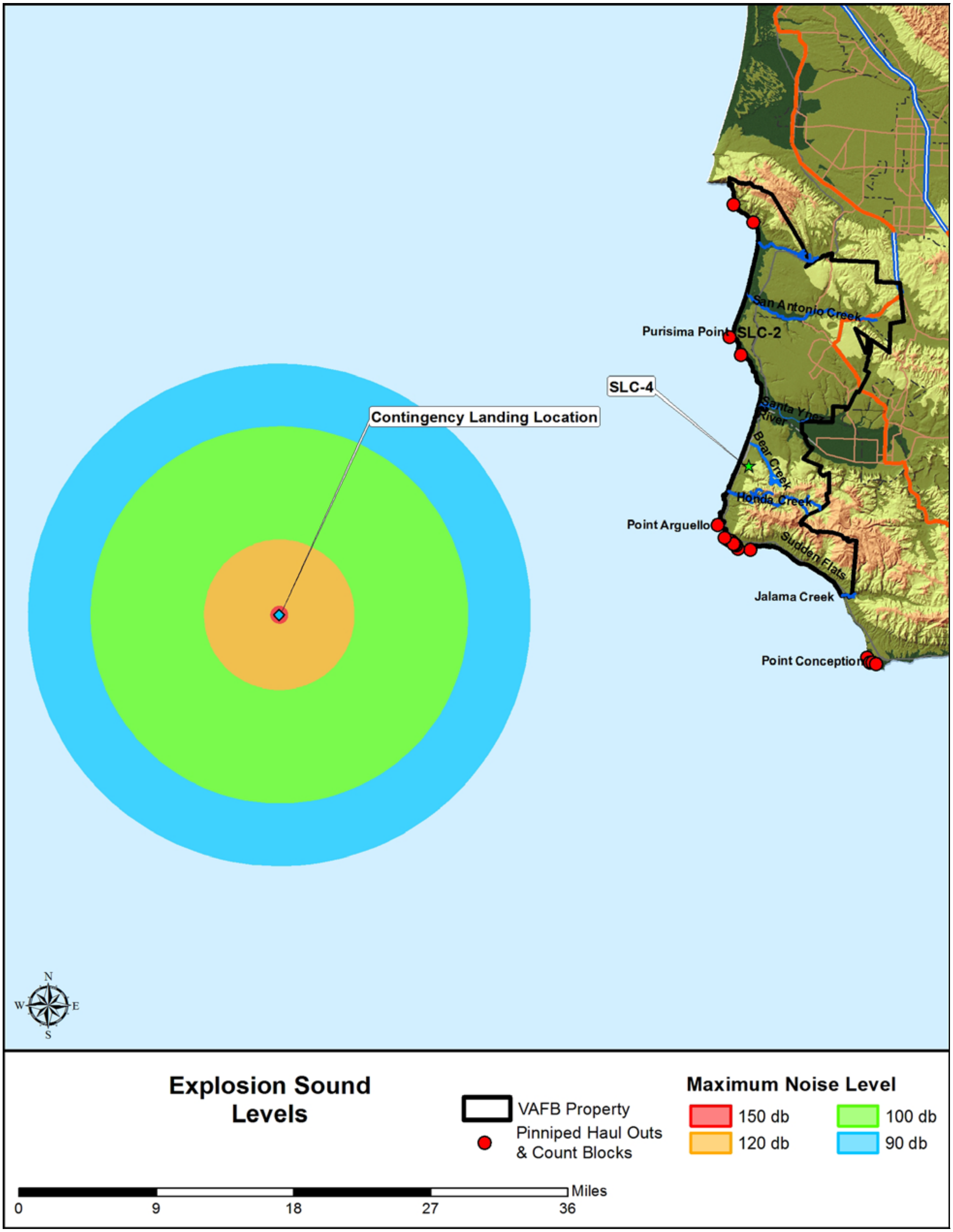


**Figure 2-7.** Estimated Explosion Blast Noise Intensity Map for an Unsuccessful Barge Landing 31 miles (50 km) off VAFB

# 3 Species and Numbers of Marine Mammals

Six pinnipeds (seals and sea lions) and 28 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 location. 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, because these species are very unlikely to occur or are not known to occur in the region (U.S. Department of the Navy 2014a): 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*). These species are not considered further in this application.

**Table 3-1.** Marine mammal species status, habitat use in project area, stock abundance, and seasonality.

| Species | MMPA Depletion Status | Occurrence within Project Area | Habitat Use in Project Area | Stock Abundance[1] | Seasonality |
|---|---|---|---|---|---|
| Pacific Harbor Seal *Phoca vitulina richardsi* | - | Common | Rocks and beach haul-outs, nearshore, open ocean | 30,968 (California) | Year round |
| California Sea Lion *Zalophus californianus* | - | Common | Rocks and beach haul-outs, nearshore, open ocean | 296,750 (U.S.) | Year round |
| Northern Elephant Seal *Mirounga angustirostris* | - | 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* | - | Rare, but increasing | Rocks and beach haul-outs, nearshore, open ocean | Unknown | Year round, rare |
| Northern Fur Seal *Callorhinus ursinus* | D/-[2] | Common | Rocks and beach haul-outs, nearshore, open ocean | 12,844 (California) | Year round |
| Guadalupe Fur Seal *Arctocephalus townsendi* | D | Rare | Rocks and beach haul-outs, open ocean | 7,408 (Mexico to California) | Slightly more common in summer and fall |
| Humpback whale *Megaptera novaeangliae* | D | 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* | D | Common Seasonal | Open ocean and coastal waters | 1,647 (Eastern North Pacific) | Most common in summer and fall months |
| Fin whale *Balaenoptera physalus* | D | Common year-round | Offshore waters, open ocean | 3,051 (California, Oregon, Washington) | Most common in summer and fall months |
| Sei whale *Balaenoptera borealis* | D | 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* | - | Rare | Open ocean | 798 (Hawaii) | Year round, rare |
| Minke whale *Balaenoptera acutorostrata* | - | Common | Nearshore and offshore | 478 (California, Oregon, Washington) | Less common in summer; small numbers around northern Channel Islands |
| Gray whale *Eschrichtius robustus* | D/-[4] | Seasonal | Nearshore and offshore | 20,990 (Eastern North Pacific) | Most abundant Jan through Apr |
| Sperm whale *Physeter microcephalus* | D | 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* | - | Potential | Nearshore and open ocean | 579 (California, Oregon, Washington) | Year round, rare |

| Species | MMPA Depletion Status | Occurrence within Project Area | Habitat Use in Project Area | Stock Abundance[1] | Seasonality |
|---|---|---|---|---|---|
| Dwarf sperm whale *Kogia sima* | - | Potential | Open ocean | Unknown | Year round, rare |
| Killer whale *Orcinus orca* | - | 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* | - | Uncommon | Offshore, open ocean | 760 (California, Oregon, Washington) | Year round, rare |
| Long-beaked common dolphin *Delphinus capensis* | - | Common | Nearshore (within 57.5 miles [92.5 km]) | 411,211 (California, Oregon, Washington) | Most abundant during May to Oct |
| Short-beaked common dolphin *Delphinus delphis* | - | Common | Nearshore and open ocean | 107,016 (California) | One of the most abundant CA dolphins; higher summer densities |
| Common bottlenose dolphin *Tursiops truncates* | - | Common | Coastal and offshore | 1,006 (California offshore) | Year round |
| Striped dolphin *Stenella coeruleoalba* | - | Uncommon | Offshore | 10,908 (California, Oregon, Washington) | More abundant in summer/fall |
| Pacific white-sided dolphin *Lagenorhynchus obliquidens* | - | Common | Open ocean and offshore | 26,930 (California, Oregon, Washington) | More abundant Nov-Apr |
| Northern right whale dolphin *Lissodelphis borealis* | - | Common | Open ocean | 8,334 (California, Oregon, Washington) | Higher densities Nov-Apr |
| Risso's dolphin *Grampus griseus* | - | Common | Nearshore and offshore | 6,272 (California, Oregon, Washington) | Higher densities Nov-Apr |
| Dall's Porpoise *Phocoenoides dalli* | - | Common | Inshore/offshore | 42,000 (California, Oregon, Washington) | Higher densities Nov-Apr |
| Cuvier's beaked whale *Ziphius cavirostris* | - | 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* | - | Potential | Open ocean | 847 (California, Oregon, Washington) | Primarily along continental slope from late spring to early fall |
| Blainville's beaked whale *Mesoplodon densirostris* | - | Rare | Open ocean | Unknown | Distributed throughout deep waters and continental slope regions; difficult to detect given diving behavior |

| Species | MMPA Depletion Status | Occurrence within Project Area | Habitat Use in Project Area | Stock Abundance[1] | Seasonality |
|---|---|---|---|---|---|
| Ginkgo-toothed beaked whale *Mesoplodon ginkgodens* | - | Rare | Open ocean | Unknown | Year round, rare |
| Perrin's beaked whale *Mesoplodon perrini* | - | Potential | Open ocean | Unknown | Year round, rare |
| Stejneger's beaked whale *Mesoplodon stejnegeri* | - | Potential | Open ocean | Unknown | Year round, rare |
| Hubbs' beaked whale *Mesoplodon carlhubbsi* | - | Potential | Open ocean | Unknown | Year round, rare |
| Pygmy beaked whale *Mesoplodon peruvianus* | - | Potential | Open ocean | Unknown | Year round, rare |

[1] Carretta et al. 2015
[2] The eastern Pacific stock is listed as depleted under the MMPA, while the San Miguel Island stock is protected under the MMPA but is not considered depleted (Carretta et al. 2015).
[3] Calambokidis et al. 2001
[4] Both populations of gray whale are protected under the MMPA; the western north pacific stock is listed as endangered under the ESA and depleted under the MMPA. Eastern gray whales are frequenty observed in Southern California waters.

Notes: SOC = Species of Concern; FD = Federally de-listed; FE = Federal Endangered Species; FT = Federal Threatened Species; FC = Federal Candidate Species; D = MMPA Depleted Strategic Stock; NL = Not listed under the ESA

# 4 Affected Species Status and Distribution

The following six pinnipeds and 28 cetaceans may be present in the affected area during boost-back and landing events and therefore potentially impacted by the Proposed Action. Density estimates reported below are from U.S. Department of the Navy (2014a) and are conservatively estimated as the highest at-sea seasonal and geographic densities reported within the affected area for each species. Haul out count data presented below are from a combination of monthly counts performed at haul outs on VAFB from 2013 through 2015 (ManTech SRS Technologies, Inc. 2014, 2015; VAFB, unpublished data), counts conducted by NOAA Fisheries during aerial surveys at the Northern Channels Islands and the Point Conception area (M. Lowry, NOAA Fisheries, unpubl. data), and NOAA Fisheries stock assessments (Carretta et al. 2015).

## 4.1 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 haul outs 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 coasts of San Miguel, Santa Rosa, and Santa Cruz Islands (Lowry 2002). 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. The at-sea estimated density for harbor seals is assumed to be 0.02 individuals per $km^2$ in the affected area (U.S. Department of the Navy 2014a).

## 4.2 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 haul outs on VAFB increased substantially, ranging from 47 to 416 during monthly counts (ManTech SRS Technologies 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 1 pup was observed in 2015 (VAFB, unpubl. data). 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 (Lowry 2002). 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 haul outs 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 haul outs 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 estimate density for California sea lions is assumed to be 2.5 individuals per $km^2$ in the affected area (U.S. Department of the Navy 2014a).

## 4.3 Northern Elephant Seal (*Mirounga angustirostris*)

Northern elephant seals haul-out sporadically on rocks and beaches along the coastline of VAFB, ranging from 0 to 191 elephant seals within the affected area during monthly counts in 2013 and 2015 (ManTech SRS Technologies, Inc. 2014, 2015; VAFB, unpubl. data). However, northern elephant seals do not currently pup on the VAFB coastline 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. 11 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). 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 haul outs 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). The at-sea estimate density for northern elephant seals is assumed to be 0.05 individuals per $km^2$ in the affected area (U.S. Department of the Navy 2014a).

## 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 2013). 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 ESA 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 area (U.S. Department of the Navy 2014a).

## 4.5 Northern Fur Seal (*Callorhinus ursinus*)

Two stocks of northern fur seals are recognized in United States waters: an eastern Pacific stock and a California stock which includes San Miguel Island (Carretta et al. 2015). The eastern Pacific stock is listed as depleted under the MMPA, while the San Miguel Island stock is protected under the MMPA but is not considered depleted (Carretta et al. 2015). Adult males stay from May through August, with some non-breeding specimens remaining until November. Adult females generally stay from June to as late as November. 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 VAFB's analysis of the effects of sonic boom on this species during space vehicle launches (VAFB 2013) and a synopsis of more than 20 years of observations during launches and consideration of the expected numbers of northern fur seals potentially hauled out (MMCG and SAIC 2012), we estimate that up to 250 pups and 1,000 juveniles and adults may be hauled out on San Miguel Island and affected by a sonic boom produced by the Falcon 9 First Stage return flight. 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 seal is assumed to be 0.005 individuals per $km^2$ in the affected area (U.S. Department of the Navy 2014a).

## 4.6 Guadalupe Fur Sea (*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. 2015). The estimated at-sea density of this species is assumed to be 0.007 individuals per $km^2$ in the affected area (U.S. Department of the Navy 2014a). The Guadalupe seal is listed as depleted under the MMPA and listed as threatened under the Endangered Species Act (ESA).

## 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 0.02 individuals per $km^2$ in the affected area (U.S. Department of the Navy 2014a).

## 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 (Bailey 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 0.01 individuals per $km^2$ in the affected area (U.S. Department of the Navy 2014a).

## 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 0.01 individuals per $km^2$ in the affected area (U.S. Department of the Navy 2014a).

## 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 is assumed to be 0.00009 individuals per $km^2$ in the affected area (U.S. Department of the Navy 2014a).

## 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 miles (555 km) of the California coast (Barlow 1995). The at-sea estimated density for Bryde's whales is assumed to be 0.00001 individuals per $km^2$ in the affected area (U.S. Department of the Navy 2014a).

## 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 0.0007 individuals per $km^2$ in the affected area (U.S. Department of the Navy 2014a).

## 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 0.002 per $km^2$ in the affected area (U.S. Department of the Navy 2014a).

## 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 0.009 individuals per $km^2$ in the affected area (U.S. Department of the Navy 2014a).

## 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 pygmy sperm whales is assumed to be 0.001 individuals per $km^2$ in the affected area (U.S. Department of the Navy 2014a).

## 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 dwarf sperm whales is assumed to be 0.001 individuals per $km^2$ in the affected area (U.S. Department of the Navy 2014a).

## 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 0.0007 individuals per $km^2$ in the affected area (U.S. Department of the Navy 2014a).

## 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 0.0003 individuals per $km^2$ in the affected area (U.S. Department of the Navy 2014a).

## 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 miles (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 200; 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 0.69 individuals per $km^2$ in the affected area (U.S. Department of the Navy 2014a).

## 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 miles (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 1.3 individuals per $km^2$ in the affected area (U.S. Department of the Navy 2014a).

## 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 0.71 individuals per $km^2$ in the affected area (U.S. Department of the Navy 2014a).

## 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 miles (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 0.03 individuals per $km^2$ in the affected area (U.S. Department of the Navy 2014a).

## 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 dolphins is assumed to be 0.75 individuals per $km^2$ in the affected area (U.S. Department of the Navy 2014a).

## 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. 1995; Forney and Barlow 1998; Leatherwood and Walker 1979).The at-sea estimated density for northern right whale dolphins is assumed to be 0.107 individuals per $km^2$ in the affected area (U.S. Department of the Navy 2014a).

## 4.25 Risso's Dolphin (*Grampus griseus*)

Off California, they are commonly seen over the slope and in offshore waters (Caretta 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 0.20 individuals per $km^2$ in the affected area (U.S. Department of the Navy 2014a).

## 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 dolphins is assumed to be 0.06 individuals per $km^2$ in the affected area (U.S. Department of the Navy 2014a).

## 4.27 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 0.005 individuals per $km^2$ in the affected area (U.S. Department of the Navy 2014a).

## 4.28 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 0.0015 individuals per $km^2$ in the affected area (U.S. Department of the Navy 2014a).

## 4.29 Blainville's Beaked Whale (*Mesoplodon densirostris*)

There are a handful of known records of the Blainville's beaked whale from the coast of California and Baja California, Mexico, but the species does not appear to be common in California waters (Carretta et al. 2010; Mead 1989; Pitman et al. 1988). The at-sea estimated density for Blainville's beaked whales is assumed to be 0.0001 individuals per $km^2$ in the affected area (U.S. Department of the Navy 2014a).

## 4.30 Ginko-toothed Beaked Whale (*Mesoplodon ginkgodens*)

The distribution of the ginkgo-toothed beaked whale likely includes the California Current system North Pacific Gyre. The known records of the ginkgo-toothed beaked whale are from strandings, one of which occurred in California (Jefferson et al. 2008; MacLeod and D'Amico 2006). The at-sea estimated density for Ginko-toothed beaked whales is assumed to be 0.0003 individuals per $km^2$ in the affected area (U.S. Department of the Navy 2014a).

## 4.31 Perrin's Beaked Whale (*Mesoplodon perrini*)

Perrin's beaked whale range generally includes the California Current system and North Pacific Gyre (MacLeod et al. 2006). Perrin's beaked whale is known only from five stranded specimens along the California coastline (Dalebout et al. 2002; MacLeod et al. 2006). Regional distribution and abundance within the California Current system have not been estimated to date, due to scarcity of data. Known records of this species come from five strandings from 1975 to 1997. These strandings include two at U.S. Marine Corps Base Camp Pendleton, and one each at Carlsbad, Torrey Pines State Reserve, and Monterey (Dalebout et al. 2002; Mead 1981), all of which are in California. The at-sea estimated density for Perrin's beaked whales is assumed to be 0.001 individuals per $km^2$ in the affected area (U.S. Department of the Navy 2014a).

### 4.32 Stejneger's Beaked Whale (*Mesoplodon stejnegeri*)

This species may be found in the California Current system and has an assumed preferences for colder water (Jefferson et al. 2008; MacLeod et al. 2006). The southern limit in the central Pacific is unknown but is likely to range between 50° N and 60° N, and 30° N (Loughlin and Perez 1985; MacLeod et al. 2006). The at-sea estimated density for Stejneger's beaked whales is assumed to be 0.001 individuals per $km^2$ in the affect area (U.S. Department of the Navy 2014a).

### 4.33 Hubbs' Beaked Whale (*Mesoplodon carlhubbsi*)

MacLeod et al. (2006) speculated that the distribution might be continuous across the north Pacific between about 30° N and 45° N, but this remains to be confirmed. Mead (1989) speculated that the Hubbs' beaked whales' range includes the northernmost central California coastline. The at-sea estimated density for Hubbs' beaked whales is assumed to be 0.001 individuals per $km^2$ in the affected area (U.S. Department of the Navy 2014a).

### 4.34 Pygmy Beaked Whale (*Mesoplodon peruvianus*)

Beaked whales normally inhabit continental slope and deep oceanic waters (greater than 656 ft. [200 m]) and are only occasionally reported in waters over the continental shelf (Canadas et al. 2002; Ferguson et al. 2006; MacLeod et al. 2006; Pitman 2008; Waring et al. 2001). Based on stranding data from the Pacific coast of Mexico, the range of the pygmy beaked whale generally includes the California Current system and North Pacific Gyre (Aurioles and Urban-Ramirez 1993; Jefferson et al. 2008; Urban-Ramirez and Aurioles-Gamboa 1992). The at-sea estimated density for Pygmy beaked whales is assumed to be 0.0003 individuals per $km^2$ in the affected area (U.S. Department of the Navy 2014a).

## 5 Type of Incidental Taking Authorization Requested

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 31 miles (50 km) offshore of VAFB.

The specific activities outlined in Section 1 that are analyzed in Section 6 for potential impacts to marine mammals are listed below with the 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 31 miles (50 km) offshore:

   a. Sonic boom (in-air impulsive noise).
   b. Landing noise (in-air non-pulse noise) and visual stimuli.

3) Unsuccessful barge landing attempt at the contingency landing location 31 miles (50 km) offshore:
   a. Potential debris impact (direct physical impact) and behavioral disruption.
   b. Explosion noise (in-air explosive noise and transmission of in-air explosive noise to in-water explosive noise).
   c. Expended debris as a result of the explosion of the First Stage.
   d. Spilled fuel as a result of the explosion of the First Stage.

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 31 miles (50 km) offshore:
   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.
   c. Vessel noise (in-water non-pulse noise) – no effect on pinnipeds and cetaceans.
3) Unsuccessful barge landing attempt at the contingency landing location 31 miles (50 km) offshore:
   a. Potential debris impact (direct physical impact) and behavioral disruption – discountable effect on pinnipeds and cetaceans.
   b. Explosion noise (in-air impulsive noise) – no effect on pinnipeds and cetaceans.
   c. Expended debris as a result of the explosion of the First Stage – no effect on pinnipeds and cetaceans.

d. Spilled fuel as a result of the explosion of the First Stage – discountable effect on pinnipeds and cetaceans.

Therefore, SpaceX requests the issuance of an Incidental Harassment Authorization 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.

2) Boost-back and landing of the Falcon 9 First Stage on a barge at the contingency landing location 31 miles (50 km) offshore:

    a. Sonic boom (in-air impulsive noise) may cause behavioral disturbance (Level B harassment) to six pinniped species listed in Section 4.

# 6 Take Estimates for Marine Mammals

There are 34 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. These include potential debris strike as a result of an unsuccessful barge landing, various potential acoustic impacts, and interactions with expended materials.

## 6.1 Debris Strike Analysis

Under the contingency barge landing action, in the event of an unsuccessful barge landing, the First Stage booster is expected to explode upon impact with the barge. The maximum estimated remaining fuel and oxidizer onboard the booster when it explodes would be the equivalent a net explosive weight of 503 lbs. of TNT (although differing from TNT in brisance). The resulting explosion of the estimated onboard remaining fuel would be capable of scattering debris a maximum estimated range of approximately 1,250 feet (384 m) from the landing point and thus spread over a radial area of 114 acres (0.46 $km^2$) as an impact area. Based on engineering analysis collected during a flight anomaly that occurred during a Falcon 9 test at SpaceX's Texas Rocket Development Facility, debris could impact 0.000706 $km^2$ of the total 0.46 $km^2$ impact area. Debris impacting an individual marine mammal, though highly unlikely as discussed further below, would cause injury and potential mortality, and thus constitute Level A harassment under the MMPA.

Using a statistical probability analysis for estimating direct air strike impact developed by the U.S. Navy (U.S. Department of the Navy 2014b), the probability of impact of debris with a marine mammal (*P*) can be estimated for individual marine mammals of each species that may occur in the impact footprint area (*I*) (0.000706 $km^2$). For this analysis, we assumed a dynamic scenario with broadside collision, in which the width of the impact footprint is enhanced by a factor of five (5) to reflect forward momentum created by an explosion (U.S. Department of the Navy 2014b). Forward momentum typically accounts for five object lengths, thus the applied factor of five (5) area (U.S. Department of the Navy 2014b).

The probability of impact with a single animal (*P*) is calculated as the likelihood that an animal footprint area (*A*, defined as the adult length [$L_a$] and width [$W_a$] for each species) intersects the impact footprint area (*I*) within the overall "testing area" (*R*). Note that to calculate (*P*) it is assumed that the animal is in the testing area <u>and</u> is at or near the ocean surface. For the purposes of this model, *R* was estimated as the maximum range of debris spread as a result of the First Stage explosion at the landing location (0.46 $km^2$). The probability impact with a single animal (*P*) depends on the degree of overlap of *A* and *I*. To calculate this area of overlap ($A_{tot}$), a buffer distance is added around *A* that is equal to one-half of the impact area (0.5**I*). This buffer accounts for an impact with the center of the object anywhere within the combined area of overlap ($A_{tot}$) would result in an impact with the animal. $A_{tot}$ is then calculated as $(L_a + 2*W_i)*(W_a + (1 + 5)*L_i)$, where $W_i$ and $L_i$ are the length and width of the impact area (*I*). We assumed that $W_a = W_i$ = square root of *I*. The single animal impact probability (*P*) for each species is then calculated as the ratio of total area ($A_{tot}$) to testing area (*R*): $P = A_{tot}/R$. This single animal impact probability (*P*) is then multiplied by the number of animals expected in the testing area ($N$ = density * $R$) to estimate the probability of impacting an individual for each species per event (*T*).

SpaceX proposes to conduct up to six contingency offshore landings per year, which may result in between zero and six explosions of the First Stage annually (as recovery actions continue, we expect to assess each incident, refine methodology and ultimately reduce the risk or explosion for the purpose of first-stage recover and re-use). In the model presented herein, we assume that the maximum of six events per year would result in an explosion. This is a conservative estimate, since the actual number of contingency landing events resulting in the First Stage explosion is likely to be less than six. In addition, the model conservatively utilized the highest estimated at-sea individual densities for each species within the geographic area of potential impact (see Section 4 above). The results of the debris strike analysis are presented below in Table 6-1.

Even with these intentionally conservative estimates of parameters and assumptions in the model, the results indicate that it is highly unlikely that debris would strike any individuals of any marine mammal species (Table 6-1). These probabilities are sufficiently low such that it is reasonable to conclude that the risk of injury, and thus Level A harassment, to marine mammals from debris strike following the explosion of the Falcon 9 First Stage is negligible and therefore would have a discountable effect on species protected under the MMPA.

**Table 6-1.** Estimated at-sea density of individuals per km$^2$, probability of direct impact of rocket debris per event (take estimate per event), and take estimates per year (six events).

| Species | Estimated At-Sea Density (km$^2$)* | Probability of Debris Impact (Injury) per Event (*T*) | Level A Harassment Estimated # of Debris Impacts (Injuries) per Year^ |
|---|---|---|---|
| Harbor Seal | 0.0200 | 0.0002 | 0.0010 |
| California Sea Lion | 2.5000 | 0.0222 | 0.1330 |
| Northern Elephant Seal | 0.0500 | 0.0005 | 0.0030 |
| Steller Sea Lion | 0.0001 | 0.0000008 | 0.000005 |
| Northern Fur Seal | 0.005 | 0.00004 | 0.003 |
| Guadalupe Fur Seal | 0.0070 | 0.00006 | 0.0003 |
| Humpback Whale | 0.0169 | 0.0002 | 0.001 |
| Blue Whale | 0.0102 | 0.0001 | 0.0008 |
| Fin Whale | 0.0132 | 0.0002 | 0.0010 |
| Sei Whale | 0.00009 | 0.000001 | 0.000006 |
| Bryde's Whale | 0.00001 | 0.0000001 | 0.0000006 |
| Minke Whale | 0.0007 | 0.000007 | 0.00004 |
| Gray Whale | 0.0024 | 0.00003 | 0.0002 |
| Sperm Whale | 0.0085 | 0.0001 | 0.0006 |
| Pygmy Sperm Whale | 0.0010 | 0.000009 | 0.00005 |
| Dwarf Sperm Whale | 0.0010 | 0.000009 | 0.00005 |
| Killer Whale | 0.0007 | 0.000007 | 0.00004 |
| Short-Finned Pilot Whale | 0.0003 | 0.000003 | 0.00002 |
| Long-Beaked Common Dolphin | 0.6870 | 0.00612 | 0.0367 |
| Short-Beaked Common Dolphin | 1.3190 | 0.0117 | 0.0703 |
| Common Bottlenose Dolphin | 0.7140 | 0.0065 | 0.0392 |
| Striped Dolphin | 0.0300 | 0.0003 | 0.0016 |
| Pacific White-Sided Dolphin | 0.7500 | 0.0067 | 0.0400 |
| Northern Right-Whale Dolphin | 0.1070 | 0.0013 | 0.0075 |
| Risso's Dolphin | 0.2000 | 0.0018 | 0.0110 |
| Dall's Porpoise | 0.0550 | 0.0005 | 0.0029 |
| Cuvier’s Beaked Whale | 0.0050 | 0.00005 | 0.0003 |
| Baird's Beaked Whale | 0.0015 | 0.00002 | 0.0001 |
| Blainville's Beaked Whale | 0.0001 | 0.000001 | 0.000006 |
| Ginkgo-toothed Beaked Whale | 0.0003 | 0.000003 | 0.00002 |
| Perrin’s Beaked Whale | 0.0010 | 0.00001 | 0.00006 |
| Stejneger’s Beaked Whale | 0.0010 | 0.000009 | 0.00006 |
| Hubb’s Beaked Whale | 0.0010 | 0.000009 | 0.00006 |
| Pygmy Beaked Whale | 0.0003 | 0.000003 | 0.00002 |

* U.S. Department of the Navy 2014a.
^ Based on six unsuccessful barge landing events per year.

## 6.2 Acoustic Impact Thresholds

NOAA Fisheries has 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 (Table 6-2; NOAA Fisheries 2015). In addition, NOAA Fisheries provided sound threshold guidance for in-water explosives (Table 6-3; J. Carduner, NOAA Fisheries, pers.

comm.). These thresholds were used to determine the potential geographic area where acoustic impacts to marine mammals from the boost-back and landing actions would be possible. After estimating the geographic areas of potential impact for each acoustic stressor, marine mammal density data (U.S. Department of the Navy 2014a), haul out 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.

**Table 6-2.** NOAA Fisheries interim sound threshold guidance[1].

| Criterion | Criterion Definition | Threshold |
|---|---|---|
| **In-Water Acoustic Thresholds** | | |
| Level A | PTS (injury) conservatively based on TTS | 190 $dB_{rms}$ for pinnipeds<br>180 $dB_{rms}$ for cetaceans |
| Level B | Behavioral disruption for impulsive noise | 160 $dB_{rms}$ |
| Level B | Behavioral disruption for non-pulse noise | 120 $dB_{rms}$ |
| **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 $dB_{rms}$ |

[1] NOAA Fisheries 2015

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.

**Table 6-3.** NOAA Fisheries sound threshold guidance for in-water explosives[1].

| Group | Species | Behavior | | Slight Injury | | | Mortality |
|---|---|---|---|---|---|---|---|
| | | Behavioral (for ≥ 2 pulses per24 hrs) | TTS | PTS | Gastro-Intestinal Tract | Lung | |
| Low-Frequency Cetaceans | Mysticetes | 167 dB SEL | 172 dB SEL or 224 Db peak SPL | 187 dB SEL or 230 dB peak SPL | 237 dB SPL or 104 psi | $39.1\ M^{1/3}$ $(1+[D_{Rm}/10.081]^{1/2}$ Pa-sec Where: M=mass of the animal in kg $D_{Rm}$=depth of the receiver in meters | $91.4\ M^{1/3}$ $(1+[D_{Rm}/10.081]^{1/2}$ Pa-sec Where: M=mass of the animal in kg $D_{Rm}$=depth of the receiver in meters |
| Mid-Frequency Cetaceans | Most delphinids, medium & large toothed whales | 167 dB SEL | 172 dB SEL or 224 Db peak SPL | 187 dB SEL or 230 dB peak SPL | | | |
| High-Frequency Cetaceans | Elephant & harbor seal | 172 dB SEL | 177 dB SEL or 212 Db peak SPL | 192 dB SEL or 218 Db peak SPL | | | |
| Otariidae | Sea lions & fur seals | 195 dB SEL | 200 dB SEL or 212 Db peak SPL | 215 dB SEL or 218 Db peak SPL | | | |

[1] J. Carduner, NOAA Fisheries, pers. comm.

## 6.3 In-Water Acoustic Impacts

### 6.3.1 First Stage Explosion (Unsuccessful Barge Landing)

Explosions near the water surface can introduce loud, impulsive, broadband sounds into the marine environment. These sounds can be within the audible range of most marine mammals, but the duration of individual sounds is very short. The direct sound from explosions would last less than a second, and most events involve only one explosion. Furthermore, events are dispersed in time, with maximum of six (6) barge landing attempts occurring each year.

If an explosion occurs upon the barge, as in an unsuccessful barge landing, exceptionally little of the acoustic energy from the explosion would transmit into the water (Yagla and Stiegler 2003). An explosion on the barge would create a blast in-air that propagates away in all directions, including toward the water surface, although the barge's deck would act as a barrier that would minimize the amount of energy directed directly downward towards the water (Yagla and Stiegler 2003). As described above, most sound enters the water in a narrow cone beneath the sound source (within 13 degrees of vertical). Since the explosion would occur on the barge, most of this sound would be reflected by the barge's surface, and sound waves would approach the water's surface at angles higher than 13 degrees, minimizing transmission into the ocean. An explosion on the barge would also send energy through the ship structure, into the water, and away from the ship. This effect was investigated in conjunction with the measurements described in Yagla and Steigler (2003). The energy transmitted through a ship to the water for the firing of a typical 5-inch round was about 6 percent of that from the air blast impinging on the water. Therefore, sound transmitted from the gun through the hull into the water is a minimal component of overall weapons firing noise, and would be expected to be a minimal component for an explosion occurring on the surface of the barge.

Depending on the amount of fuel remaining in the booster at the time of the explosion, the intensity of the explosion will likely vary. As indicated above, the explosive equivalence of the First Stage with maximum fuel and oxidizer is 503 lb. of TNT. Explosion shock theory has proposed specific relationships for the peak pressure and time constant in terms of the charge weight and range from the detonation position (Pater 1981; Plotkin et al. 2012). For an in-air explosion equivalent to 500 lbs of TNT, at 0.5 feet the explosion would be approximately 250 db re 20 uPa. If it is assumed that the structure of the barge would absorb and reflect 94 percent of this energy, the amount of energy that would be transferred into the water would be far less than the NOAA Fisheries acoustic criteria for in-water explosive noise (Table 6-3). As a result, in-water sound generated by an explosion of the Falcon 9 First Stage during an unsuccessful barge landing attempt would not effect marine mammals protected under the MMPA.

### 6.3.2 Vessel Noise

In coordination with NOAA Fisheries, it was determined that vessel noise produced during the proposed action would not be significant enough to result in any harassment of marine mammals protected under the MMPA (J. Carduner, NOAA Fisheries, pers. comm.). Therefore, it is unnecessary for SpaceX to seek MMPA authorization for the incidental take of marine mammals at sea as a result of vessel noise related to the Proposed Action.

## 6.4 In-Air Acoustic Impacts

Cetaceans spend their entire lives in the water and spend most of their time (>90% 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% of the time because their ears are nearly always below the water's surface. As a result, in-air noise caused by sonic boom, landing engine noise, and potential explosion of the First Stage during an unsuccessful barge landing will 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, will create in-air noise that may impact marine mammals that are hauled out and these potential impacts are analyzed below.

### 6.4.1 Sonic Boom

During the return flight of the Falcon 9 First Stage, an overpressure ranging from 0.1 to 3.1 psf would be generated, whether landing on the pad at SLC-4W or a barge at the contingency landing location. 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 (Figures 2-1 through 2-4). The U.S. Air Force 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 U.S. Air Force has shown that certain species, including northern elephant seal and northern fur seal tend not to respond or respond only mildly (eg. 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.). Therefore, SpaceX estimates that for northern elephant seal, northern fur seal, and Guadalupe fur seal that, conservatively, approximately 10% of the individuals potentially exposed to a 1.0 to 3.1 psf sonic boom during a boost-back event would experience behavioral disruption that would constitute Level B harassment. For harbor seal, California sea lion, and Steller sea lion, SpaceX estimates that the number of individuals that would experience behavioral disruption that constitutes Level B harassment is the total number of individuals of each species that could be hauled out in the area potentially exposed to a 1.0 to 3.1 psf sonic boom during a boost-back event (Figures 2-1 through 2-4). SpaceX assumes that the modeled boom contour lines will vary slightly in reality thus includes haul outs within approximately 5 miles (8.0 km) of 1.0 to 3.1 psf sonic boom contour lines. Therefore, for a SLC-4W landing, haul outs are included from the areas of Point Arguello and Point Conception (Figure 2-2), all of San Miguel Island (Figure 2-3), the northwestern half of Santa Rosa Island (Figure 2-3), and northwestern quarter of Santa Cruz Island (Figure 2-3). For a contingency landing event, sonic booms are sufficiently off shore so that only haul outs along the northwestern edge of San Miguel Island may be exposed to a 1.0 psf or greater sonic boom (Figure 2-4).

The annual take estimate assumes six SLC-4W landing events (Table 6-4) or six contingency landing events (Table 6-5) occur each year. Where sufficient data exists, SpaceX used the average number of individuals of each species from multiple count data for haul outs 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. Sufficient count data is not available for the Northern Channel Islands to use average monthly values for these species; however, a synopsis of more than 20 years of observations during launch monitoring for VAFB (MMCG and SAIC 2012) provides valid estimates for these species. 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).

**Table 6-4.** SLC-4W landing – Estimated average number of individuals hauled out within areas impacted by a sonic boom greater than or equal to 1.0 psf (Level B harassment take estimate per event), and maximum number of individuals affected annually (Level B harassment take estimates per year; six events).

| Species | Geographic Location | Estimated Avg # at Haul Outs in 1.0 – 3.1 psf Area per Boost-Back | Level B Harassment Estimated # Individuals in 1.0 – 3.1 psf Exposure Area per Event per Year[^] |
|---|---|---|---|
| Harbor Seal | VAFB[a] | 366 | 12,942 |
| | Pt. Conception[b] | 488 | |
| | San Miguel Island[b] | 752 | |
| | Santa Rosa Island[b] | 412 | |
| | Santa Cruz Island[b] | 139 | |
| California Sea Lion | VAFB[a] | 416 | 56,496 |
| | Pt. Conception | n/a | |
| | San Miguel Island[c] | 9,000 | |
| | Santa Rosa Island[c] | | |
| | Santa Cruz Island[c] | | |
| Northern Elephant Seal | VAFB[a] | 19* | 960* |
| | Pt. Conception[d] | 1* | |
| | San Miguel Island[c] | 150* | |
| | Santa Rosa Island[c] | | |
| | Santa Cruz Island[c] | | |
| Steller Sea Lion | VAFB[a] | 16 | 120 |
| | Pt. Conception | n/a | |
| | San Miguel Island | 4 | |
| | Santa Rosa Island | n/a | |
| | Santa Cruz Island | n/a | |
| Northern Fur Seal | VAFB | n/a | 3,000* |
| | Pt. Conception | n/a | |
| | San Miguel Island[c] | 500* | |
| | Santa Rosa Island | n/a | |
| | Santa Cruz Island | n/a | |
| Guadalupe Fur Seal | VAFB | n/a | 18 |
| | Pt. Conception | n/a | |
| | San Miguel Island[e] | 3 | |
| | 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 and VAFB, unpubl. data).
[b] NOAA Fisheries aerial survey data June 2002 and May 2004 (M. Lowry, NOAA Fisheries, unpubl. data).
[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 six SLC-4W landing events per year.
* 10% of animals exposed to sonic booms above 1.0 psf are assumed to experience Level B exposure.

**Table 6-5.** Contingency landing – Estimated average number of individuals hauled out within areas impacted by a sonic boom greater than or equal to 1.0 psf (Level B harassment take estimate per event), and maximum number of individuals affected annually (Level B harassment take estimates per year; six events).

| Species | Geographic Location* | Estimated Avg # at Haul Outs in 1.0 – 3.1 psf Area per Boost-Back | Level B Harassment Estimated # Individuals in 1.0 – 3.1 psf Exposure Area per Event per Year^ |
|---|---|---|---|
| Harbor Seal | San Miguel Island[a] | 200 | 1,200 |
| California Sea Lion | San Miguel Island[b] | 4,500 | 27,000 |
| Northern Elephant Seal | San Miguel Island[b] | 75* | 450* |
| Steller Sea Lion | San Miguel Island[b] | 4 | 24 |
| Northern Fur Seal | San Miguel Island[b] | 125* | 750* |
| Guadalupe Fur Seal | San Miguel Island[c] | 3 | 18 |

*Potential impact of 1.0 to 3.1 psf sonic boom to northwestern edge of San Miguel Island only.
[a] NOAA Fisheries aerial survey data June 2002 and May 2004 (M. Lowry, NOAA Fisheries, unpubl. data).
[b] VAFB 2013; MMCG and SAIC 2012.
[c] DeLong and Melin 2000; J. Harris, NOAA Fisheries, pers. comm.
^ Based on six contingency landing events per year.

### 6.4.2 Landing Noise and Visual Disturbance

The Falcon 9 First Stage will generate non-pulse engine noise up to 110 dB re 20 uPa while landing on the pad at SLC-4W (Figure 2-5) or a barge at the contingency landing location (Figure 2-6). This landing noise event would be of short duration (17 seconds). Landing noise between 70 and 90 dB would overlap pinniped haul outs at and near Point Arguello and haul outs at Purisima Point (Figure 2-5). NOAA Fisheries interim guidance thresholds for in-air acoustic impacts resulting in Level A harassment have not been established (Table 6-2; NOAA Fisheries 2015). However, NOAA Fisheries has established interim guidance for Level B harassment for harbor seals (90 dB; Table 6-2; NOAA Fisheries 2015) and for non-harbor seal pinnipeds (100 dB; Table 6-2; NOAA Fisheries 2015). There are no pinniped haul outs within the area impacted by landing noise at 90 dB or greater for either a SLC-4W landing (Figure 2-5) or a contingency landing (Figure 2-6). In addition, the trajectory of the return flight includes a nearly vertical descent in both the SLC-4W landing (Figure 1-4) and the contingency landing (Figure 1-5). As a result, there would be no significant visual disturbance since it would either be shielded by coastal bluffs or too far away to cause significant stimuli. Therefore, landing noise and visual disturbance associated with the Falcon 9 First Stage boost-back will not result in Level B harassment of marine mammals.

### 6.4.3 First Stage Explosion (Unsuccessful Barge Landing)

In the event of an unsuccessful barge landing, the Falcon 9 First Stage would explode and generate an in-air impulsive sound pressure level up to 180 dB (Figure 2-7). NOAA Fisheries interim guidance thresholds for in-air acoustic impacts resulting in Level A harassment have not been established (Table 6-3; NOAA Fisheries 2015). An explosive impulsive in-air noise at 90 dB or greater would impact an area within a 16.5 miles (26.5 km) radius of the contingency landing location. There are no pinniped haul outs within this area (Figure 2-7); therefore noise generated by an explosion of the Falcon 9 First Stage during a contingency landing would not result in Level B harassment of marine mammals.

## 6.5 Expended Materials and Fluids

### 6.5.1 Floating Debris

SpaceX has experience performing recovery operations after water and unsuccessful barge landings for previous Falcon 9 First Stage landing attempts. This experience, in addition to the debris catalog that identifies all floating debris, has revealed that approximately 25 pieces of debris remain floating after an unsuccessful barge landing. The surface area potentially impacted with debris would be less than 114 acres (0.46 $km^2$), and the vast majority of debris would be recovered. All other debris sinks to the bottom of the ocean.

These 25 pieces of floating debris are primarily made up of Carbon Over Pressure Vessels (COPVs), the LOX fill line, and carbon fiber constructed landing legs. SpaceX has performed successful recovery of all of these floating items during previous landing attempts. An unsuccessful barge landing would result in a very small debris field, making recovery of debris relatively straightforward and efficient. All debris recovered offshore would be transported back to Long Beach Harbor.

Since the area impacted by debris is very small, the likelihood of adverse effects to marine mammals is very low. Denser debris that would not float on the surface is anticipated to sink relatively quickly and is composed of inert materials which would not affect water quality or bottom substrate potentially used by marine mammals. The rate of deposition would vary with the type of debris; however, none of the debris is so dense or large that benthic habitat would be degraded. Also, the area that would be impacted per event by sinking debris is only a maximum of 0.17 acres (0.000706 $km^2$), a relatively small portion of the total 114 acres (0.46 $km^2$) potential impact area, based on a maximum range of 1,250 feet (384 m) that a piece of debris would travel following an explosion. As a result, debris from an unsuccessful barge landing that enters the ocean environment approximately 31 miles (50 km) offshore of VAFB would not have an effect on marine mammal species.

### 6.5.2 Rocket Propellant

In the event of an unsuccessful landing attempt, the First Stage would explode upon impact with the barge. At most, the First Stage would contain 400 gallons of rocket propellant (RP-1 or "fuel") on board. In the event of an unsuccessful barge landing, most of this fuel would be consumed during the subsequent explosion. Residual fuel after the explosion (estimated to be between 50 and 150 gallons) would be released into the ocean. Final volumes of fuel remaining in the First Stage upon impact may vary, but are anticipated to be below this high range estimate.

The fuel used by the First Stage, RP-1, is a Type 1 "Very Light Oil", which is characterized as having low viscosity, low specific gravity, and are highly volatile (U.S. Fish and Wildlife Service 1998). Clean-up following a spill of very light oil is usually not possible, particularly with such a small quantity of oil that would enter the ocean in the event of an unsuccessful barge landing (U.S. Fish and Wildlife Service 1998). Therefore, no attempt would be made to boom or recover RP-1 fuel from the ocean.

In relatively high concentrations, exposure to very light oils can cause skin and eye irritation, increased susceptibility to infection, respiratory irritation, gastrointestinal inflammation, ulcers, bleeding, diarrhea, damage to organs, immune suppression, reproductive failure, and death. The effects of exposure primarily depend on the route (internal versus external) and amount (volume and time) of exposure. Although the U.S. Environmental Protection Agency has established exposure levels for kerosene and jet fuel (RP-1 is a type of kerosene) for toxicity in mammals and the environment (U.S. Environmental Protection Agency 2011), in reality it is difficult to predict exposure levels, even with a known amount of fuel released. This is because exposure level is dependent not only on the amount of fuel in the spill area, but also on unpredictable factors, including the behavior of the animal and the amount of fuel it contacts, ingests, or inhales.

However, precluding these factors is the overall risk of a marine mammal being within the fuel spill area before the RP-1 dissipates. This risk depends primarily on how quickly RP-1 dissipates in the environment and the area affected by the spill. Since RP-1 is lighter than water and almost completely immiscible (i.e. very little will dissolve into the water column), RP-1 would stay on top of the water surface. Due to its low viscosity, it would rapidly spread into a very thin layer (several hundred nanometers) on the surface of water and would continue to spread as a function of sea surface, wind, current, and wave conditions. This spreading rapidly reduces the concentration of RP-1 on the water surface at any one location and exposes more surface area of the fuel to the atmosphere, thus increasing the amount of RP-1 that is able to evaporate.

RP-1 is highly volatile and evaporates rapidly when exposed to the air (U.S. Fish and Wildlife Service 1998). The evaporation rate for jet fuel (a kerosene similar to RP-1) on water, can be determined by the following equation from Fingas (2013): $\%EV = (0.59 + 0.13T)/t$, where $\%EV$ is the percent of mass evaporated within a given time in minutes ($t$) at a given temperature in $^{o}$C ($T$). If we assume an air temperature of 50$^{o}$F (10$^{o}$C), the percent of mass evaporated versus time can be determined, as shown in Figure 14. Although it would require one to two days for the RP-1 to completely dissipate, over 90% of its mass would evaporate within the first seven minutes and 99% of its mass would evaporate within the first hour (Figure 14). In the event of adverse ocean conditions (e.g., large swells, large waves) and weather conditions (e.g., fog, rain, high winds) RP-1 would be volatilized more rapidly due to increased agitation and thus dissipate even more quickly and further reduce the likelihood of exposure.

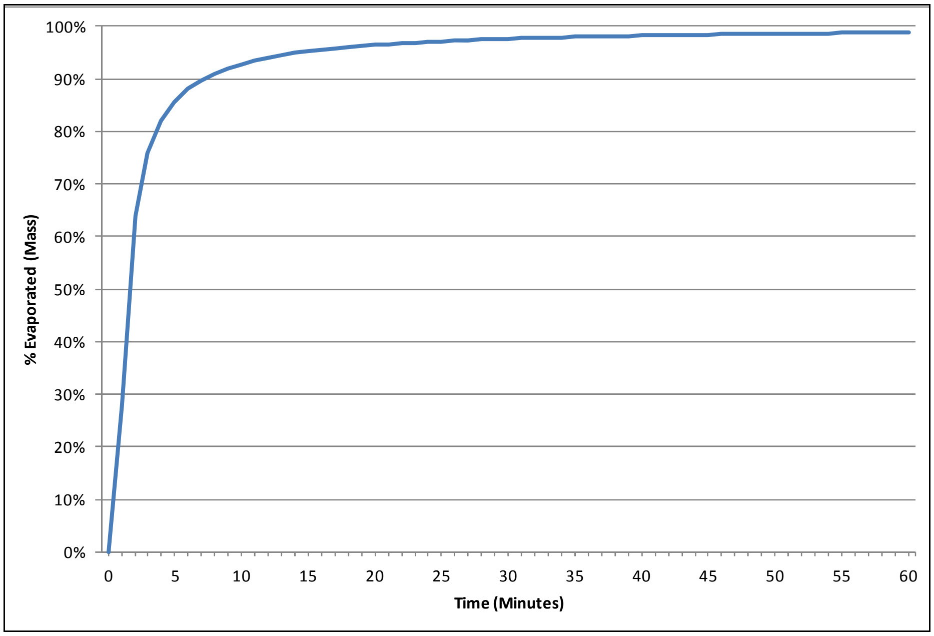


**Figure 6-1.** Evaporation rate of Jet A1 fuel (similar to RP-1) as function of time (minutes) (Fingas 2013).

Since RP-1 would remain on the surface of the water, in order for a marine mammal to be directly exposed to RP-1, it would have to surface within the spill area very soon after the spill occurs (minutes). Given the relatively small volume of RP-1 that would be spilled (50 to 150 gallons), the exposure area would be small and thus unlikely that a marine mammal would be within the exposure area. Based on the thinness of the layer of RP-1 on the water surface, spreading on the surface (thus rapidly reducing concentration), and rapid evaporation (further reducing concentration), an animal would need to be at the surface within the layer of RP-1 and be exposed to a toxic level within a very short period of time (minutes) after the spill to experience negative effects. Additionally, since the spill would occur concurrent to the explosion of the First Stage, any animals that may have been in the immediate area of the barge would likely submerge and move away from the area due to the disturbance associated with the explosion.

Similarly, since RP-1 would be a very thin, rapidly evaporating layer on the water surface, fish and other prey species would not be negatively impacted to any significant degree.

It is therefore highly unlikely that spilled RP-1 as a result of an unsuccessful barge landing that enters the ocean environment approximately 31 miles (50 km) from shore would have an effect on marine mammal species.

# 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. These include debris impact, in-water acoustic impacts from sonic boom, in-water acoustic impacts from first stage explosion, in-water impacts from vessel noise, landing noise, in-air impacts from explosion noise, and expended materials and fluids. Below is a discussion of the biological context and consequences of the in-air sonic boom on hauled out pinnipeds, identified in Section 6 areas the only stressor that may result in Level B harassment to pinnipeds.

## 7.1 Sonic Boom

Pinnipeds will 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 have ranged 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 will 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 be dependent 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 will 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 U.S. Air Force 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. More powerful sonic booms have flushed animals from haul outs 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 the 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.

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 will likely be even lower than the estimated values shown in Tables 6-5 and 6-6. Additionally, the sonic boom events would be infrequent (up to six 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.

**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 & Associated Reaction** |
|---|---|---|
| Athena II (27 April 1999) | 1.0 | *Z. californianus* – 866 alerted; 232 flushed into water<br>*M. angustirostris* & *C. ursinus* – alerted but did not flush |
| Athena II (24 September 1999) | 0.95 | *Z. californianus* – 600 alerted; 12 flushed into water<br>*M. angustirostris* & *C. ursinus* – alerted but did not flush |
| Delta II 20 (November 2000) | 0.4 | *Z. californianus* – 60 flushed into water; no reaction from rest<br>*M. angustirostris* – no reaction |
| Atlas II (8 September 2001) | 0.75 | *Z. californianus* and *M. angustirostris* – no reaction<br>*P. vitulina* – 2 of 4 flushed into water |
| Delta II (11 February 2002) | 0.64 | *Z. californianus, C. ursinus,* & *M. angustirostris* – no reaction |
| Atlas II (2 December 2003) | 0.88 | *Z. californianus* – 40% alerted; several flushed to water<br>*M. angustirostris* – no reaction |
| Delta II (15 July 2004) | 1.34 | *Z. californianus* – 10% 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 |

# 8 Impacts on Subsistence Use

Potential impacts resulting from the Proposed Action will 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).

In the event of an unsuccessful barge landing and a resulting explosion of the Falcon 9 First Stage, up to 25 pieces of floating debris would remain floating (see Section 6.5.1). SpaceX would recover all floating debris. Denser debris that would not float on the surface are anticipated to sink relatively quickly and are composed of inert materials. The rate of deposition would vary with the type of debris; however, none of the debris is very dense or large that it would negatively impact benthic habitat.

# 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 six 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 U.S. Air Force (MMCG and SAIC 2012).

The area of benthic habitat impacted by falling debris is very small (0.17 acres [0.000706 $km^2$]) and all debris that would sink are composed of inert materials that would not affect water quality or bottom substrate potentially used by marine mammals. None of the debris are so dense or large that benthic habitat would be degraded. As a result, debris from an unsuccessful barge landing that enters the ocean environment approximately 31 miles (50 km) would not have a significant effect on marine mammal habitat.

# 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.

# 12 Arctic Subsistence Plan of Cooperation

Potential impacts resulting from the Proposed Action will 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 will 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 will be performed prior to all boost-back events. PCBoom, a commercially available modeling program, or an acceptable substitute, will be used to model sonic booms. Launch parameters specific to each launch will 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 will be analyzed from NOAA weather records for the region, then run through the model. Among other factors, these will include the presence or absence of the jet stream, and if present, its direction, altitude and velocity. The type, altitude, and density of clouds will also be considered. From these data, the models will predict peak amplitudes and impact locations.

## 13.2 Pinniped Monitoring

- Should model results indicate that a peak overpressure of 1 psf or greater is likely to impact VAFB, then acoustic and biological monitoring will be implemented.
- If it is determined that a sonic boom of 1 psf or greater is likely to impact one of the Northern Channel Islands between 1 March and 30 June, greater than 1.5 psf between 1 July and 30 September, and greater than 2 psf between 1 October and 28 February, monitoring will be conducted at the haul out site closest to the predicted sonic boom impact area.
- Monitoring would commence at least 72 hours prior to the boost-back and continue until at least 48 hours after the event. Monitoring data collected would include multiple surveys each day that record the species; number of animals; general behavior; presence of pups; age class; gender; and reaction to booms or other natural or human-caused disturbances. Environmental conditions such as tide, wind speed, air temperature, and swell would also be recorded. If the boost-back is scheduled for daylight; video recording of pinnipeds on NCI would be conducted during the boost-back in order to collect required data on reaction to launch noise.

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

## 13.3 Reporting

- SpaceX will submit a report after each Falcon 9 boost-back event that includes:
  - Summary of activity (dates, times, and specific locations)
  - Summary of monitoring measures implemented
  - Detailed monitoring results and a comprehensive summary addressing goals of monitoring plan, including:
    - Number, species, and any other relevant information regarding marine mammals observed and estimated exposed/taken during activities
    - Description of the observed behaviors (in both presence and absence of activities)
    - Environmental conditions when observations were made
    - Assessment of the implementation and effectiveness of monitoring measures

# 14 Suggested Means of Coordination

SpaceX will 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.

# 15 List of Preparers

Alice Abela (ManTech SRS Technologies, Inc.), Wildlife Biologist
*B.S. Biology, California Polytechnic State University, San Luis Obispo, California*

John LaBonte, Ph.D. (ManTech SRS Technologies, Inc.), Wildlife Biologist, Project Manager
*Ph.D. Biology, University of California, Santa Barbara*
*B.S. Ecology, Behavior, and Evolution, University of California, San Diego*

Lawrence Wolski (ManTech SRS Technologies, Inc.), Marine Scientist
*M.S., 1999, Marine Sciences, University of San Diego*
*B.S., 1994, Biology, Loyola Marymount University*

Michael Zickel (ManTech SRS Technologies, Inc.), Environmental Scientist
*M.S., 2005, Marine Estuarine Environmental Science, University of Maryland-College Park, Chesapeake Biological Lab*
*B.S., 1992, Physics, College of William and Mary*

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