Final Supplemental Environmental Assessment

Boost-Back and Landing of the Falcon 9 Full Thrust First Stage at Iridium Landing Area

Vandenberg Air Force Base, California and Offshore Landing Contingency Option

20 September 2016

30th Space Wing, Installation Management Flight
1028 Iceland Avenue, Building 11146
Vandenberg Air Force Base, California 93437
FINDING OF NO SIGNIFICANT IMPACT
Boost-Back and Landing of the Falcon 9 First Stage within the Iridium Landing Area

This Finding of No Significant Impact (FONSI) hereby incorporates by reference and attaches hereto the Final Supplemental Environmental Assessment (SEA), Boost-Back and Landing of the Falcon 9 First Stage at the Iridium Landing Area. This SEA supplements the Final Environmental Assessment (EA) Boost-Back and Landing of the Falcon 9 Full Thrust First Stage at SLC-4 West at Vandenberg Air Force Base, California and Offshore Landing Contingency Option (United States Air Force [USAF], 2016) (hereinafter referred to as the “Falcon 9 Boost-Back EA” [USAF, 2016]). The SEA considered all potential environmental impacts of the Proposed Action (Alternative 1) and the No Action Alternative, including cumulative impacts, and identified management protective measures to avoid, prevent, or minimize environmental impacts.

PROPOSED ACTION (ALTERNATIVE 1)
The Proposed Action (Alternative 1) is Space Exploration Technologies Corporation’s (SpaceX’s) proposal to use an alternate conditional landing area for the Falcon 9 First Stage (referred to as the “Iridium Landing Area”) in addition to the landing areas proposed in the Falcon 9 Boost-Back EA. This landing area may be used up to six times per year. SpaceX developed the Proposed Action based on the purpose, need, and selection criteria discussed in Chapters 1 (Purpose of and Need for the Proposed Action) and 2 (Description of the Proposed Action and Alternatives) of the attached SEA. The Proposed Action is for the boost-back maneuver (in-air), return flight, and landing of the Falcon 9 First Stage on an autonomous barge specifically designed for the landing. The barge would be located approximately 120 nautical miles southwest of San Nicolas Island within the United States Exclusive Economic Zone.

NO ACTION ALTERNATIVE
The Council on Environmental Quality Regulations requires the assessment of the No Action Alternative (40 Code of Federal Regulations [C.F.R.] § 1502.14). Under the No Action Alternative, the Iridium Landing Area would not be used as a conditional landing area for subsequent SpaceX missions with heavy payloads. The No Action Alternative would not meet the Proposed Action’s purpose and need.

SUMMARY OF FINDINGS
The attached SEA analyzed the potential environmental consequences of activities associated with the Proposed Action and the No Action Alternative. A detailed review of the Falcon 9 Boost-Back EA (USAF, 2016) was conducted and concluded that there was no new information or change to the project other than the addition of the proposed Iridium Landing Area as a conditional landing area. Resources that are potentially affected by this change are considered in more detail to determine whether additional analysis is required (40 C.F.R. § 1501.4[c]). The resources analyzed in the SEA include air quality, sound, biological resources, water resources, and coastal zone management. Vandenberg Air Force Base (VAFB) does not anticipate that this change would alter the analysis for any additional resource that was described and assessed in the Falcon 9 Boost-Back EA (USAF, 2016). Potential adverse impacts were noted for the
Proposed Action to the following resources (discussed below): air quality, biological resources, and water resources.

**Air Quality:** Emissions from the Falcon 9 First Stage and support vessels would impact air quality. However, emissions from the Proposed Action would be below the major source thresholds for all criteria pollutants, and the Proposed Action’s impacts to air quality would not be significant.

**Biological Resources:** The Proposed Action may affect marine species within or near the Iridium Landing Area due to debris impacts, acoustic impacts, and expended materials. The USAF has determined, and requested that the National Marine Fisheries Service (NMFS) concur, that the Falcon 9 First Stage boost-back and landing on a barge located within the Iridium Landing Area may affect, but is not likely to adversely affect, seven federally listed marine mammal species, five federally listed turtles, and three federally listed fish species under the Endangered Species Act of 1973, as amended (16 U.S.C. §§ 1531 et seq.). The USAF has also requested NMFS's concurrence that the boost-back and landing within this area may adversely affect Essential Fish Habitat protected under the Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. §§ 1801–1882); however, only temporary and no more than minimal effects are expected. The USAF and SpaceX have coordinated with NMFS to identify and contribute to a marine debris removal program to offset these impacts. In addition, the Iridium Landing Area was designed to avoid impacting marine mammal haul-out areas. NMFS concluded on 29 August 2016 that a boost-back landing within the Iridium Landing Area would not result in a take of a marine mammal under the Marine Mammals Protection Act of 1972 (16 U.S.C. §§ 1361–1407), and SpaceX’s existing Incidental Harassment Authorization (IHA) for Level B harassment does not require a revision for this action.

**Water Resources:** SpaceX would continue to follow proper solid and hazardous waste management procedures as described in the Falcon 9 Boost-Back EA (USAF, 2016), which reduces or eliminates the potential for water contamination. For an unsuccessful landing attempt, the First Stage would explode and residual fuel (estimated to be between 50 and 150 gallons) could be released into the ocean. In addition, approximately 25 pieces of floating debris would be present after a First Stage explosion, which SpaceX would recover promptly. Very light oils, including Rocket Propellant 1 (RP-1), are highly volatile, which means they evaporate quickly when exposed to the air. They are usually completely dissipated within one to two days after a spill. The probability of exposure to spilled RP-1 after first stage explosion is very small since the volume of spilled RP-1 would be small (50–150 gallons) and would dissipate quickly (minutes). Therefore, the Proposed Action’s impacts to water resources would not be significant.

**PUBLIC REVIEW AND COMMENT**
The USAF made the Draft SEA available for public review and comment for 15 days following the publication of the Notice of Availability (NOA) in the San Diego Union-Tribune. The USAF also distributed the Draft SEA and FONSI per a revised distribution list because of a change in the Proposed Action's region of influence. Appendix C (Notice of Availability for Public Review, Proof of Delivery/Publication, Comments Received on Final Draft, and Responses) contains a:
copy of the NOA, proofs of publication, proof of library deliveries, and VAFB's National Environmental Policy Act (NEPA) distribution list. No public comments were received on the Draft SEA during the public review period.

FINDING OF NO SIGNIFICANT IMPACT

Based on my review of the facts and analyses contained in the attached SEA, conducted per the NEPA, 42 U.S. Code 4321 et seq., implementing Council on Environmental Quality Regulations, 40 C.F.R. Parts 1500–1508, and 32 C.F.R. Part 989, Environmental Impact Analysis Process, I conclude that implementing the Proposed Action (chosen alternative), with incorporation of required environmental protection measures, will not have a significant effect on the human environment. Therefore, further analysis with an Environmental Impact Statement is not required, and a FONSI is appropriate.

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Command Civil Engineer

Date

Attachment: Draft Supplemental Environmental Assessment (2016) Boost-Back and Landing of the Falcon 9 First Stage at the Iridium Landing Area
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SO₂  sulfur dioxide
SOCAL  Southern California
SpaceX  Space Exploration Technologies Corporation
TNT  trinitrotoluene
TTS  Temporary Threshold Shift
U.S.  United States
USAF  United States Air Force
USEPA  United States Environmental Protection Agency
USFWS  United States Fish and Wildlife Service
VAFB  Vandenberg Air Force Base
1 Purpose of and Need for the Proposed Action

This Supplemental Environmental Assessment (SEA) evaluates the potential environmental impacts associated with the boost-back and vertical landing of the Falcon 9 Full Thrust First Stage booster on a special purpose barge (hereafter referred to as an autonomous drone ship or drone ship) southwest of San Nicolas Island as a contingency landing area for heavy payloads. Space Exploration Technologies Corporation (SpaceX) is currently operating the Falcon Launch Vehicle Program at Space Launch Complex 4 East (SLC-4E) on Vandenberg Air Force Base (VAFB), which includes performing regular employment of stage recovery (boost-back and landing) by returning the Falcon 9 Full Thrust First Stage to Space Launch Complex 4 West (SLC-4W) or another SpaceX launch facility for potential reuse approximately six times per year.

This SEA has been prepared per the National Environmental Policy Act (NEPA) of 1969, as amended (42 United States Code [U.S.C.] §§ 4321 et seq.); the White House Council on Environmental Quality (CEQ) Regulations for Implementing the Procedural Provision of NEPA (40 Code of Federal Regulations [C.F.R.] Parts 1500–1508); 32 C.F.R. Part 989; and Federal Aviation Administration (FAA), Order 1050.1F, Environmental Impacts: Policies and Procedures. Per agreements between the United States (U.S.) Air Force (USAF) and the FAA, the USAF is the lead agency for the preparation and coordination of the NEPA documentation for the Proposed Action (40 C.F.R. § 1501.5), and the FAA and the National Aeronautics and Space Administration (NASA) will act as cooperating agencies (40 C.F.R. § 1501.6).

1.1 Background

In April 2016, the USAF issued a Final Environmental Assessment (EA) for Boost-Back and Landing of the Falcon 9 Full Thrust First Stage at SLC-4 West at Vandenberg Air Force Base, California and Offshore Landing Contingency Option (hereafter referred to as “Falcon 9 Boost-Back EA”), which is hereby incorporated by reference (USAF, 2016). This EA assessed the construction of a new concrete landing pad at SLC-4W and proposed boost-back maneuver (in-air), return flight, and landing of the Falcon 9 First Stage on the new SLC-4W pad. This action also included a conditional landing area on an autonomous barge located approximately 27 nautical miles (nm) (50 kilometers [km]) offshore of VAFB. The USAF signed a Finding of No Significant Impact (FONSI) for this project on 26 April 2016. Implementation of this project is currently underway.

1.2 Purpose and Need

As previously described in the Falcon 9 Boost-Back EA (USAF, 2016), the purpose of the project is to substantially reduce the cost to the government of reliable U.S. enterprise access to space through the reuse of the Falcon 9 Full Thrust First Stage booster, thus complying with the National Space Policy. The purpose of the Proposed Action is also to fulfill the FAA’s responsibilities as authorized by Executive Order (EO) 12465, Commercial Expendable Launch Vehicle Activities; and the Commercial Space Launch Act for oversight of commercial space launch activities. The reuse of the Falcon 9 Full Thrust First Stage would enable SpaceX to efficiently conduct lower-cost launch missions from VAFB in support of commercial and government clients.
The need for the Proposed Action results from the statutory direction from Congress under the Commercial Space Launch Act to protect the public health and safety, safety of property, and national security and foreign policy interests of the United States and to encourage, facilitate, and promote commercial space launch and reentry activities by the private sector to strengthen and expand U.S. space transportation infrastructure during commercial launch or reentry activities.

The Proposed Action is needed so that SpaceX can implement missions for the USAF and the NASA (under the Space Act Agreement). In addition, the Proposed Action supports VAFB’s vision of becoming the “world's most innovative space launch and landing team” (U.S. Air Force 2014).

The Iridium payload is heavy, and there would not be enough fuel for the rocket to successfully return to VAFB or the contingency landing area offshore of VAFB and perform a boost-back landing. Therefore, a new boost-back landing area is needed in addition to landing at the SLC 4W pad and the conditional landing area described in the EA to accommodate the boost-back and landing of heavier payloads for the Falcon 9, which could be used up to six times per year.

1.3 Project Location

VAFB occupies approximately 99,100 acres (ac.) (400 square kilometers [km²]) of central Santa Barbara County, California (Figure 1-1), approximately halfway between San Diego and San Francisco. VAFB occurs in a transitional ecological region that includes the northern and southern distributional limits for many plant and animal species. The Santa Ynez River and State Highway 246 divide VAFB into two distinct parts: North Base and South Base.

The proposed Iridium Landing Area would be located approximately 122 nm (225 km) southwest of San Nicolas Island coastal waters and 133 nm (245 km) southwest of San Clemente Island coastal waters and may extend as far north as 32nd parallel north (32°N), as far east as the Patton Escarpment, and as far south and west as the U.S. Pacific Coast Region Exclusive Economic Zone (Figure 1-2). The Iridium Landing Area includes portions of the Department of the Navy’s Southern California Range Complex and the Western San Clemente Operating Area.

1.4 Scope of the Supplemental Environmental Assessment

This SEA is tiered from and is intended to supplement and update the Falcon 9 Boost-Back EA (USAF, 2016). This assessment expands the scope of previous analysis to include the Iridium Landing Area. Agencies are required to prepare supplemental environmental assessments when there is a substantial change to a proposed action that is relevant to environmental concerns, or if there are significant new circumstances or information relevant to environmental concerns and bearing on the proposed action or its environmental impacts (40 C.F.R. § 1502.9[c]).

A detailed review of the Falcon 9 Boost-Back EA was conducted, which concluded that there was no new information or change to the project other than the addition of the proposed Iridium Landing Area as a conditional landing area. Resources that are potentially affected by this change are considered in more detail to determine whether additional analysis is required (40 C.F.R. § 1501.4[c]).
Figure 1-1. Regional Location of Iridium Landing Area
Figure 1-2. Proposed Project Area and Vicinity
This SEA identifies, describes, and evaluates the potential environmental impacts that could result from the Proposed Action and the No Action Alternative, as well as possible cumulative impacts from other past, present, and reasonably foreseeable actions within the region of influence. The SEA identifies environmental permits relevant to the Proposed Action. The SEA describes, in terms of a regional overview or a site-specific description, the affected environment and environmental consequences of the action. Finally, the SEA identifies management measures to avoid, prevent, or minimize environmental impacts.

1.5 Interagency and Intergovernmental Coordination and Consultation

Under the Coastal Zone Management Act (CZMA) of 1972 (16 U.S.C. 2452–24645), a federal action that may affect the coastal zone must be carried out in a manner that is consistent with state coastal zone management programs. On 31 August 2015, the California Coastal Commission (CCC) concurred with a negative determination (ND) (ND-0027-15) for recurring Falcon 9 first stage boost-back landings at SLC-4W or a barge approximately 27 nm (50 km) offshore of VAFB. The Executive Director determined that the proposed project would not adversely affect coastal resources. The USAF determined the proposed new Iridium Landing Area does not raise any new coastal resource issues not previously addressed and the CCC concurred with this determination (Appendix A).

Under Section 7 of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 et seq.), federal agencies are required to assess the effect of projects authorized, funded by, or carried out by federal agencies on federally listed threatened or endangered species. Section 7 consultations with the U.S. Fish and Wildlife Service (USFWS) and National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NOAA Fisheries) are required for federal projects if such actions have the potential to directly or indirectly affect listed species or destroy or adversely modify critical habitat. The proposed addition of the Iridium Landing Area would not affect any federally listed species that are managed by USFWS. VAFB initiated informal consultations with NOAA Fisheries for non-adverse impacts to federally protected wildlife species associated with the boost-back and landing of the Falcon 9 Full Thrust First Stage offshore of VAFB (USAF, 2016). VAFB reinitiated informal consultation under Section 7 of the ESA with NOAA Fisheries for the Iridium Landing Area and received concurrence that the proposed action was not likely to adversely affect federally listed species (Appendix B).

The Fishery Conservation and Management Act (16 U.S.C. §§ 1801–1882), as amended and reauthorized by the Magnuson-Stevens Fishery Conservation and Management Act, provides NOAA Fisheries legislative authority to regulate fisheries and protect important habitat through the creation of Essential Fish Habitat (EFH) as necessary habitat for fish spawning, breeding, feeding, and growth to maturity. VAFB prepared an EFH Assessment and reinitiated consultation with NOAA Fisheries, who concurred that the action may adversely affect EFH; however only temporary and no more than minimal effects are expected (Appendix B).

Per the Marine Mammal Protection Act of 1972 (16 U.S.C. §§ 1361 et seq.), SpaceX obtained an incidental harassment authorization (IHA) for pinniped species for the boost-back and landing at SLC-4W and the contingency landing approximately 27 nm (50 km) offshore of VAFB (Appendix B). SpaceX notified NOAA Fisheries of the proposed boost-back and landing at the Iridium
Landing Area on 2 August 2016. NOAA Fisheries determined that boost-back and landing at the Iridium Landing Area would not result in a take of a marine mammal, and no revision of SpaceX's IHA was needed on 3 August 2016 (Appendix B).
2 Description of the Proposed Action and Alternatives

This chapter provides detailed descriptions of the Proposed Action (Alternative 1) and the No Action Alternative. Chapter 2 also describes selection criteria used to identify and select alternatives and summarizes alternatives that were considered but eliminated from further analysis.

2.1 Introduction

The Falcon 9 Full Thrust First Stage is 12 feet (ft.) (3.7 meters [m]) in diameter and 160 ft. (49 m) in height, including the interstage that would be attached during landing. The First Stage includes nine Merlin engines with a total lift off thrust of approximately 1.53 million pounds (lb.) and consists of aluminum liquid oxygen (LOX) and rocket propellant (RP-1) tanks that hold approximately 662,250 lb. of LOX and 260,760 lb. of RP-1. Pursuant to the 2011 EA, the First Stage is dropped into the Pacific Ocean, approximately 261–435 nm (480–800 km) west of the Baja California coast, and is non-recoverable.

The Falcon 9 Boost-Back EA (USAF, 2016) proposed the boost-back and landing of a recoverable First Stage, which features a partially reusable launching system. This EA analyzed the construction of a new concrete landing pad at SLC-4W and proposed boost-back maneuver (in-air), return flight, and landing of the Falcon 9 First Stage on a new SLC-4W pad. The EA also included a conditional landing area on an autonomous barge located at least approximately 27 nm (50 km) offshore of VAFB and implementation of an autonomous flight termination system.

The Proposed Action for this SEA includes the Falcon 9 boost-back and landing on an autonomous barge within the Iridium Landing Area. The Iridium Landing Area was not previously analyzed. This landing area would be used for heavier payloads when a rocket cannot return to VAFB and may be used up to six times per year.

2.2 Selection Criteria

A range of reasonable alternatives were identified by evaluating the ability of each alternative to meet the purpose of and need for the Proposed Action and their ability to meet the following selection criteria.

- Criterion 1: Support a boost-back trajectory that would achieve the lowest stress on the rocket during re-entry.
- Criterion 2: Be able to achieve boost-back trajectory with a relatively small amount of fuel remaining after the primary mission compared to smaller missions.
- Criterion 3: Minimize potential negative effects to the environment.
- Criterion 4: Accommodate landing locations as far from the coastline as possible.
- Criterion 5: Allow for shelter of the recovery vessels on the leeward side of an island to reduce impact to recovery personnel and equipment during six-hour transit from “protected location” to final landing location.

In addition, CEQ Regulations for Implementing the Procedural Provisions of NEPA (40 C.F.R. Parts 1500–1508) require federal agencies to use the NEPA process to identify and assess the
reasonable alternatives to the Proposed Action that would avoid or minimize adverse effects of those actions on the quality of the human environment. A number of alternatives were originally considered but dismissed from detailed analysis in the Falcon 9 Boost-Back EA (USAF, 2016). The Proposed Action was carried forward for further evaluation because this alternative best met the purpose and need and the selection criteria.

2.3 Alternative 1 (Proposed Action)

As an alternative to landing the Falcon 9 Full Thrust First Stage on the SLC-4W pad at VAFB or on a drone ship no less than approximately 27 nm (50 km) offshore of VAFB, SpaceX proposes to land the Falcon 9 Full Thrust First Stage on an autonomous barge within the Iridium Landing Area (Proposed Action). The Proposed Action is necessary to provide for an alternative landing location if it is determined that the rocket would not be able to make it safely back to VAFB or offshore of VAFB and perform a boost-back and landing.

Alternative 1 meets all of the selection criteria, except for Criterion 4, and has been selected as the Proposed Action because the contingency landing location is the furthest SpaceX is able to place the landed stage from the coastline while maintaining a boost-back trajectory that would reduce the stress on the rocket. Thus, this alternative would preserve the rocket for repeated use and accommodate heavier payloads.

The Iridium Landing Area would be used as a contingency landing area for up to six landings per year. There would be no change to the rocket, vessels, equipment, and personnel performing this action as described in the Falcon 9 Boost-Back EA (USAF, 2016). The rocket would still launch from VAFB and the autonomous drone ship would launch from the Port of Long Beach. The landing noise, vessel noise, and explosion noise and debris would all be the same as that described for the contingency landing area in the Falcon 9 Boost-Back EA. The primary difference between the barge landing off the coast of VAFB and the barge landing within the Iridium Landing Area would be the landing location.

2.3.1 Falcon 9 Boost-Back and Landing

As described in the Falcon 9 Boost-Back EA (USAF, 2016), SpaceX proposes to return the Falcon 9 Full Thrust First Stage to SLC-4W at VAFB for potential reuse. 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 triggered to flip the First Stage into position for retrograde burn. Three of the nine First Stage Merlin 1D engines would restart to conduct the retrograde burn 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 be cut off to end the boost-back burn. The First Stage should 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 should slow the First Stage to a velocity of zero before landing on the landing pad at SLC 4W. Figure 2-1 provides a graphical depiction of the boost-back and landing sequence. The frequency of boost-back and landings at SLC-4W of the Falcon 9 Full Thrust First Stage would be up to six per year.
Boost-back trajectories would be specific to each particular mission but would fall within lower and upper limit azimuths (153 degrees to 301 degrees), as defined for the Western Range in Volume 1 (1 July 2004) of the AFSPCMA 91-710, Range Safety Requirements. Figure 2-2 shows an example of the boost-back trajectory of the First Stage and the second stage trajectory. The detailed sequence of events for First Stage landing along with trajectory data would be provided in the Flight Safety Data Plan (FSDP) once it is finalized.

SpaceX would submit a Final Flight Data Package (FFDP) to the 30th Space Wing, Office of the Chief of Safety (30 SW/SE) specific to each particular mission to assess the acceptance of flight and determination of the hazards to the general public. This data would be used to perform launch vehicle risk assessments, develop in-flight abort criteria and identify risk mitigation measures (e.g., evacuation of launch area, definition of hazardous airspace/seascape) to ensure safety of flight. Each stage of the Falcon 9 vehicle would have a USAF-approved Flight Termination System that would be used to explode the stage and terminate its flight if any of the predetermined flight criteria are violated during flight.

![Diagram](image)

**Figure 2-1. Stages of Boost-Back and Propulsive Landing**
Figure 2-2. Trajectories for Variations of the Contingency First Stage Return Path to a Drone Ship Landing within the Iridium Landing Area (yellow line)

The landing trajectory would take into account all valuable assets to minimize risk of impact from potential debris corridors if the flight must be terminated.

Prior to a drone ship landing, a Notice to Mariners and a Notice to Airmen for all pilots would be issued via the Range. As described in the Falcon 9 Boost-Back EA, three vessels would be required for a drone ship landing:

1. Drone Ship/Landing Platform – approximately 300 ft. (91.4 m) long and 150 ft. (45.7 m) wide
2. Support Vessel – approximately 165 ft. (50.3 m) long research vessel
3. Ocean Tug – 120 ft. (36.6 m) open water commercial tug

The support vessels would originate from Long Beach Harbor to position for support for contingency landings. The tug and support vessel would be staged just outside of the landing location. The drone ship to be used as the landing platform is a McDonough Marine Deck Barge with dimensions of 300 ft. (91.4 m) by 100 ft. (30.5 m) (Figure 2-3). The barge has an operational
displacement of 24,000,000 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. (45.7 m) and installing a dynamic positioning system and a redundant communications and command and control system. Following barge modification, the drone ship was inspected by the U.S. Coast Guard; SpaceX has obtained a Certificate of Inspection for its operation under the service of Research Vessel.

![Image](image_url)

**Figure 2-3. Drone Ship Landing Platform**

The Support Vessel is a 165 ft. (50.3 m) long research vessel that is capable of housing the crew, instrumentation, and communication equipment, and supporting debris recovery efforts, if necessary. The U.S. Coast Guard would have a representative on this vessel and a representative in the Launch and Landing Control on VAFB during the operation to coordinate and approve access back to the drone ship after the landing.

The Tug is a 120 ft. (36.6 m) open-water commercial ocean vessel. The primary operation of the tug is to tow the drone ship into position at the landing area and tow the drone ship and rocket back to Long Beach Harbor. After landing, the First Stage would be secured onto the drone ship and transported to the Long Beach Harbor for off-loading and transport to a SpaceX testing facility in Hawthorne, California, 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. Hazardous materials would be off-loaded from the First Stage after the drone ship is docked in Long Beach Harbor (see Falcon 9 Boost-Back EA [USAF, 2016], for discussion of fuels).
The sonic boom and landing noise are an expected part of the Proposed Action and help define the region of influence for the affected environment. As such, they are described here and the effects of the expected sonic boom and landing noise are described further in Chapter 4 (Environmental Consequences). During descent, a sonic boom (overpressure of high-energy impulsive sound) would be generated while the first-stage booster is supersonic. The overpressure would be directed northward and would reach as high as 3.85 pounds per square foot (psf) within the Iridium Landing Area (Figure 2-4; Bradley, 2016). Engine noise from the landing would be less than the noise generated during the launch (Figure 2-5). The SLC-4W pad-based landing engine noise modeling was roughly extrapolated to show potential noise impacts for landing within the Iridium Landing Area. Neither the sonic boom nor the engine noise from landing would be heard on land.

Although propellants would be burned to depletion during flight, there is a potential for approximately 7,000 lb. of densified LOX and a maximum of 2,750 lb. of RP-1 to remain in the Falcon 9 Full Thrust First Stage upon landing, which is the same as that described within the Falcon 9 Boost-Back EA. Final volumes of fuel remaining in the First Stage upon landing may vary and would be included in the FSDP.

Safing activities would begin upon completion of all landing activities and engine shutdown. The LOX oxidizer system would be purged, and any excess fuel would be drained into a suitable truck mounted container or tanker for disposal or re-use. Any remaining pressurants (i.e., helium or nitrogen) would be vented, and any flight termination system (FTS) explosives would also be rendered “inert” prior to declaring the vehicle safe. The vehicle would then be lifted and placed onto the stand; the landing legs would then be removed or folded back into place. The vehicle would then be lowered into a horizontal position, placed on a transport vehicle and taken to a post-processing facility. A ground crew would perform and supervise all landing operations and would be familiar with the operating protocol including all potential “off nominal” events.
Figure 2-4. Estimation of a Sonic Boom Overpressure Drone Ship Landing within the Iridium Landing Area with an Incoming Trajectory for a Heavy Payload

Source: Bradley (2016)
Figure 2-5. Estimation of Landing Noise Intensity for Drone Ship Landing within the Iridium Landing
2.3.1.1 Concept of Operation for Drone Ship Landing

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

<table>
<thead>
<tr>
<th>Time</th>
<th>Action Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-12 Hours</td>
<td>Drone ship/landing platform on-station and crew begins system activations</td>
</tr>
<tr>
<td>T-6 Hours</td>
<td>Tow line is released and the drone ship is holding position via the dynamic positioning system</td>
</tr>
<tr>
<td>T-4 Hours</td>
<td>The crew transfers from the drone ship to the support vessel</td>
</tr>
<tr>
<td>T-2 Hours</td>
<td>The support vessel departs the area to a pre-determined staging area, and VAFB Range Safety is notified</td>
</tr>
<tr>
<td>T-1 Hour</td>
<td>The support vessel is at the staging area, and Range Safety has been notified</td>
</tr>
<tr>
<td>T+8 minutes</td>
<td>Landing occurs</td>
</tr>
<tr>
<td>T+10 minutes</td>
<td>Range Safety confirms it is safe for the support vessel and tug to return to the landing area and conveys permission to reenter area</td>
</tr>
<tr>
<td>T+60 minutes</td>
<td>The support vessel and tug are back at the landing area</td>
</tr>
<tr>
<td>T+2 hours</td>
<td>The drone ship/landing platform is secured to the tow line for towing to Long Beach Harbor</td>
</tr>
</tbody>
</table>

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

2.3.1.1.1 For an Unsuccessful Drone Ship Landing Attempt

As of 25 August 2016, SpaceX has attempted drone ship landings on 11 separate occasions, 10 off the coast of Florida and one off the coast of California (Figure 2-6). Seven of these attempts were not successful, including the attempt off the coast of California, and resulted in the First Stage impacting the drone ship and exploding. A photograph of the drone ship after one of the unsuccessful landing attempts is shown in Figure 2-7. In the event of an unsuccessful landing attempt, the First Stage would explode upon impact with the drone ship. A system safety analysis was performed by Bastion Services related to First Stage recovery operations. This analysis concentrated on safety hazards related to an unsuccessful First Stage landing attempt. The explosive equivalence of the First Stage with maximum fuel and oxidizer is 503 lb. 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.
Figure 2-6. Drone Ship Landing Attempt

Figure 2-7. Drone Ship Landing Platform after an Unsuccessful Landing Attempt
SpaceX has experience performing recovery operations after unsuccessful drone ship landings for previous Falcon 9 Full Thrust 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 drone ship landing. The surface area potentially impacted with debris would be less than 114 ac. (0.46 km²), 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 drone ship 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.

Upon impact with the drone ship, the First Stage should contain at most 2,750 lb. of RP-1 on board. If the landing is unsuccessful, most of this fuel would be burnt off during the subsequent explosion; residual fuel would be released onto the drone ship deck at the location of impact. In cases where the First Stage booster misses the drone ship entirely, SpaceX’s scientists deduce that 2,750 lb. of RP-1 would be released into the ocean. Final volumes of fuel remaining in the First Stage upon landing may vary and would be included in the FSDP, but SpaceX’s scientists anticipate it to be below the high range estimations. 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 one to two days after a spill. Cleanup following a spill is usually not necessary, or possible, with spills of very light oil, particularly with such a small quantity of oil (U.S. Fish and Wildlife Service 1998). Therefore, no attempt would be made to boom or recover RP-1, if any of the fuel is released directly into the ocean. Any RP-1 remaining on the drone ship deck from an unsuccessful landing attempt would be recovered, contained, and handled per federal, state, and local agency requirements.

The trajectory path of the First Stage for a drone ship landing was shown in Figure 2-2. The explosion of the First Stage would generate an in-air impulsive noise that would propagate in a radial fashion away from the drone ship. The potential impulse noise is anticipated to be similar to the contingency landing area offshore of VAFB. Figure 2-8 depicts the estimated blast noise for an unsuccessful drone ship landing attempt for the Iridium Landing Area, which was extrapolated from the contingency landing area model (USAF, 2016). 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. These estimates are conservatively overestimated for purposes of this assessment.
Figure 2-8. Estimated Explosion Blast Noise Intensity Map for an Unsuccessful Drone Ship Landing within the Iridium Landing Area
2.3.2 Environmental Protection Measures

The environmental protection measures (EPMs) described in the Falcon 9 Boost-Back EA (USAF, 2016) would continue to be implemented for the Falcon 9 boost-back and landing. The measures that would be applicable to the Iridium Landing Area are provided below. There would be no change to the measures identified for SLC-4W or at the contingency area offshore of VAFB.

Implementation of these EPMs would avoid or minimize potential adverse effects to various environmental resources. Mandatory EPMs (denoted by “shall” or “would”) are part of the project design and would be implemented as part of the Proposed Action to avoid, minimize, reduce, or compensate for the anticipated potential environmental impacts. Discretionary measures (denoted by “may” or “could”) may or may not be implemented to further reduce environmental impacts. Implementation of all measures would be overseen by qualified SpaceX personnel or contractor staff.

2.3.2.1 Biological Resources – 4 (Bio-4)

The following measures would be implemented to monitor potential impacts to offshore marine mammals and the offshore marine environment:

- Sonic boom modeling will be performed prior to each boost-back event. Launch parameters specific to each launch will be incorporated into each model to predict peak amplitudes and impact locations.
- Acoustic measurements of the sonic boom created during boost-back at the monitoring location would be recorded to determine the overpressure level.
- A compensatory mitigation plan will be implemented to offset adverse effects to the EFH resulting from the discharge of unrecoverable marine debris.

2.3.2.2 Human Health and Safety

The following measures would be implemented to minimize the potential for adverse impacts on human health and safety:

- All safety precautions for SLC-4 Operations and evacuation procedures for the project site area would be followed per Space Launch Vehicle Flight Hazard Zone requirements.
- SpaceX and subcontractors would comply with federal Occupational Safety and Health Administration (OSHA), Air Force Occupational Safety and Health (AFOSH), and California’s Division of Occupational Safety and Health (Cal/OSHA) requirements.
- SpaceX would prepare and submit a health and safety plan to VAFB and would appoint a trained individual as safety officer.

2.3.2.3 Hazardous Materials and Waste

The fueling of support vessels and equipment would occur at port. Spill containment equipment would be present at all project areas where fuels or other hazardous substances are brought to the area. In addition, qualified personnel would conduct daily inspections of the equipment and the staging and maintenance areas for leaks of hazardous substances.
2.4 No Action Alternative

Under the No Action Alternative, the Iridium Landing Area would not be used for boost-back and landing of the Falcon 9. The No Action Alternative does not meet the purpose of and need for the Proposed Action because the Falcon 9 cannot return to VAFB with a heavier payload and perform a boost-back and landing.

2.4.1 Other Alternatives Considered But Eliminated from Further Analysis

Other alternatives that were considered for this action but were determined to be unreasonable to meet the underlying purpose of and need for the Proposed Action are described as follows:

SpaceX considered using a parachute system for the Iridium mission and splashing down off the coast of Baja California, Mexico. However, SpaceX had run several tests on this system, none of which were successful. SpaceX could not control the rocket upon reentry, and the stress of reentry ripped apart the parachute. Therefore, this alternative would not meet Criterion 1 (support a boost-back trajectory that would achieve the lowest stress on the 30 rocket during reentry) and was eliminated from consideration for purposes of this SEA. No other reasonable alternatives were identified and carried forward for analysis.
3  Affected Environment

This chapter describes the existing environment near and within the project area for Alternative 1 (Proposed Action) and the No Action Alternative. The area considered for most resources was within the Iridium Landing Area and those areas potentially impacted by overpressure and landing noise. A wider regional area was evaluated for some environmental resources.

The resources identified for analysis in this SEA include air quality and climate, biological resources, water resources, and coastal zone management. The following resources were considered but not analyzed in this SEA because the resource would not be affected or there would be no change from what was analyzed in the Falcon 9 Boost-Back EA:

- **Environmental Justice.** Because the Proposed Action would occur offshore, there would be no impact to minority or low-income communities. Therefore, this resource was considered but not analyzed in this SEA.

- **Socioeconomics.** The Proposed Action would not have a socioeconomic impact on the region. Therefore, this resource was considered but not analyzed in this SEA.

- **Children’s Environmental Health and Safety Risks.** Because the Proposed Action would occur offshore in the open ocean, and because noise (engine noise and sonic boom) would not impact land, there would be no effects to children.

- **Recreation.** The Proposed Action would not impact recreation given its location from shore. Therefore, this resource was considered but not analyzed in this SEA.

- **Department of Transportation Act, Section 4(f).** Because the Proposed Action would occur offshore in the open ocean, and because noise (engine noise and sonic boom) would not impact a Section 4(f) property, there would be no effects to Section 4(f) properties.

- **Floodplains.** The Proposed Action would not impact floodplains. Therefore, this resource was considered but not analyzed in this SEA.

- **Sound (Airborne).** The sonic boom, explosion, and landing noise would not overlap any sensitive receptor, such as residential, educational, health, and religious structures and sites; parks; recreational areas (including areas with wilderness characteristics); wildlife refuges; and cultural and historical sites. Given that noise from boost-back activities would occur well offshore of sensitive receptors, there would be no significant impacts
associated with implementation of the Iridium Landing Area. Therefore, this resource was considered but not analyzed in this SEA.

- **Cultural Resources.** There are no known cultural resources within the Iridium Landing Area. Therefore, this resource was considered but not analyzed in this SEA.

- **Geology and Earth Resources.** The Proposed Action would not affect geology or earth resources. Therefore, this resource was considered but not analyzed in this SEA.

- **Natural Resources and Energy Supply.** The Proposed Action would not require utility use above that required for the launch. The Proposed Action would not result in the development of new facilities or result in consumption of natural resources. Therefore, there would be no additional impacts related to natural resources and energy supply.

- **Human Health and Safety.** The Falcon 9 Boost-Back EA analyzed the project's impact on human health and safety (USAF, 2016). There would be no additional conditions that could adversely impact human health and safety that were not analyzed in the Falcon 9 Boost-Back EA. All activities would continue to be subject to the requirements of the federal OSHA, Air Force Office of Safety and Health (AFOSH), and California OSHA regulations and procedures. In addition, missile/space launch, vehicle flight hazard zones, and explosive safety zones as well as debris impact corridors would continue to be utilized as described in the Falcon 9 Boost-Back EA. Therefore, the Proposed Action would not additionally affect human health and safety, and this resource was considered but not analyzed in this SEA.

- **Hazardous Materials and Waste Management.** The Falcon 9 Boost-Back EA analyzed the project's impact on hazardous materials and waste management (USAF, 2016). The Proposed Action would not change or alter the management of hazardous waste or materials. In addition, the Proposed Action would not include any hazardous waste or materials that were not identified in the Falcon 9 Boost-Back EA. The Proposed Action would also not increase the amount of hazardous waste or materials described in the Falcon 9 Boost-Back EA. Therefore, the Proposed Action would not additionally affect hazardous materials and waste management, and this resource was considered but not analyzed in this SEA.

- **Solid Waste Management.** The Proposed Action would not change nor alter the management of solid waste as described in the Falcon 9 Boost-Back EA. In addition, the Proposed Action would not include any additional solid waste that was not identified in the Falcon 9 Boost-Back EA. Therefore, the Proposed Action would not additionally affect solid waste management, and this resource was considered but not analyzed in this SEA.

- **Land Use and Aesthetics.** Land use was considered but not analyzed in this SEA because the Proposed Action would not change land use or affect land use planning. Additionally, there would be no conversion of prime agricultural land to other uses, and no decrease in its productivity. The proposed Iridium Landing Area is far enough from shore that its
inclusion would have no impacts on land use or aesthetics. Therefore, this resource was considered but not analyzed in this SEA.

- **Transportation.** The same roads and ports would be used for the Iridium Landing Area as those discussed in the EA (USAF, 2016). Therefore, this resource was considered but not analyzed in this SEA. As discussed in the Falcon 9 Boost-Back EA, VAFB would issue a Notice to Airmen and a Notice to Mariners prior to drone ship landings at the Iridium Landing Area.

3.1 Air Quality and Climate

3.1.1 Definition of Resource

Air quality is defined by ambient air concentrations of specific pollutants determined by the U.S. Environmental Protection Agency (USEPA) to be of concern with respect to the health and welfare of the general public. Six major pollutants of concern, called “criteria pollutants,” are carbon monoxide (CO), sulfur dioxide (SO₂), nitrogen dioxide (NO₂), ozone (O₃), suspended particulate matter less than or equal to 10 microns in diameter (PM₁₀), fine particulate matter less than or equal to 2.5 microns in diameter (PM₂.₅), and lead (Pb). The USEPA has established National Ambient Air Quality Standards (NAAQS) for these pollutants. Areas that violate a federal air quality standard are designated as non-attainment areas.

Climate change is a global phenomenon that can have local impacts. Scientific measurements show that Earth’s climate is warming, with concurrent impacts including warmer air temperatures, increased sea level rise, increased storm activity, and an increased intensity in precipitation events. Research has shown there is a direct correlation between fuel combustion and greenhouse gas (GHG) emissions. GHGs are defined as including carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride. CO₂ is the most important anthropogenic GHG because it is a long-lived gas that remains in the atmosphere for up to 100 years.

3.1.2 Regional Setting

VAFB is within Santa Barbara County and under the jurisdiction of the Santa Barbara County Air Pollution Control District (SBCAPCD). The SBCAPCD is the agency responsible for the administration of federal and state air quality laws, regulations, and policies in Santa Barbara County, which is within the South Central Coast Air Basin (SCCAB). The SCCAB includes San Luis Obispo, Santa Barbara, and Ventura Counties.

Support vessels would originate from Long Beach Harbor and transit to the Iridium Landing Area. Long Beach Harbor and adjacent coastal waters are within Los Angeles County and under the jurisdiction of the South Coast Air Quality Management District (SCAQMD), which is part of South
Coast Air Basin (SCAB). The SCAB includes Los Angeles County, Orange County, and Western San Bernardino County.

3.1.3 Region of Influence

For purposes of this EA, the Region of Influence (ROI) is defined by the difference in activities from the Falcon 9 EA (USAF, 2016), which concentrated activities in the SCCAB. As indicated in Chapter 2, the primary difference in activities is the usage of the Iridium Landing Site. With regards to air quality, the primary difference would be the route that the support barges take to reach the Iridium Landing Site, which begins in the Long Beach Harbor and transits south/southwest. Therefore, the ROI for this analysis is Long Beach Harbor and adjacent coastal waters, which are in the SCAB and, for purposes of GHG calculations, south of the Iridium Landing Area.

3.1.4 Federal Requirements

The USEPA is the agency responsible for enforcing the Clean Air Act (CAA) of 1970 and its 1977 and 1990 amendments. The purpose of the CAA is to establish NAAQS, classify areas as to their attainment status relative to the NAAQS, develop schedules and strategies to meet the NAAQS, and regulate emissions of criteria pollutants and air toxics to protect public health and welfare. Under the CAA, individual states are allowed to adopt ambient air quality standards and other regulations, provided they are at least as stringent as federal standards. The Clean Air Act Amendments (CAAA) (1990) established new deadlines for achievement of the NAAQS, dependent upon the severity of non-attainment.

The USEPA requires each state to prepare a State Implementation Plan (SIP), which describes how that state will achieve compliance with the NAAQS. A SIP is a compilation of goals, strategies, schedules, and enforcement actions that will lead the state into compliance with all federal air quality standards.

The CAAA also require that states develop an operating permit program that would require permits for all major sources of pollutants. The program would be designed to reduce mobile source emissions and control emissions of hazardous air pollutants through establishing control technology guidelines for various classes of emission sources.

New Source Review: A New Source Review (NSR) is required when a source has the potential to emit any pollutant regulated under the CAA in amounts equal to or exceeding specified major source thresholds (100 or 250 tons per year) which are predicated on a source’s industrial category. Through the SBCAPCD’s permitting processes, all stationary sources are reviewed and are subject to an NSR process.

Executive Order 13693: This EO, Planning for Federal Sustainability in the Next Decade, was signed by President Obama on 19 March 2015. The EO sets a goal of reducing Federal agency GHG emissions by 40 percent over the next decade. The EO sets agency GHG reduction targets and sustainability goals, and requires the head of each Federal agency to propose (to the Chair of the CEQ and the Director of the Office of Management and Budget) percentage reduction targets for agency-wide reductions of scope 1 and 2 and scope 3 GHG emissions in absolute terms by the
end of fiscal year 2025 relative to a fiscal year 2008 baseline. The EO also sets sustainability goals
for Federal agencies.

**General Conformity:** Under 40 C.F.R. Part 93 and the provisions of Part 51, Subchapter C.,
Chapter I, Title 40, Appendix W of the C.F.R., of the CAA as Amended, federal agencies are
required to demonstrate that federal actions conform with the applicable SIP. The USEPA general
conformity rule applies to federal actions occurring in non-attainment or maintenance areas.

In August 2016, CEQ released final guidance regarding the consideration of GHGs in NEPA
documents for federal actions (CEQ, 2016). The 2016 guidance encourages agencies to draw from
their experience and expertise to determine the appropriate level and type of analysis required
to comply with NEPA; discusses methods to appropriately analyze reasonably foreseeable direct,
indirect, and cumulative GHG emissions and climate effects; and recommends that agencies
quantify a proposed action’s projected direct and indirect GHG emissions, taking into account
available data and GHG quantification tools.

### 3.1.5 Local Requirements

The ROI for this analysis is Long Beach Harbor and adjacent coastal waters, which are in the SCAB
under the jurisdiction of the SCAQMD. The SCAB is classified as an attainment/unclassified area
for the NAAQS for CO, NO₂, SO₂, and PM₁₀, and a nonattainment area for O₃. The SCAB is
considered a nonattainment area for the California Ambient Air Quality Standards (CAAQS) for
O₃, PM₁₀ and PM₂.₅. The SCAB is classified as an attainment/unclassified area for the CAAQS for
other criteria pollutants. Table 3-1 presents a summary of ambient air quality measurements for
the period of 2013–2015 at the Long Beach Monitoring Station, along with the CAAQS and NAAQS
attainment/nonattainment designations.

**Table 3-1. Background Ambient Air Quality at Long Beach Monitoring Stations**

(concentrations in ppm unless otherwise indicated)

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Averaging Time</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>CAAQS (ppm)</th>
<th>CAAQS Designation</th>
<th>NAAQS (ppm)</th>
<th>NAAQS Designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ozone</td>
<td>8 hour</td>
<td>0.069</td>
<td>0.072</td>
<td>0.066</td>
<td>0.070</td>
<td>Nonattainment</td>
<td>0.075*</td>
<td>Nonattainment (extreme)</td>
</tr>
<tr>
<td></td>
<td>1 hour</td>
<td>0.090</td>
<td>0.087</td>
<td>0.087</td>
<td>0.09</td>
<td>Nonattainment</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>PM₁₀</td>
<td>Annual</td>
<td>N/A</td>
<td>29.5</td>
<td>31.3</td>
<td>20 µg/m³</td>
<td>Nonattainment</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Arithmetic Mean</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>24 hour</td>
<td>N/A</td>
<td>84.0</td>
<td>80.0</td>
<td>50 µg/m³</td>
<td>Nonattainment</td>
<td>150 µg/m³</td>
<td>Attainment (maintenance)</td>
</tr>
<tr>
<td>PM₂.₅</td>
<td>Annual</td>
<td>N/A</td>
<td>N/A</td>
<td>12.9</td>
<td>12 µg/m³</td>
<td>Nonattainment</td>
<td>12.0 µg/m³</td>
<td>Nonattainment (serious)</td>
</tr>
<tr>
<td></td>
<td>Arithmetic Mean</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>24 hour</td>
<td>N/A</td>
<td>N/A</td>
<td>48.8</td>
<td>-</td>
<td>-</td>
<td>35 µg/m³</td>
<td>Nonattainment (serious)</td>
</tr>
<tr>
<td>NO₂</td>
<td>Annual</td>
<td></td>
<td></td>
<td></td>
<td>0.030</td>
<td>Attainment</td>
<td>0.053</td>
<td>Attainment (maintenance)</td>
</tr>
<tr>
<td></td>
<td>1 hour</td>
<td>81.2</td>
<td>135.9</td>
<td>101.8</td>
<td>0.18</td>
<td>Attainment</td>
<td>0.100</td>
<td>Unclassifiable/Attainment</td>
</tr>
</tbody>
</table>

**Final Supplemental Environmental Assessment**

*Boost-Back & Landing of Falcon 9 Full Thrust First Stage at Iridium Landing Area*
3.2 Biological Resources

The following biological resources are present within the affected environment of Alternative 1 (Proposed Action) including special status wildlife species, and sensitive marine habitats. No vegetation types or special status plant species would be affected; therefore, these resources are not discussed further.

Under Section 7 of the ESA of 1973, as amended (16 U.S.C. 1531 et seq.), federal agencies are required to assess the effect of any project on species that are federally threatened, endangered, or proposed for listing based on the best scientific data available. Section 7 consultations with the USFWS and NOAA Fisheries are required for federal projects if such actions have the potential to directly or indirectly affect listed species, or destroy or adversely modify critical habitat.

It is also USAF policy to consider species listed by state agencies and other federal special status species when evaluating the impacts of a project. In California, these include “fully protected” wildlife species, which are protected by the California Department of Fish and Wildlife, per the California Fish and Game Code Sections 3511, 4700, 5050, and 5515. Although not subject to the requirements of the California Endangered Species Act, as a goal of its Integrated Natural Resource Management Plan, VAFB also protects and conserves species considered sensitive by the state when not in direct conflict with the military mission.

The Marine Mammal Protection Act (MMPA) of 1972 (16 U.S.C. §§ 1361–1407) restricts the taking of marine mammals, and its implementing regulations at 50 C.F.R. Part 216 prohibit the “taking” of any marine mammals. Taking includes injuring, killing, or harassing a marine mammal stock in the wild. The MMPA defines harassment as any act of pursuit, torment, or annoyance that has the potential to injure a marine mammal or marine mammal stock in the wild, or has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding,
feeding, or sheltering. Implementation of the MMPA is a joint effort between NOAA Fisheries and USFWS. NOAA Fisheries is responsible for the management and conservation of cetaceans (whales and dolphins) and pinnipeds (seals and sea lions), while USFWS is responsible for southern sea otters.

The Fishery Conservation and Management Act (16 U.S.C. §§ 1801–1882), as amended and reauthorized by the Magnuson-Stevens Fishery Conservation and Management Act, provides NOAA Fisheries legislative authority to regulate fisheries and protect important habitat through the creation of EFH as necessary habitat for fish spawning, breeding, feeding, and growth to maturity.

VAFB is also subject to the requirements of the Migratory Bird Treaty Act (MBTA) of 1918 (16 U.S.C. §§ 703–712) as amended. Under the MBTA, agencies are prohibited from pursuing, hunting, taking, capturing, possessing, importing, exporting, transporting, selling, purchasing, bartering, or offering for sale migratory birds or attempting to engage in such activities (16 U.S.C. § 703).

3.2.1 Region of Influence

The existing biological setting includes the regional setting of the Iridium Landing Area and areas potentially impacted by sonic boom, landing noise, and noise of potential explosion. The ROI of Alternative 1 (Proposed Action) is shown in Figures 2-4, 2-5, and 2-8, and overlaps wildlife resources, including special status marine species and sensitive marine habitats occurring in these regions of potential impacts, which are discussed below.

3.2.2 Methodology

Potentially affected biological resources were determined by considering all areas potentially impacted by visual disturbance, direct impact, landing noise, explosion noise, and sonic boom within the ROI. The California Natural Diversity Database, the Cetacean Density and Distribution Mapping Working Group records, North American range maps for seabird species (Sibley, 2003), and marine mammal density estimates (U.S. Department of the Navy, 2016) were reviewed to assess the potential occurrence, distribution, and habitat use of wildlife resources, including special status species, within the Action Area.

3.2.3 Special Status Species

The ROI for special status wildlife species includes marine areas that would potentially be affected by impacts of Alternative 1 (Proposed Action), primarily acoustic impacts, but also by expended materials in the vicinity of the Iridium Landing Area. Fish, sea turtle, marine mammal, and seabird species protected under the MBTA, ESA, or MMPA and managed by NOAA Fisheries have the potential to occur in the vicinity of the Iridium Landing Area.

Table 3-2 lists special status species that may occur within ROI of Alternative 1 (Proposed Action). The likelihood of ESA-listed seabirds occurring within the area potentially impacted during a Iridium landing event is very low; thus, it is highly unlikely that any of individual ESA-listed sea birds would be adversely affected under Alternative 1, and ESA-listed species are not carried forward for analyses. No additional species may be present within the ROI other than
those discussed in the Falcon 9 Boost-Back EA (USAF, 2016). Brief descriptions of these species and their potential for occurring in the project area were provided in the Falcon 9 Boost-Back EA (USAF, 2016); therefore, descriptions are not included here.

Table 3-2. Special Status Species within the Region of Influence

<table>
<thead>
<tr>
<th>Species</th>
<th>Conservation Status</th>
<th>Occurrence/Estimated Density within Proposed Action Area</th>
<th>Habitat</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fish</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steelhead trout Oncorhynchus mykiss</td>
<td>FE</td>
<td>Potential</td>
<td>The California Current and open ocean</td>
</tr>
<tr>
<td>Scalloped Hammerhead Shark Sphyrna lewini</td>
<td>FE</td>
<td>Common</td>
<td>Open ocean at depths of 1,000 meters, and coastal waters</td>
</tr>
<tr>
<td>Green sturgeon Acipenser medirostris</td>
<td>FT</td>
<td>Potential</td>
<td>Coastal marine at depths of 20–70 meters</td>
</tr>
<tr>
<td>Basking shark Cetorhinus maximus</td>
<td>SOC</td>
<td>Common</td>
<td>The California Current and open ocean</td>
</tr>
<tr>
<td>Bocaccio Sebastes paucispinis</td>
<td>SOC</td>
<td>Common</td>
<td>The California Current and open ocean</td>
</tr>
<tr>
<td>Cowcod Sebastes levis</td>
<td>SOC</td>
<td>Common</td>
<td>The California Current and open ocean</td>
</tr>
<tr>
<td><strong>Sea Turtles</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Green sea turtle Chelonia mydas</td>
<td>FT/FE1</td>
<td>Potential</td>
<td>Tropical and subtropical coastal and open ocean waters; rocky ridges, channels, and floating kelp</td>
</tr>
<tr>
<td>Hawksbill sea turtle Eretmochelys imbricata</td>
<td>FE</td>
<td>Very Rare</td>
<td>Tropical coastal and open ocean waters</td>
</tr>
<tr>
<td>Loggerhead sea turtle Caretta caretta</td>
<td>FE2</td>
<td>Rare</td>
<td>Temperate to tropical regions with coastal estuaries to the open ocean</td>
</tr>
<tr>
<td>Olive ridley sea turtle Lepidochelys olivacea</td>
<td>FT/FE3</td>
<td>Potential</td>
<td>Primarily open ocean in tropical and subtropical regions</td>
</tr>
<tr>
<td>Leatherback sea turtle Dermochelys coriacea</td>
<td>FE</td>
<td>Potential</td>
<td>Tropical to subpolar oceans; open ocean and rarely coastal waters</td>
</tr>
<tr>
<td><strong>Pinnipeds</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pacific Harbor Seal Phoca vitulina richardsi</td>
<td>NL</td>
<td>Unlikely</td>
<td>Rocks and beach haul-outs, nearshore</td>
</tr>
<tr>
<td>California Sea Lion Zalophus californianus</td>
<td>NL</td>
<td>Unlikely</td>
<td>Rocks and beach haul-outs, nearshore</td>
</tr>
<tr>
<td>Northern Elephant Seal Mirounga angustirostris</td>
<td>NL</td>
<td>Rare</td>
<td>Rocks and beach haul-outs, nearshore</td>
</tr>
<tr>
<td>Steller Sea Lion Eumetopias jubatus</td>
<td>FD</td>
<td>Unlikely</td>
<td>Rocks and beach haul-outs, nearshore</td>
</tr>
<tr>
<td>Northern Fur Seal Callorhinus ursinus</td>
<td>NL, D/4</td>
<td>Unlikely</td>
<td>Rocks and beach haul-outs, nearshore</td>
</tr>
<tr>
<td>Guadalupe Fur Seal Arctocephalus townsendi</td>
<td>FT, D</td>
<td>Rare</td>
<td>Open ocean</td>
</tr>
<tr>
<td><strong>Cetaceans</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Humpback whale Megaptera novaeangliae</td>
<td>FE, D</td>
<td>Common Seasonal</td>
<td>Open ocean and coastal waters</td>
</tr>
<tr>
<td>Blue whale Balaenoptera musculus</td>
<td>FE, D</td>
<td>Common Seasonal</td>
<td>Open ocean and coastal waters</td>
</tr>
<tr>
<td>Fin whale Balaenoptera physalus</td>
<td>FE, D</td>
<td>Common year-round</td>
<td>Offshore waters, open ocean</td>
</tr>
<tr>
<td>Sei whale Balaenoptera borealis</td>
<td>FE, D</td>
<td>Rare</td>
<td>Offshore waters, open ocean</td>
</tr>
<tr>
<td>Species</td>
<td>Range</td>
<td>Habitat</td>
<td></td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>------------</td>
<td>--------------------------------</td>
<td></td>
</tr>
<tr>
<td>Bryde’s whale <em>Balaenoptera brydei/edeni</em></td>
<td>NL</td>
<td>Rare</td>
<td></td>
</tr>
<tr>
<td>Minke whale <em>Balaenoptera acutorostrata</em></td>
<td>NL</td>
<td>Common</td>
<td></td>
</tr>
<tr>
<td>Gray whales <em>Eschrichtius robustus</em></td>
<td>FE/NL, D</td>
<td>Seasonal</td>
<td></td>
</tr>
<tr>
<td>Sperm whale <em>Physeter macrocephalus</em></td>
<td>FE, D</td>
<td>Common year-round</td>
<td></td>
</tr>
<tr>
<td>Pygmy sperm whale <em>Kogia breviceps</em></td>
<td>NL</td>
<td>Potential</td>
<td></td>
</tr>
<tr>
<td>Dwarf sperm whale <em>Kogia sima</em></td>
<td>NL</td>
<td>Potential</td>
<td></td>
</tr>
<tr>
<td>Killer whale <em>Orcinus arca</em></td>
<td>NL</td>
<td>Uncommon</td>
<td></td>
</tr>
<tr>
<td>Short-finned pilot whales <em>Globicephala macrorhynchus</em></td>
<td>NL</td>
<td>Uncommon</td>
<td></td>
</tr>
<tr>
<td>Long-beaked common dolphins <em>Delphinus capensis</em></td>
<td>NL</td>
<td>Uncommon</td>
<td></td>
</tr>
<tr>
<td>Short-beaked common dolphins <em>Delphinus delphis</em></td>
<td>NL</td>
<td>Common</td>
<td></td>
</tr>
<tr>
<td>Common bottlenose dolphin <em>Tursiops truncates</em></td>
<td>NL</td>
<td>Common</td>
<td></td>
</tr>
<tr>
<td>Striped dolphin <em>Stenella coeruleoalba</em></td>
<td>NL</td>
<td>Uncommon</td>
<td></td>
</tr>
<tr>
<td>Rough-toothed dolphin <em>Steno bredanensis</em></td>
<td>NL</td>
<td>Rare</td>
<td></td>
</tr>
<tr>
<td>Pacific white-sided dolphin <em>Lagenorhynchus obliquidens</em></td>
<td>NL</td>
<td>Common</td>
<td></td>
</tr>
<tr>
<td>Northern right whale dolphin <em>Lissodelphis borealis</em></td>
<td>NL</td>
<td>Common</td>
<td></td>
</tr>
<tr>
<td>Risso’s dolphin <em>Grampus griseus</em></td>
<td>NL</td>
<td>Common</td>
<td></td>
</tr>
<tr>
<td>Dall’s Porpoise <em>Phocoenoides dalli</em></td>
<td>NL</td>
<td>Inshore/offshore</td>
<td></td>
</tr>
<tr>
<td>Cuvier’s beaked whale <em>Ziphius cavirostris</em></td>
<td>NL</td>
<td>Potential</td>
<td></td>
</tr>
<tr>
<td>Baird’s beaked whale <em>Berardius bairdi</em></td>
<td>NL</td>
<td>Potential</td>
<td></td>
</tr>
<tr>
<td>Blainville’s beaked whale <em>Mesoplodon densirostris</em></td>
<td>NL</td>
<td>Potential</td>
<td></td>
</tr>
<tr>
<td>Ginkgo-toothed beaked whale <em>Mesoplodon ginkgodens</em></td>
<td>NL</td>
<td>Potential</td>
<td></td>
</tr>
<tr>
<td>Perrin’s beaked whale <em>Mesoplodon perrini</em></td>
<td>NL</td>
<td>Potential</td>
<td></td>
</tr>
<tr>
<td>Stejneger’s beaked whale <em>Mesoplodon stejnegeri</em></td>
<td>NL</td>
<td>Potential</td>
<td></td>
</tr>
<tr>
<td>Hubbs’ beaked whale <em>Mesoplodon carlhubbsi</em></td>
<td>NL</td>
<td>Potential</td>
<td></td>
</tr>
<tr>
<td>Pygmy beaked whale <em>Mesoplodon peruvianus</em></td>
<td>NL</td>
<td>Potential</td>
<td></td>
</tr>
<tr>
<td>Seabirds</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short-tailed albatross <em>Phoebastria albatrus</em></td>
<td>FE, MBTA</td>
<td>Rare</td>
<td></td>
</tr>
<tr>
<td>Black-footed albatross <em>Phoebastria nigripes</em></td>
<td>BCC, MBTA</td>
<td>Uncommon migrant</td>
<td></td>
</tr>
<tr>
<td>Laysan albatross <em>Phoebastria immutabilis</em></td>
<td>BCC, MBTA</td>
<td>Uncommon migrant</td>
<td></td>
</tr>
<tr>
<td>Northern fulmar <em>Fulmarus glacialis</em></td>
<td>MBTA</td>
<td>Winter migrant</td>
<td></td>
</tr>
<tr>
<td>Mottled petrel <em>Pterodroma inexpectata</em></td>
<td>MBTA</td>
<td>Rare</td>
<td></td>
</tr>
<tr>
<td>Cook’s petrel <em>Pterodroma cookii</em></td>
<td>MBTA</td>
<td>Rare</td>
<td></td>
</tr>
</tbody>
</table>

The table lists various marine mammals and seabirds, their ranges, and habitats. The ranges include the following:

- **NL**: Nearshore
- **FE**: Nearshore and offshore
- **D**: Nearshore and offshore
- **MBTA**: Nearshore and offshore

The habitats include:

- **Open ocean**
- **Nearshore**
- **Nearshore and offshore**
- **Nearshore and open ocean**
- **Offshore**
- **Near (within 57.5 mi. [92.5 km])**
- **Uncommon migrant**
- **Common migrant**
<table>
<thead>
<tr>
<th>Species</th>
<th>Agency</th>
<th>Status</th>
<th>Habitat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Murphy’s petrel <em>Pterodroma ultima</em></td>
<td>MBTA</td>
<td>Rare</td>
<td>Open ocean</td>
</tr>
<tr>
<td>Buller’s shearwater <em>Puffinus bulleri</em></td>
<td>MBTA</td>
<td>Uncommon migrant</td>
<td>Open ocean</td>
</tr>
<tr>
<td>Sooty shearwater <em>Puffinus griseus</em></td>
<td>MBTA</td>
<td>Common migrant</td>
<td>Open ocean</td>
</tr>
<tr>
<td>Pink-footed shearwater <em>Puffinus creatopus</em></td>
<td>BCC</td>
<td>Common migrant</td>
<td>Open ocean</td>
</tr>
<tr>
<td>Flesh-footed shearwater <em>Puffinus carneipes</em></td>
<td>MBTA</td>
<td>Rare</td>
<td>Open ocean</td>
</tr>
<tr>
<td>Black-vented shearwater <em>Puffinus opisthomelas</em></td>
<td>BCC, MBTA</td>
<td>Common migrant</td>
<td>Open ocean</td>
</tr>
<tr>
<td>Wilson’s storm-petrel <em>Oceanites oceanicus</em></td>
<td>MBTA</td>
<td>Rare</td>
<td>Open ocean</td>
</tr>
<tr>
<td>Leach’s storm-petrel <em>Oceanodroma leucorhoa</em></td>
<td>MBTA</td>
<td>Uncommon migrant</td>
<td>Open ocean</td>
</tr>
<tr>
<td>Black storm-petrel <em>Oceanodroma melanias</em></td>
<td>MBTA</td>
<td>Common migrant</td>
<td>Open ocean</td>
</tr>
<tr>
<td>Least storm-petrel <em>Oceanodroma microsoma</em></td>
<td>MBTA</td>
<td>Uncommon migrant</td>
<td>Open ocean</td>
</tr>
<tr>
<td>Fork-tailed storm-petrel <em>Oceanodroma furcata</em></td>
<td>MBTA</td>
<td>Rare</td>
<td>Open ocean</td>
</tr>
<tr>
<td>Cassin’s auklet <em>Ptychoramphus aleuticus</em></td>
<td>BCC, MBTA</td>
<td>Uncommon migrant</td>
<td>Open ocean</td>
</tr>
<tr>
<td>Ashy storm-petrel <em>Oceanodroma homochroa</em></td>
<td>BCC, MBTA</td>
<td>Common</td>
<td>Open ocean</td>
</tr>
<tr>
<td>Xantus’s murrelet <em>Synthliboramphus hypoleucus</em></td>
<td>FC, MBTA</td>
<td>Rare</td>
<td>Open ocean</td>
</tr>
</tbody>
</table>

1 As a species, the green sea turtle is listed as Threatened. However, the Florida and Mexican Pacific Coast nesting populations are listed as Endangered. Green sea turtles found in the Study Area may include individuals from the Mexican Pacific Coast population.
2 The only distinct population segment of loggerheads that occurs in the Study Area—the North Pacific Ocean distinct population segment—is listed as Endangered.
3 NOAA Fisheries and USFWS only consider the breeding populations of Mexico’s Pacific coast as Endangered. Other populations are listed as Threatened (NOAA Fisheries and USFWS 1998).
4 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).
5 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 frequently observed in Southern California waters.
6 Xantus’s murrelet has been separated into Scripp’s murrelet (*Synthliboramphus Scrippsi*) and Guadalupe murrelet (*Synthliboramphus Hypoleucus*) in 2012 (Hamara et al., 2014), although the USFWS has not yet recognized this new taxonomy.

Notes: SOC = Species of Concern, BCC = Federal Bird of Conservation Concern, FC = Federal Candidate Species, FD = Federally de-listed, FE = Federal Endangered Species, FT = Federal Threatened Species, D = MMPA Depleted Strategic Stock, MBTA = Migratory Bird Treaty Act, NL = Not Listed

3.2.4 Essential Fish Habitat

The Iridium Landing Area is within the jurisdiction of the Pacific Fisheries Management Council (PFMC). The PFMC has designated EFH and Habitat Areas of Potential Concerns (HAPC) for Pacific Groundfish (Pacific Fisheries Management Council, 2016c), Pacific Coast Salmon (Pacific Fisheries Management Council, 2016d), Coastal Pelagic Species (Pacific Fisheries Management Council, 2016a), and Highly Migratory Species (Pacific Fisheries Management Council, 2016b). EFH for the Pacific Coast Groundfish is located within the perimeter of the Iridium Landing Area; however, a 5-mile buffer was established around each EFH and HAPC for groundfish as depicted in Figure 1-2. Alternative 1 (Proposed Action) does occur within EFH for various federally managed fish species within the Coastal Pelagic Species and Highly Migratory Species Fishery Management Plans (FMPs).
HAPC designated for groundfish include all waters, substrates, and associated biological communities falling within estuaries, canopy kelp or kelp forests, seagrasses, rocky reefs, and other habitat areas of interest (Pacific Fisheries Management Council, 2016c). Rocky reefs are submerged rock outcrops occurring from the intertidal zone to deep water. The rocky reef designation also includes seamounts, which force deep nutrient-rich water to the surface. Off the coast of California, these include Gumdrop Seamount, Pioneer Seamount, Guide Seamount, Taney Seamount, Davidson Seamount, and San Juan Seamount, as well as Mendocino Ridge, Cordell Bank, and Monterey Canyon.

Coastal Pelagic Species include finfish, such as Pacific sardine (*Sardinops sagax*), Pacific chub mackerel (*Scomber japonicus*), northern anchovy (*Engraulis mordax*), jack mackerel (*Trachurus symmetricus*), and market squid. The EFH for Coastal Pelagic Species includes all marine and estuary water from the coasts of California, Oregon, and Washington to the limits of the Exclusive Economic Zone (i.e., approximately 200 nautical miles from shore) and above the thermocline, where sea surface temperatures seasonally range between 50° and 70° Fahrenheit (F) (10° and 26° Celsius [C]) (Pacific Fisheries Management Council, 2016a). A thermocline is an area in the water column where water temperatures change rapidly with depth. Water temperature is typically colder below the thermocline and warmer above the thermocline. The southern boundary of EFH for Coastal Pelagic Species is the United States and Mexico maritime boundary. The northern boundary of EFH for coastal pelagic species is variable and is defined as the position of the 50° F (10° C) isotherm, which varies seasonally and annually, but even during the warmest times would be located north of the landing site (Pacific Fisheries Management Council, 2016a). There are no HAPCs designated for coastal pelagic species.

Highly Migratory Species include five species of tuna (*Thunnus* spp. and *Katsuwonus pelamis*) and five species of shark (*Alopias* spp. and *Isurus oxyrinchus, Prionace glauca*) as well as the striped marlin (*Tetrapturus audax*), swordfish (*Xiphias gladius*), and Dorado or Dolphinfish (*Coryphaena hippurus*) (Pacific Fisheries Management Council, 2016b). These are pelagic species that are listed in an annex to Article 64 of the United Nations Convention on the Law of the Sea. The EFH extends between 3 and 200 nm (5.5 and 370.4 km) from shore and is bounded by the maritime boundaries of the United States and Canada to the north and United States and Mexico to the south. There are no HAPCs designated at this time for Highly Migratory Species.

### 3.3 Water Resources

For purposes of this SEA, the ROI for water resources include those areas where Proposed Action may affect surface water, groundwater, wetlands, or Waters of the United States. For this SEA, the ROI would include that area of the Pacific Ocean within and in the immediate vicinity of the Iridium Landing Area as described in Chapters 1 and 2. Although impacts to the Pacific Ocean were analyzed in the Falcon 9 Boost-Back EA, impacts within and in the vicinity of the Iridium Landing Area were not considered as part of the ROI in the EA. There are no jurisdiction wetlands in the vicinity of the project area, and the Proposed Action would not affect groundwater.
3.3.1.1 Affected Environment

The Clean Water Act (33 U.S.C. §§ 1251 et seq.) is the primary federal law that protects water quality. This Act regulates and establishes a permitting system for point source (e.g., pipes) and non-point source (e.g., stormwater runoff) discharges to Waters of the United States. Waters of the United States may encompass navigable waters, wetlands, tributaries, and territorial seas. The Porter-Cologne Water Quality Act (California Water Code §§ 13000–13999.10) is the principal State law governing water quality and allocation within the State of California. In addition, the California Ocean Plan provides water quality objectives to protect ocean water quality (State Water Resources Control Board, 2015).

As defined by the 1982 United Nations Convention on the Law of the Sea, U.S. territorial water extends 12 nm (22.2 km) offshore from the mean low water mark of a coastal state. The United States has complete sovereignty within these waters. U.S. territorial waters include California state waters, which extend 3 nm (5.5 km) from the mean low water mark (Outer Continental Shelf Lands Act of 1953 [43 U.S.C. § 1331 et seq.]). Within state waters, California manages, develops, and leases resources. Meanwhile, the federal government retains the power to regulate commerce, navigation, and the national defense within these waters.

The Contiguous Zone is measured 24 nm (44.5 km) from the mean low water mark. Within this zone, the United States can enforce its customs, immigration, and sanitary laws. The Exclusive Economic Zone extends 200 nm (370.4 km) from the territorial water baseline. The United States has exclusive sovereign rights within this zone for the purpose of exploring, exploiting, conserving, and managing natural resources, which includes the protection of the marine environment.

3.3.1.2 Existing Conditions

Water quality in marine environments is determined by complex interactions between physical, chemical, and biological processes, which includes temperature, salinity, nutrients, tides, weather, and pH as well as the presence of hydrocarbons, metals, persistent organic pollutants (e.g., pesticides), sediments, and debris.

The majority of seawater pollution within southern California is from municipal discharge, including point source (e.g., pipes) and non-point source (e.g., stormwater runoff) discharges. For example, plumes of contaminated runoff have been known to extend up to approximately 22 nm (40 km) offshore (California Department of Fish and Game, 2001). In addition, runoff from agricultural land can result in toxic algal blooms, commonly referred to as “red tides.” Offshore oil and gas exploration also has the potential to introduce pollutants into the marine environment via oil leaks, sediments, discharges, and accidental spills. Commercial, recreational, institutional, and military vessels are other potential sources of water contaminants in the Pacific Ocean.

There is little information on open ocean water quality, particularly near the proposed Iridium Landing Area. San Nicolas Island and San Clemente Island, which are managed by the Department of the Navy, are east of the project area. California State Water Resources Control Board lists the ocean around these islands, including Begg Rock, as State Water Quality Protection...
Areas of Special Biological Significance (ASBS). ASBS are state waters that the State Water Quality Board monitors and maintains for water quality (California State Water Resources Control Board, 2003). Water quality along San Clemente Island has been tested using the California Ocean Plan criteria, which found low concentrations of contaminants (U.S. Department of the Navy, 2013, 2006).

### 3.4 Coastal Zone Management

For purposes of this SEA, the ROI for coastal zone management is the same as that identified in the Falcon 9 Boost-Back EA (USAF, 2016). The ROI for coastal zone management extends to those coastal resources that may be affected by the Proposed Action, including natural resources (e.g., wildlife and plants), land uses, and water uses as well as public access to and recreation within the California Coastal Zone.

The CZMA, 16 U.S.C. §§ 1451 et seq., is the primary federal law regarding the management of coastal resources. Federal actions that have reasonably foreseeable effects on natural resources or land or water uses in the coastal zone, regardless of the project’s location, are required to be consistent, to the maximum extent practicable, with the enforceable policies of federally approved state coastal management programs (16 U.S.C. § 1456; 15 C.F.R. Part 930). Federal agencies submit a consistency determination to the state coastal management program when an action could foreseeably affect coastal resources. If a Federal action would not foreseeably affect the coastal zone, then the Federal agency may prepare a negative determination for that action.

The California Coastal Zone Management Program was formed through the California Coastal Act of 1972. NOAA approved California’s Coastal Management Program in 1978. The California Coastal Zone extends, generally, 1,000 yards inland and up to 3 nm (5.5 km) seaward. However, the California Coastal Zone may extend up to 5 miles inland for significant coastal estuarine, habitat, and recreational areas and less than 1,000 yards inland in urban areas. Federal lands are typically excluded from the California Coastal Zone. Although the project would not occur within the California Coastal Zone, it may potentially affect coastal resources; therefore, a consistency determination or a negative determination would be required for the Proposed Action.
4 Environmental Consequences

This chapter presents the results of the analysis of potential environmental effects of implementing Alternative 1 and the No Action Alternative as described in Chapter 2 (Description of the Proposed Action and Alternatives). For each environmental component, anticipated impacts are assessed considering short- and long-term effects.

4.1 Air Quality and Climate

As described in Section 2.3 (Alternative 1 [Proposed Action]), the Iridium Landing Area would be used for up to six landings per year. There would be no change to the rocket, vessels, equipment, and personnel performing this action as described in the Falcon 9 EA (USAF, 2016). The rocket would still launch from VAFB, and the autonomous drone ship would launch from the Port of Long Beach. The primary difference between the barge landing off the coast of VAFB and the barge landing within the Iridium Landing Area would be the landing location. Therefore, only the portion of the activity that differs from the Falcon 9 EA is analyzed, in this case, vessel emissions for the contingency drone ship landing within and beyond California Coastal Zone.

4.1.1 Alternative 1 (Proposed Action)

As an alternative to landing the Falcon 9 Full Thrust First Stage on the SLC-4W pad at VAFB or on a drone ship no less than approximately 27 nm (50 km) offshore of VAFB, SpaceX proposes to land the Falcon 9 Full Thrust First Stage on an autonomous barge within the Iridium Landing Area. The proposed Iridium Landing Area would be located approximately 122 nm (226 km) southwest of San Nicolas coastal waters and 133 nm (245 km) southwest of San Clemente Island coastal waters and would require approximately 40 hours transit time each way. The vessels would be within the boundary of California Coastal Zone for approximately two hours of the total transit time (one hour outbound and one hour inbound). Emissions from the operation of the three vessels would be below the major source threshold of 100 tons per year for all criteria pollutants (Table 4-1).

Table 4-1. Proposed Action Vessel Emissions for the Contingency Drone Ship Landing Within and Beyond California Coastal Zone (tons/year)

<table>
<thead>
<tr>
<th>Operations</th>
<th>ROG</th>
<th>NOx</th>
<th>CO</th>
<th>SOx</th>
<th>PM10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combined emissions for all three vessels per roundtrip transit (entire transit)</td>
<td>0.00011</td>
<td>0.00253</td>
<td>0.00078</td>
<td>0.00027</td>
<td>0.00012</td>
</tr>
<tr>
<td>Combined emissions for all three vessels per roundtrip transit (CA Coastal waters only)</td>
<td>0.000003</td>
<td>0.000060</td>
<td>0.000019</td>
<td>0.000006</td>
<td>0.000003</td>
</tr>
<tr>
<td>Total emissions for six roundtrip transits/year (entire transit)</td>
<td>0.000652</td>
<td>0.015177</td>
<td>0.004670</td>
<td>0.001594</td>
<td>0.000743</td>
</tr>
<tr>
<td>Total emissions for six roundtrip transits/year (CA Coastal waters only)</td>
<td>0.000016</td>
<td>0.000360</td>
<td>0.000112</td>
<td>0.000037</td>
<td>0.000018</td>
</tr>
</tbody>
</table>

Notes: CO = Carbon Monoxide, NOx = Nitrogen Oxide, PM2.5 = particulate matter less than 2.5 microns, PM10 = particulate matter less than 10 microns, ROG = reactive organic gases, SOx = Sulfur Dioxide
4.1.2 No Action Alternative

Under the No Action Alternative, the drone ship landing site would be located no closer than approximately 27 nm (50 km) from shore, and the vessels would be within the boundary of California Coastal Zone for approximately 43 hours of the total transit time (21.5 hours outbound and 21.5 hours inbound). As presented in the Falcon 9 EA (USAF 2016), emissions from the operation of the three vessels would be below the major source threshold of 100 tons per year for all criteria pollutants (Table 4-2) and would result in less than significant impacts to air quality.

Table 4-2. No Action Alternative Vessel Emissions for the Contingency Drone Ship Landing Within and Beyond California Coastal Zone (tons/year)

<table>
<thead>
<tr>
<th>Operations</th>
<th>ROG</th>
<th>NO\textsubscript{x}</th>
<th>CO</th>
<th>SO\textsubscript{x}</th>
<th>PM\textsubscript{10}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combined emissions for all three vessels per roundtrip transit (entire transit)</td>
<td>0.00010</td>
<td>0.00229</td>
<td>0.00070</td>
<td>0.00024</td>
<td>0.00011</td>
</tr>
<tr>
<td>Combined emissions for all three vessels per roundtrip transit (CA Coastal waters only)</td>
<td>0.000056</td>
<td>0.001290</td>
<td>0.000401</td>
<td>0.000134</td>
<td>0.000064</td>
</tr>
<tr>
<td><strong>Total emissions for six roundtrip transits/year (entire transit)</strong></td>
<td>0.000589</td>
<td>0.013737</td>
<td>0.004223</td>
<td>0.001445</td>
<td>0.000671</td>
</tr>
<tr>
<td>Total emissions for six roundtrip transits/year (CA Coastal waters only)</td>
<td>0.000339</td>
<td>0.007740</td>
<td>0.002404</td>
<td>0.000801</td>
<td>0.000387</td>
</tr>
</tbody>
</table>

Notes: CO = Carbon Monoxide, NO\textsubscript{x} = Nitrogen Oxide, PM\textsubscript{2.5} = particulate matter less than 2.5 microns, PM\textsubscript{10} = particulate matter less than 10 microns, ROG = reactive organic gases, SO\textsubscript{x} = Sulfur Dioxide

**Total Emissions calculation in the Falcon 9 EA was incorrectly calculated, as estimated numbers of transits was assumed to be 36 transits rather than 6 transits. Numbers in this table have been updated accordingly.

4.1.3 Summary of Impacts to Air Quality

To determine the potential impacts to air quality from the Proposed Action, the total emissions were compared to those reported in the Falcon 9 EA (USAF 2016). The relocation of landing site to the Iridium site increases the emissions of criteria pollutants by far less than one ton, and the decrease of operational time while in the California Coastal Zone decreases criteria pollutant emissions (Table 4-3). Emissions from the operation of the three vessels would not cause the overall emissions reported in the Falcon 9 EA to exceed the major source threshold of 100 tons per year for all criteria pollutants and would therefore result in less than significant impacts to air quality.
Table 4-3. Summary of Annual Air Emission for the Proposed Action (tons/year)

<table>
<thead>
<tr>
<th>Operations</th>
<th>ROG</th>
<th>NOx</th>
<th>CO</th>
<th>SOx</th>
<th>PM10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Emissions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Action</td>
<td>0.000589</td>
<td>0.013737</td>
<td>0.004223</td>
<td>0.001445</td>
<td>0.000671</td>
</tr>
<tr>
<td>Proposed Action</td>
<td>0.000652</td>
<td>0.015177</td>
<td>0.004670</td>
<td>0.001594</td>
<td>0.000743</td>
</tr>
<tr>
<td>Proposed Action Difference</td>
<td>0.000063</td>
<td>0.00144</td>
<td>0.00045</td>
<td>0.00015</td>
<td>0.00007</td>
</tr>
</tbody>
</table>

| California Coastal Zone Total Emissions |       |       |       |       |       |
| No Action                               | 0.000589 | 0.013737 | 0.004223 | 0.001445 | 0.000671 |
| Proposed Action                         | 0.000016 | 0.000360 | 0.000112 | 0.000037 | 0.000018 |
| Proposed Action Difference               | -0.000573 | -0.013377 | -0.004111 | -0.001408 | -0.000653 |

Notes: CA = California, CO = Carbon Monoxide, NOx = Nitrogen Oxide, PM2.5 = particulate matter less than 2.5 microns, PM10 = particulate matter less than 10 microns, ROG = reactive organic gases, SOx = Sulfur Dioxide

4.1.4 Greenhouse Gas Emissions

Similar to the analysis for criteria pollutants, this Supplemental EA only analyses the difference in the Proposed Action as compared to that reported in the Falcon 9 EA (USAF 2016). Therefore, only the portion of the activity that differs from the Falcon 9 EA is analyzed for GHG emissions, in this case, vessel emissions for the contingency drone ship landing.

4.1.4.1 Alternative 1 (Proposed Action)

Under the Proposed Action, the relocation to the Iridium Landing Area would result in approximately 1.106 metric tons of carbon dioxide equivalent (CO2e) per year (Table 4-4). The contribution of this quantity of GHG emissions to global climate change would be negligible. Emissions from the six landings at the Iridium Landing Area would not have a significant adverse environmental impact on GHG emissions or climate change.

Table 4-4. Alternative 1 (Proposed Action) Alternative GHG Emissions

<table>
<thead>
<tr>
<th>Scenario/Activity</th>
<th>CO2</th>
<th>CH4</th>
<th>N2O</th>
<th>CO2e</th>
</tr>
</thead>
<tbody>
<tr>
<td>GHG Emission for Drone Ship, Tug, and Support Vessel (per single landing event)</td>
<td>0.15664</td>
<td>0.00007</td>
<td>0.00033</td>
<td>0.18438</td>
</tr>
<tr>
<td>Maximum Total Annual GHG Emissions for Drone Ship, Tug and Support Vessel (Assumes 6 Contingency Landings/year)</td>
<td>0.93985</td>
<td>0.00039</td>
<td>0.00196</td>
<td>1.10627</td>
</tr>
</tbody>
</table>

Notes: CH4 = methane, CO2 = carbon dioxide, CO2e = (CO2 * 1) + (CH4* 21) + (N2O * 298), N2O = nitrous oxide

4.1.4.2 No Action Alternative

Under the No Action Alternative, the emissions from the barge and support boat activities during six annual landings would be approximately 0.901 ton of CO2e per year (Table 4-5), and these emissions would not have a significant adverse environmental impact on GHG emissions or climate change.
Table 4-5. No Action Alternative GHG Emissions

<table>
<thead>
<tr>
<th>Scenario/Activity</th>
<th>CO₂</th>
<th>CH₄</th>
<th>N₂O</th>
<th>CO₂e</th>
</tr>
</thead>
<tbody>
<tr>
<td>GHG Emission for Drone Ship, Tug, and Support Vessel (per Contingency Landing</td>
<td>0.12546</td>
<td>0.00006</td>
<td>0.00029</td>
<td>0.15024</td>
</tr>
<tr>
<td>event)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum Total Annual GHG Emissions for Drone Ship, Tug and Support Vessel</td>
<td>0.75277</td>
<td>0.00035</td>
<td>0.00175</td>
<td>0.90144</td>
</tr>
<tr>
<td>(Assumes 6 Contingency Landings/year)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: CH₄ = methane, CO₂ = carbon dioxide, CO₂e = (CO₂ * 1) + (CH₄ * 21) + (N₂O * 298), N₂O = nitrous oxide

4.1.4.3 Summary of Impacts to Greenhouse Gas Emissions

To determine the potential impacts to GHGs from the Proposed Action, the total emissions were compared to those reported in the Falcon 9 EA (USAF 2016). The relocation of landing site to the Iridium site increases the emissions of GHGs by less than one ton (Table 4-6). Emissions from the operation of the three vessels would not cause the overall emissions reported in the Falcon 9 EA to exceed the significance threshold of 10,000 metric tons of CO₂e per year. Furthermore, most emissions would occur outside the boundary of California Coastal Zone. Therefore, emissions from landing at the Iridium Landing Area would not have a significant adverse environmental impact on GHG emissions or climate change.

Table 4-6. No Action Alternative GHG Emissions

<table>
<thead>
<tr>
<th>Scenario/Activity</th>
<th>CO₂</th>
<th>CH₄</th>
<th>N₂O</th>
<th>CO₂e</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Total Annual GHG Emissions for Drone Ship, Tug and Support Vessel</td>
<td>0.12546</td>
<td>0.00006</td>
<td>0.00029</td>
<td>0.15024</td>
</tr>
<tr>
<td>(No Action Alternative)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum Total Annual GHG Emissions for Drone Ship, Tug and Support Vessel</td>
<td>0.75277</td>
<td>0.00035</td>
<td>0.00175</td>
<td>0.90144</td>
</tr>
<tr>
<td>(Proposed Action)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change in Greenhouse Gas Emissions</td>
<td>0.62731</td>
<td>0.00029</td>
<td>0.00146</td>
<td>0.7512</td>
</tr>
</tbody>
</table>

Notes: CH₄ = methane, CO₂ = carbon dioxide, CO₂e = (CO₂ * 1) + (CH₄ * 21) + (N₂O * 298), N₂O = nitrous oxide

4.2 Biological Resources

4.2.1 Alternative 1 (Proposed Action)

4.2.1.1 Special Status Species

Impacts to marine species known to occur within the Iridium Landing Area would be similar or less than that of the conditional landing area of the Falcon 9 Boost-Back EA (USAF, 2016). However, the action area does not include, nor would the activity affect, critical habitat for the leatherback sea turtle (77 Federal Register [FR] 4170) or steelhead (70 FR 52488).
4.2.1.1 First Stage Explosion

**Debris Strike**

As with the conditional landing area, the primary potential affect would be from a debris strike from an explosion of the Falcon 9 First Stage. The maximum estimated remaining fuel and oxidizer onboard the booster when it explodes would be the equivalent to a net explosive weight of 503 lb. of TNT, although differing from TNT in brisance (i.e., shattering capability of a high explosive). The resulting explosion of the estimated onboard remaining fuel would be capable of scattering debris a maximum estimated range of approximately 1,250 ft. (384 m) from the landing point and thus spread over a radial area of 114 ac. 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 would impact 0.17 ac. (0.000706 km^2) of the total 114 ac. (0.46 km^2) impact area.

Using a statistical probability analysis for estimating direct air strike impact developed by the U.S. Navy (U.S. Department of the Navy, 2014a) the probability of impact of debris with a marine mammal can be estimated for individual marine mammals of each species that may occur in the impact footprint area. We conservatively applied density estimates using the highest density of marine mammal species occurring in the area for the entire action area (U.S. Department of the Navy, 2016). For sea turtle species, densities were estimated by consulting the Marine Species Density Database (U.S. Department of the Navy, 2014b). This report noted that there was insufficient data to generate reliable density estimates for sea turtles in the Navy's Southern California Testing and Training Complex (see Figure 1-1). Therefore, a conservative estimate of 0.035 individual per km^2 was used based on data for leatherback sea turtle north of the Iridium Landing Area (see USAF, 2016).

SpaceX proposes to conduct up to six landings in the Iridium Landing Area per year, which may result in between zero and six explosions of the First Stage. We assume that the maximum of six events per year result in an explosion. This is a conservative estimate, since the actual number of landing events at the Iridium Landing Area resulting in the First Stage explosion is likely to be less than six. Table 4-7 shows the probability that debris during an explosion could impact an individual of a special status marine species.

<table>
<thead>
<tr>
<th>Species</th>
<th>Estimated At-Sea Density (km^2)</th>
<th>Probability of Impact per Event</th>
<th>Estimated Number of Impacts per Year^</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harbor Seal</td>
<td>0.0183</td>
<td>0.0001</td>
<td>0.0006</td>
</tr>
<tr>
<td>California Sea Lion</td>
<td>0.0677</td>
<td>0.0006</td>
<td>0.0036</td>
</tr>
<tr>
<td>Northern Elephant Seal</td>
<td>0.0500</td>
<td>0.0005</td>
<td>0.0030</td>
</tr>
<tr>
<td>Steller Sea Lion</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Northern Fur Seal</td>
<td>0.0210</td>
<td>0.0002</td>
<td>0.0012</td>
</tr>
<tr>
<td>Guadalupe Fur Seal^</td>
<td>0.0083</td>
<td>0.0007</td>
<td>0.0004</td>
</tr>
<tr>
<td>Humpback Whale^</td>
<td>0.0019</td>
<td>0.0002</td>
<td>0.0001</td>
</tr>
<tr>
<td>Blue Whale^</td>
<td>0.0055</td>
<td>0.0007</td>
<td>0.0004</td>
</tr>
<tr>
<td>Fin Whale^</td>
<td>0.0082</td>
<td>0.0001</td>
<td>0.0006</td>
</tr>
<tr>
<td>Sei Whale^</td>
<td>0.00008</td>
<td>0.00009</td>
<td>0.00005</td>
</tr>
</tbody>
</table>

---

Final Supplemental Environmental Assessment

Boost-Back & Landing of Falcon 9 Full Thrust First Stage at Iridium Landing Area
<table>
<thead>
<tr>
<th>Species</th>
<th>Density</th>
<th>Density</th>
<th>Density</th>
</tr>
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<tbody>
<tr>
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<td>0.00002</td>
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<td>Sperm Whale</td>
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<td>0.0006</td>
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<td>0.00006</td>
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<tr>
<td>Short-Finned Pilot Whale</td>
<td>0.0011</td>
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<td>0.0004</td>
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<td>0.0012</td>
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<td>Blainville's Beaked Whale</td>
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<td>0.0012</td>
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<td>Stejneger's Beaked Whale</td>
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<td>0.0002</td>
<td>0.0012</td>
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<td>Hubbs' Beaked Whale</td>
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<td>0.0012</td>
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<td>0.0002</td>
<td>0.0012</td>
</tr>
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<td>Loggerhead Sea Turtle</td>
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<td>0.0018</td>
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<td>Olive Ridley Sea Turtle</td>
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<td>0.0018</td>
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<td>Hawksbill Sea Turtle</td>
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<td>0.0003</td>
<td>0.0018</td>
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<tr>
<td>Leatherback Sea Turtle</td>
<td>0.035</td>
<td>0.0003</td>
<td>0.0018</td>
</tr>
</tbody>
</table>

1 Federally threatened species.
2 Federally endangered species
* U.S. Department of the Navy, 2016
^ Up to six events per year

Sufficient density data are not available to conduct a debris strike analysis in the manner conducted above for special status fish species. However, fish, if present in the area of potential debris impacts, would be less likely to be at or near the water surface where debris could strike them than marine mammals or sea turtles.

**Explosion Noise (in-water)**

Noise resulting from an unsuccessful drone ship landing (explosion) can introduce loud, impulse, broadband sounds into the ocean or near the water’s surface. These sounds can be within the audible range of most marine mammals (Table 4-8), but the expected duration 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 a maximum of six drone ship landing attempts occurring each year. The spacing of the landing attempts would likely reduce the potential for long-term auditory masking. However, because of its intensity, the direct sound from an explosion could cause behavioral or physiological effects to marine mammals.
If an explosion occurs upon the drone ship, as in an unsuccessful drone ship landing, exceptionally little of the acoustic energy from the explosion would transmit into the water (Yagla and Stiegler, 2003). An explosion on the drone ship would create a blast in air that propagates away in all directions, including toward the water surface, although the drone ship’s deck would act as a barrier that would minimize the amount of energy directed directly downward towards the water (Yagla and Stiegler, 2003). 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 drone ship, most of this sound would be reflected by the drone ship’s surface, and sound waves would approach the water’s surface at angles higher than 13°, minimizing transmission into the ocean.

An explosion on the drone ship 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 Stiegler (2003). The energy transmitted through the 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 drone ship.

Depending on the amount of fuel remaining in the booster at the time of the explosion, the intensity of the explosion would 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. Utilizing these equations, and modifying them for use in the far-field (Continental Shelf Associates, Inc., 2004), the received level at 32.8 ft. (10 m) during a surface water explosion would be approximately 268 decibels referenced to 1 micropascal (dB re 1 μPa). Assuming that the drone ship absorbs approximately 94 percent of that energy (Yagla and Stiegler, 2003), the received level at a 32.8 ft. (10 m) distance underwater from the drone ship would be 21 dB re 1 μPa. This is far below the threshold levels at which physiological impacts would occur for cetaceans and pinnipeds (Table 4-9). Onset TTS and PTS SPL values are the same for cetaceans and sea turtles. Therefore, a sea turtle would not experience physiological impacts as a result of the explosion of the First Stage during an unsuccessful drone ship landing. The resulting pressure level that is transmitted through the drone ship would also not be great enough to cause physiological impacts to fish (USAF, 2016).
Table 4-8. Estimated At-Sea Density of Individuals per km$^2$ and Probability of an Individual Occurring within the Impact Area for Explosion

<table>
<thead>
<tr>
<th>Species</th>
<th>Estimated At-Sea Density (km$^2$)*</th>
<th>Probability of Animal in Noise Impact Zone</th>
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</thead>
<tbody>
<tr>
<td>Harbor Seal</td>
<td>0.0183</td>
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<tr>
<td>California Sea Lion</td>
<td>0.0677</td>
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</tr>
<tr>
<td>Northern Elephant Seal</td>
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<td>0.6283</td>
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<tr>
<td>Steller Sea Lion</td>
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<td>0</td>
</tr>
<tr>
<td>Northern Fur Seal</td>
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<td>0.2639</td>
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<td>Guadalupe Fur Seal</td>
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<tr>
<td>Humpback Whale</td>
<td>0.0019</td>
<td>0.0002</td>
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<tr>
<td>Blue Whale</td>
<td>0.0055</td>
<td>0.0007</td>
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<tr>
<td>Fin Whale</td>
<td>0.0082</td>
<td>0.0010</td>
</tr>
<tr>
<td>Sei Whale</td>
<td>0.0008</td>
<td>0.00001</td>
</tr>
<tr>
<td>Bryde’s Whale</td>
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<td>0.000002</td>
</tr>
<tr>
<td>Minke Whale</td>
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<td>0.00009</td>
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<tr>
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<td>0</td>
</tr>
<tr>
<td>Sperm Whale</td>
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<td>Dwarf Sperm Whale</td>
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<td>Killer Whale</td>
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<td>Short-Finned Pilot Whale</td>
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<td>Long-Beaked Common Dolphin</td>
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<tr>
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<td>Rough Toothed Dolphin</td>
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<tr>
<td>Northern Right-Whale Dolphin</td>
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<td>Baird’s Beaked Whale</td>
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<tr>
<td>Blainville’s Beaked Whale</td>
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<td>0.00001</td>
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<tr>
<td>Ginkgo-toothed Beaked Whale</td>
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<td>Perrin’s Beaked Whale</td>
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<tr>
<td>Stejneger’s Beaked Whale</td>
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<td>0.0024</td>
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<td>Hubbs’ Beaked Whale</td>
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<td>0.0024</td>
</tr>
<tr>
<td>Pygmy Beaked Whale</td>
<td>0.0192</td>
<td>0.0024</td>
</tr>
<tr>
<td>Green Sea Turtle</td>
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<td>0.0044</td>
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<tr>
<td>Loggerhead Sea Turtle</td>
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<td>0.0044</td>
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<tr>
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<tr>
<td>Hawksbill Sea Turtle</td>
<td>0.035</td>
<td>0.0044</td>
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<tr>
<td>Leatherback Sea Turtle</td>
<td>0.035</td>
<td>0.0044</td>
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</table>

* U.S. Department of the Navy, 2016
Table 4-9. NOAA Fisheries Sound Threshold Guidance for In-Water Explosives

<table>
<thead>
<tr>
<th>Group</th>
<th>Species</th>
<th>Level B</th>
<th>Level A</th>
<th>Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Behavioral (for ≥ 2 pulses/24 hours)</td>
<td>TTS</td>
<td>PTS</td>
</tr>
<tr>
<td>Low-Frequency Cetaceans</td>
<td>Mysticetes</td>
<td>167 dB SEL or 224 dB peak SPL</td>
<td>187 dB SEL or 230 dB peak SPL</td>
<td>104 psi (237 dB SPL)</td>
</tr>
<tr>
<td>Mid-Frequency Cetaceans</td>
<td>Most delphinids, medium and large toothed whales</td>
<td>167 dB SEL or 224 dB peak SPL</td>
<td>187 dB SEL or 230 dB peak SPL</td>
<td></td>
</tr>
<tr>
<td>High-Frequency Cetaceans</td>
<td>Porpoises and Kogia spp.</td>
<td>146 dB SEL or 195 dB peak SPL</td>
<td>161 dB SEL or 201 dB peak SPL</td>
<td>39.1 M^{1/3} (1+[D_{rm}/10.08]^{1/2} Pa·sec</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Where: M=mass of the animal in kg D_{rm}=depth of the receiver in meters</td>
</tr>
<tr>
<td>Phocids</td>
<td>Elephant and harbor seal</td>
<td>172 dB SEL or 212 dB peak SPL</td>
<td>192 dB SEL or 218 dB peak SPL</td>
<td></td>
</tr>
<tr>
<td>Otariids</td>
<td>Sea lions and fur seals</td>
<td>200 dB SEL or 212 dB peak SPL</td>
<td>215 dB SEL or 218 dB peak SPL</td>
<td></td>
</tr>
</tbody>
</table>

Notes: ≥ = greater than or equal to, dB = decibel(s), psi = pound(s) per square inch, PTS = Permanent Threshold Shift, SEL = Sound Exposure Level, SPL = Sound Pressure Level, TTS = Temporary Threshold Shift
Source: Carduner (2015a)

Rocket Propellant

As described in the Falcon 9 Boost-Back EA (USAF, 2016), in the event of an unsuccessful landing attempt, the First Stage would explode upon impact with the drone ship and residual fuel would be released into the ocean. At most, the First Stage would contain 2,750 lb. of rocket propellant (RP-1 or “fuel”) on board. In the event of an unsuccessful drone ship landing, most of this fuel would be burnt off during the subsequent explosion. Final volumes of fuel remaining in the First Stage upon impact may vary, but are anticipated to be below the high range estimations.

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 high volatility (USFWS, 1998). Due to its high volatility,
RP-1 evaporates quickly when exposed to the air, and would completely dissipate within one to two days after a spill in the water. Cleanup following a spill of very light oil is usually not necessary or not possible, particularly with such a small quantity of oil that would enter the ocean in the event of an unsuccessful drone ship landing (USFWS 1998). Therefore, no attempt would be made to boom nor 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 EPA 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. EPA, 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 an animal being within the fuel spill area before the RP-1 dissipates. For the case of RP-1, a Very Light Oil, 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 the water and would continue to spread as a function of sea surface conditions, 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 (USFWS 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): 

\[ \%EV = \frac{(0.59 + 0.13T)}{t} \]

where \( \%EV \) is the percent of mass evaporated within a given time in minutes \( t \) at a given temperature in °C \( T \). If we assume an air temperature of 50° F (10° C), the percent of mass evaporated versus time can be determined, as shown in Figure 4-1. Although one to two days would be required for the RP-1 to completely dissipate, over 90 percent of its mass would evaporate within the first seven minutes and 99 percent of its mass would evaporate within the first hour (Figure 4-1). 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.
Given the relatively small volume of RP-1 that would be spilled (2,750 lb.), the potential exposure area would be small, and thus it is 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 drone ship 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.

**Summary of Effects from First Stage Explosion**

Overall, the probability of impacting an individual of a special status marine species as a result of impact of rocket debris, explosion noise, or expended rocket propellant is very low and any potential impact would be temporary and of a short duration. Further, SpaceX would collect any floating debris remaining after an explosion. As a result, an explosion on the drone ship during an unsuccessful drone ship landing attempt in the Iridium Landing Area generated by the Falcon 9 Full Thrust First Stage landing action would not have a significant impact on special status marine species and may affect, but is not likely to adversely affect, the following ESA-listed species: Guadalupe fur seal, blue whale, fin whale, gray whale, humpback whale, sei whale, sperm whale, green sea turtle, loggerhead sea turtle, olive Ridley sea turtle, hawksbill sea turtle, leatherback sea turtle, steelhead trout, green sturgeon, and scalloped hammerhead shark. Likewise, an explosion on the drone ship during an unsuccessful drone ship landing would not
result in take or have a significant effect on marine mammals protected under the MMPA. NOAA Fisheries has concurred with these determinations (Appendix B).

4.2.1.1.2 Noise-Related Impacts

**Sonic Boom**

Figure 2-4 provides the estimated sonic boom overpressure modeling results for the Iridium Landing Area. The sonic boom at the Iridium Landing Area is estimated to be similar to that of actual data measured during the Jason-3 barge landing in January 2016, which had a similar trajectory as Iridium, measured at 2.3 psf on the barge. Bradley (2016) estimated the sonic boom at the Iridium Landing Area would be up to 3.85 psf, slightly increasing the amount of energy transmitted into the water than what was previously predicted (3.1 psf).

In the case of a sonic boom, it is likely that some acoustic energy would transmit through the air-water interface and propagate some distance into the water column; however, exceptionally little sound would be transmitted between the air-water interface (Godin, 2008). For example, Sohn et al. (2000) performed field measurements of sonic boom penetration into the ocean and found that boom pressures exhibit a frequency-dependent decay with depth, with low frequencies penetrating significantly farther than high frequencies. All of the boom pressure signals measured in this experiment decayed to ambient levels in all frequency bands by 131 to 164 ft. (40 to 50 m). Additionally, a sonic boom of 2 psf (approximately 133.6 dB re 20 µPa) at the surface was noted to decay to approximately 152 dB re 1 µPa at a depth of 23 ft. (7 m). By 72 ft. (22 m), the received level was approximately 140 dB re 1 µPa, and by 121 ft. (37 m) the acoustic wave had been subsumed by ambient noise levels. All of these levels are below the peak SPL criteria for physiological effects from acoustics for pinnipeds and cetaceans (Table 4-9). Increasing the psf to 3.1 psf (approximately 137.4 dB re 20 µPa) or 3.85 psf (approximately 139.29 dB re 20 µPa) would slightly increase the amount of energy transmitted into the water. However, it is expected that the decay rates would be similar to those reported in Sohn et al. (2000) and would not exceed peak SPL criteria for physiological effects from acoustics. The range to potential behavioral change (160 dBrms re 1 µPa) increases, but it is anticipated to decay to levels less than 160 dB within the first 31 ft. (10 m) of the water column. Similarly, even with increases in pressure, all received levels would remain below the peak SPL criteria for physiological effects from acoustics on sea turtles. For fish, Stadler and Woodbury (2009) established that the onset of physical injury to fish would be expected if the peak SPL exceeds 206 dB re 1 µPa. The anticipated received sound levels from a sonic boom are far below these criteria for physiological effects to fish.

For in-air, there is no established criterion threshold for PTS (injury). However, the behavioral threshold for harbor seals is 90 decibels root mean square (dBrms) re 20 µPa and all other pinnipeds is 100 dBrms re 20 µPa. Therefore, any pinniped at the water surface where the ground signature is greater than 0.04 psf (for non-harbor seals) or 0.013 psf (for harbor seals) would be in the region where the behavioral thresholds are exceeded. As a result, any pinniped at the water surface underneath nearly the entire boom footprint would be considered in excess of the behavioral threshold. However, any impact would be temporary and of a short duration. Fish and sea turtles would be less likely to be at the surface during the impact of the sonic boom.
Sonic boom modeling of the Iridium trajectory predicts that the sonic boom created during the Falcon 9 First Stage boost-back and landing within the Iridium Landing Area would not reach land (Bradley, 2016; Figure 2-4). Therefore, no pinnipeds that are hauled out on land would be impacted.

For these reasons, the sonic boom generated by the Falcon 9 First Stage during the contingency landing actions at the Iridium Landing Area would not have a significant impact on special status marine species and may affect, but is not likely to adversely affect, the following seven ESA-listed marine mammals: blue whale, fin whale, gray whale, humpback whale, sei whale, sperm whale, and Guadalupe fur seal. Similarly, even with increases in pressure, all received levels would remain below the peak SPL criteria for physiological effects from acoustics on sea turtles and the sonic boom generated by the Falcon 9 First Stage during the contingency landing actions at the Iridium Landing Area may affect, but is not likely to adversely affect, the five ESA-listed sea turtles: green sea turtle, loggerhead sea turtle, olive Ridley sea turtle, hawksbill sea turtle, and leatherback sea turtle. The USAF received concurrence of these potential impacts from NOAA Fisheries (Appendix B).

NOAA Fisheries determined that in-air noise produced by the sonic boom during the First Stage landing would not be significant enough to result in any harassment of at-sea marine mammals protected under the MMPA (Carduner, 2015b). Therefore, it was unnecessary for SpaceX to seek MMPA authorization for the incidental take of marine mammals at-sea as a result of in-air noise related to the Proposed Action. On 3 August 2016, NOAA Fisheries also concurred that the landing of the Falcon 9 First Stage within the Iridium Landing Area would not require a revision to the IHA issued to SpaceX, dated 19 May 2016 (Appendix B).

**Vessel Noise**

Vessel noise has the potential to disturb marine mammals and elicit an alerting, avoidance, or other behavioral reaction. Most studies have reported that marine mammals react to vessel sounds and traffic with short-term interruption of behaviors or social interactions (Watkins 1986; Richardson et al. 1995; Magalhães et al. 2002; Noren et al. 2009). Marine mammals and sea turtles in the proposed zone of influence may be exposed to project-related vessels and vessel noise. However, it may be difficult for the animals to discern vessel noise associated with the proposed activities as additional to what is already present due to research, ecotourism, commercial or private vessels, or government activities. As a result, vessel noise generated by the support vessels required to support the contingency landing actions may affect, but are not likely to adversely affect the following ESA-listed species: Guadalupe fur seal, blue whale, fin whale, gray whale, humpback whale, sei whale, sperm whale, and green sea turtle, loggerhead sea turtle, olive Ridley sea turtle, hawksbill sea turtle, and leatherback sea turtle. Vessel noise has the potential to create in-water sound that could disturb ESA-listed fish species, which could result in behavioral (e.g., avoidance) or physiological (e.g., stress, increased heart rate) responses. While vessel movements have the potential to expose ESA-listed fish species occupying the water column to noise and general disturbance, potentially resulting in short-term behavioral or physiological responses, such responses would not be expected to compromise the health, condition, or fitness of individual fish because the impacts from vessel noise would be temporary, infrequent, and localized. As a result, vessel noise generated by the support vessels
required to support the contingency landing actions may affect, but are not likely to adversely affect the following ESA-listed fish species: scalloped hammerhead shark, steelhead, and green sturgeon.

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 (Carduner, 2015b). Therefore, it was unnecessary for SpaceX to seek MMPA authorization for the incidental take of marine mammals at-sea as a result of in-air noise-related vessel noise caused during the Proposed Action. On 3 August 2016, NOAA Fisheries also concurred that the landing of the Falcon 9 First Stage within the Iridium Landing Area would not require a revision to the IHA issued to SpaceX, dated 19 May 2016 (Appendix B).

### 4.2.1.1.3 Impacts to Seabirds

The likelihood of most species of seabirds occurring within the area potentially impacted during the Proposed Action (Alternative 1) is very low. If individual seabirds do occur within the area impacted by visual and noise impacts (sonic boom, landing noise, potential explosion noise) they would be expected to experience brief behavioral disturbance, which could cause cessation of foraging activities, and movement away from the landing location. Seabirds within the immediate area of potential impact during an explosion (114 ac. [0.46 km²]) may experience injury or mortality. There is insufficient data to estimate the likelihood of impact by debris during an explosion; however the initial visual and auditory disturbance would be likely to cause seabirds to move away from the area of potential debris impact and densities of seabirds are likely to very low. Thus, the likelihood of direct impact from debris is also likely to be very low. Similarly, the likelihood of a seabird being exposed to expended materials is also likely to be low given the brief period of potential exposure (see Section 4.2.1.1.1, First Stage Explosion) and low densities of seabirds. Therefore, the impacts of visual and noise disturbance (sonic boom, landing noise, and potential explosion noise) and the impact from debris or exposure to expended materials as a result of an explosion on the drone ship during an unsuccessful drone ship landing attempt in the Iridium Landing Area generated by the Falcon 9 Full Thrust First Stage landing action would not have a significant impact on seabirds.

### 4.2.1.2 Essential Fish Habitat

As described in Kephart (2015) and Stelle (2015), which are incorporated herein and by reference, and described above, an explosion of the Falcon 9 First Stage or the barge could release petroleum-based contaminants (i.e., fuel) or kill or injure individual fish, which may later be susceptible to predation. Adverse effects to EFH species and their prey associated with petroleum-based contaminants can range from acute toxicity at high levels of exposure to chronic sub-lethal toxicity (Khan et al, 2007; Seuront, 2011). However, the first stage booster uses RP-1, characterized as a “Very Light Oil“ that has a low viscosity, low specific gravity, high volatility. In addition, the anticipated amount of residual fuel during an unsuccessful landing attempt would be limited to between 50 and 150 gallons and would most likely be released onto the barge deck upon impact. In the event the first stage booster misses the barge entirely and the fuel is released into the ocean, the RP-1 would be expected to evaporate quickly and would completely dissipate within one to two days after a spill. Cleanup of very light oil spills are usually
not possible, especially with such small quantities. Given the small quantity and composition of the fuel that may be released, any adverse impacts from a spill of petroleum-based contaminants to EFH would be minimal.

An unsuccessful barge landing would result in a projectile range of up to 1,250 ft. (381 m). SpaceX has experience performing at-sea recovery operations after water and unsuccessful barge landings. This experience, in addition to the debris catalog that identifies floating debris, has revealed that approximately 25 pieces of debris remain floating after a water landing or unsuccessful barge landing. The surface area impacted with debris would be less than 114 ac. (0.46 km²), and the vast majority of 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 COPVs, the Liquid Oxygen 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 or water landing would result in a small debris field, making recovery relatively straightforward and efficient. Given the location of the Iridium Landing Area and SpaceX's recovery actions, it is unlikely that this debris would wash ashore along the California coastline. In the unlikely event that debris were to wash ashore, which would only occur during high westerly winds coupled with specific seasonal or tidal conditions, attempts would be made to recover the debris without affecting sensitive biological resources along the coastline. These activities would be monitored by a qualified biologist. All debris recovered offshore would be transported back to Long Beach Harbor.

Denser debris that would not float on the surface is anticipated to sink relatively quickly and is composed of inert materials that would not change the characteristics of the bottom substrate. Although the debris is inert, it could still result in adverse impacts. For instance, debris may be ingested by, or entangle, marine organisms and alter the benthic invertebrate community within the area (Stelle, 2015). Marine debris can also become snagged on or damage sensitive habitats, such as reefs, though this would only occur under a specific set of conditions, as noted in the EFH action area section.

The rate of deposition would vary with the type of debris; however, none is so dense or large that benthic habitat would be degraded. The area that would be impacted by a piece or pieces of sinking debris would be very small. The Iridium Landing Area is not located within habitat that is particularly important for ecological function, particularly vulnerable to degradation, or particularly rare. EFH for the Pacific Coast Groundfish is located within the perimeter of the Iridium Landing Area; however, a 5-mile buffer was established around each EFH and HAPC for groundfish, as depicted in Figure 1-2. The Iridium Landing Area is also outside the Southern California Bight, which extends from Point Conception to U.S. Mexico Border and as far west as the Patton Escarpment, also known as the “Continental Borderland” (Givens et al., 2014; Figure 4-2).
Figure 4-2: Essential Fish Habitat in Proximity to the Iridium Landing Area
Therefore, Alternative 1 (Proposed Action) may adversely affect EFH; however, only temporary and no more than minimal effects are expected. These impacts would be offset by implementation of a marine debris recovery program reviewed by and approved by NOAA Fisheries. NOAA Fisheries concurred with the USAF’s determination that Alternative 1 (Proposed Action) may adversely affect EFH; however only minimally and temporarily (Appendix B).

4.2.2 No Action Alternative

Under the No Action Alternative, a boost-back and landing of the Falcon 9 Full Thrust First Stage on an autonomous drone ship within the Iridium Landing area would not occur. However, the landing would be conducted at the SLC-4W pad at VAFB, with a contingency option of landing at the autonomous drone ship landing area approximately 27 nm (50 km) off the coast of Point Arguello, as discussed in Section 2.3 of the Falcon 9 Boost-Back EA (USAF, 2016).

Analysis of effects on biological resources in the Falcon 9 Boost-Back EA (USAF, 2016) concluded that the program could potentially affect seven federally listed marine mammal species, five federally listed turtles, three federally listed fish species, and marine mammal species protected under the MMPA due to debris impact, acoustic impacts, and expended materials. The USAF received concurrence from NOAA Fisheries with its assessment that the activities associated with Falcon 9 Boost-Back project (No Action Alternative herein) may affect, but was not likely to adversely affect these ESA-listed species. NOAA Fisheries also issued an IHA to SpaceX for Level B harassment of marine mammals as a result of boost-back and landing of the Falcon 9 First Stage at SLC-4W of the contingency landing area offshore of VAFB. In response to the USAF’s analysis of potential impacts to EFH, NOAA Fisheries concluded that the project could have an adverse effect on EFH over time as a result of the cumulative addition of marine debris to the sea floor. The USAF and SpaceX coordinated with NOAA Fisheries to contribute to a marine debris removal program to offset these impacts.

4.3 Water Resources

Impacts on water resources would be considered significant if a project were to cause substantial flooding or erosion; were to adversely affect any significant water body, such as a stream, lake, or bay; or were to adversely affect surface water or groundwater quality or quantity. Impacts would also be considered significant if existing drainage patterns of the site or area would be substantially altered.

4.3.1 Alternative 1 (Proposed Action)

The Iridium Landing Area is within the U.S. Exclusive Economic Zone but outside U.S. territorial waters. SpaceX would continue to use the proper management of materials and wastes (as described in Sections 4.8, Hazardous Materials and Waste Management; and 4.9, Solid Waste Management, of the Falcon 9 Boost-Back EA [USAF, 2016]) for the Proposed Action. These procedures would reduce or eliminate the potential for accidental spills or runoff of contaminants within the project area, which would directly impact water quality.

In the event of an explosion of the Falcon 9 Full Thrust First Stage resulting from an unsuccessful drone ship landing, surface water quality may be affected by expended materials. However,
SpaceX would recover all floating pieces of debris. Denser debris that would not float on the surface is anticipated to sink relatively quickly and is composed of inert materials that would not affect water quality.

In the event of an unsuccessful drone ship landing, between 50 and 150 gallons of residual RP-1 may be released into the ocean. RP-1, is a Type 1 “Very Light Oil,” which is characterized as having low viscosity, low specific gravity, and high volatility (USFWS 1998). Due to its high volatility, RP-1 evaporates quickly when exposed to the air and would completely dissipate within one to two days after a spill in the water. Cleanup following a spill of very light oil is usually not necessary or not possible, particularly with such a small quantity of oil that would enter the ocean in the event of an unsuccessful drone ship landing (USFWS 1998). Therefore, no attempt would be made to clean or recover RP-1 fuel from the ocean. 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, RP-1 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. Although it would require one to two days for the RP-1 to completely dissipate, over 90 percent of its mass would evaporate within the first seven minutes and 99 percent of its mass would evaporate within the first hour (see Section 4.3.1.4.3, Contingency Drone Ship Landing, Expended Materials and Fluids, in the Falcon 9 Boost-Back EA [USAF, 2016]). A buffer was established around San Clemente Island and San Nicolas Island, which lessens the likelihood that contaminants would spread into the ASBS around these islands. These areas are approximately 133 nm and 122 nm from the Iridium Landing Area, respectively. 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, thus dissipating even more quickly and further reducing the likelihood of exposure.

Therefore, the Proposed Action would not significantly impact water resources.

### 4.3.2 No Action Alternative

The No Action Alternative would not result in any direct or indirect impacts to water quality within and in the vicinity of the Iridium Lading Area because this area would not be utilized as a landing area. The Falcon 9 Boost-Back program would continue to operate as described in the Falcon 9 Boost-Back EA (USAF, 2016).

### 4.4 Coastal Zone Management

The California Coastal Commission reviews federal agency actions for consistency with the policies of the California Coastal Management Program. An impact on coastal resources would be considered significant if a project were inconsistent with these enforceable policies.
As stated in the Falcon 9 Boost-Back EA (USAF, 2016), applicable California Coastal Act (CCA) policies for this project included the following:

- "Providing for maximum public access to the coast;
- Protecting marine and land resources, including environmentally sensitive habitat areas, such as wetlands, riparian corridors and creeks, rare and endangered species habitat, and marine habitat, such as tide pools;
- Protecting the scenic beauty of the coastal landscape;
- Maintaining productive coastal agricultural lands;
- Recreational boating use; and
- Oil and hazardous substance spill prevention, preparedness and response in the marine environment."

4.4.1 Alternative 1 (Proposed Action)

A drone ship landing within the Iridium Landing Area would be outside the seaward limit of the California Coastal Zone and would not affect the scenic and visual qualities of coastal areas; terrestrial resources, including environmentally sensitive habitat areas; or agricultural resources. The U.S. Coast Guard would issue a Local Notice to Mariners that defines a Public Ship Avoidance Area around the contingency landing location.

Potential effects to nearshore marine resources along San Clemente Island or San Nicolas Island, such as haul-out sites for pinnipeds, would not occur because noise from the First Stage drone ship landing, including the sonic boom, would not extend to these shorelines.

Recreational boating within the Coastal Zone would only be temporarily delayed during transit of the drone ship, tug, and support vessel if recreational vessels were encountered. The three vessels would operate within established shipping and boating routes within the Coastal Zone while in route between the landing area and Long Beach Harbor. In the event of an encounter with a recreational vessel, standard rules of navigation and right-of-way would be followed, and at most, the recreational vessel would be temporarily delayed as the drone ship, tug, and support vessel transit through the area.

In the event of an unsuccessful landing attempt, the First Stage would explode upon impact with the drone ship. A debris impact analysis showed that the likelihood of debris striking individual marine mammals would be extremely unlikely to occur.

As described in Section 2.3.1.1.1 (For an Unsuccessful Drone Ship Landing Attempt) at most 2,750 lb. of RP-1 (or fuel) would be on board at the time of touch-down. Most of this fuel would be consumed during the subsequent explosion; residual fuel would be released onto the drone ship deck at the location of impact. In cases where the First Stage booster misses the drone ship entirely, SpaceX’s scientists assume that 2,750 lb. of RP-1 would be released into the ocean. In addition, approximately 25 pieces of floating debris would be present after a First Stage explosion, which SpaceX would remove promptly. The U.S. Coast Guard would keep the Public Ship Avoidance Area in place until all floating debris is removed from the water, typically several hours.
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 one to two days after a spill. Cleanup following a spill is usually not necessary, or possible, with spills of very light oil, particularly with such a small quantity of oil (USFWS 1998). Therefore, no attempt would be made to boom or recover RP-1, if any of the fuel is released directly into the ocean. Any RP-1 remaining on the drone ship deck from an unsuccessful landing attempt would be recovered, contained, and handled per federal, state, and local agency requirements. Given a spill would only occur following an explosion, it is unlikely that marine mammals, seabirds, sea turtles, and fish would remain in the immediate area and be subjected to any spill. Avoidance as a behavioral reaction would not be expected to have long-term effects and would therefore not be present when an animal returned to the coastal zone. Any release of RP-1 into the ocean within the Iridium Landing Area would not affect the California Coastal Zone since the spill should evaporate before reaching the coastal zone.

On 31 August 2015, the California Coastal Commission (CCC) concurred with a negative determination (ND-0027-15) for recurring Falcon 9 first stage boost-back landings at SLC-4W or a barge approximately 27 nm (50 km) offshore of VAFB. The Executive Director determined that the proposed project would not adversely affect coastal resources. The USAF determined the proposed new Iridium Landing Area does not raise any new coastal resource issues not previously addressed and the CCC concurred with this determination on 11 August 2016 (Appendix A).

4.4.2 No Action Alternative

Under the No Action Alternative, the Iridium Landing Area would not be used as a boost-back and landing area for the Falcon 9. The Falcon 9 Boost-Back program would continue to operate as described in the Falcon 9 Boost-Back EA (USAF, 2016). The USAF determined and the California Coastal Commission concurred that boost-back and landing of the Falcon 9 Full Thrust First Stage at VAFB and the contingency landing location at least 27 nm (50 km) offshore of VAFB would not adversely affect coastal use or resources.

4.5 Cumulative Impacts

The effects of Alternative 1 (Proposed Action) in combination with the effects of other relevant past, present, and reasonably foreseeable future projects have been evaluated in this cumulative effects analysis. The No Action Alternative is not analyzed as this alternative would have no cumulative effects on the environment (the Iridium Landing Area would not be used as a boost-back and landing area for the Falcon 9, and the Falcon 9 Boost-Back program would continue to operate as described in the Falcon 9 Boost-Back EA [USAF, 2016]). A list of relevant past, present, and reasonably foreseeable projects that have been/would be occurring at the Iridium Landing Area and vicinity is provided in Table 4-10. The foregoing analysis is based on the same resource thresholds as discussed in Sections 4.1 to 4.4.
4.5.1 Past, Present, and Reasonably Foreseeable Future Actions in the Region of Influence

The ROI is defined as the area over which effects of the Proposed Action could contribute to cumulative impacts on the environment. Therefore, the ROI includes the Iridium Landing Area and vicinity as shown in Figure 1-2. Future large projects that are currently projected in the ROI for the next several years and have the greatest potential to result in cumulative impacts are likely military activities (primarily U.S. Department of the Navy), U.S. Coast Guard operations, oil and gas development, transportation, and recreational and commercial fishing. Table 4-10 lists the past, present, and reasonably foreseeable future actions that may contribute to cumulative effects of the Proposed Action.

This section considers these actions cumulatively, based on the expected timeframe of their execution compared to the Proposed Action. Brief descriptions of each project and the resources impacted are provided below.

<table>
<thead>
<tr>
<th>Table 4-10: Federal and Non-Federal Projects</th>
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<tbody>
<tr>
<td><strong>Federal Activities</strong></td>
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<tr>
<td>U.S. Department of the Navy</td>
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<tr>
<td>Rim of the Pacific Exercise</td>
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<tr>
<td>U.S. Coast Guard</td>
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<tr>
<td>At-Sea Law Enforcement</td>
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<tr>
<td>Bureau of Ocean and Energy Management</td>
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<tr>
<td>Oil and Gas Development: Official Protraction Diagram Blocks (NH10-03; NH10-02, NH11-01; NI10-12; and NI11-10)</td>
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<tr>
<td>Other Environmental Considerations</td>
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<tr>
<td>Maritime Traffic</td>
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<tr>
<td>Commercial and Recreational Fishing</td>
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</tbody>
</table>

4.5.1.1 Hawaii and Southern California Training and Testing Environmental Impact Statement/Overseas Environmental Impact Statement

The Navy prepared a Hawaii-Southern California Training and Testing (HSTT) Environmental Impact Statement/Offshore Environmental Impact Statement (EIS/OEIS) in 2013 (U.S. Department of the Navy, 2013). A warning area (W-291) and tactical maneuvering area that are part of the Southern California (SOCAL) Range Complex are near the location of the Iridium Landing Area. The two primary components of the SOCAL Range Complex are the ocean...
operating areas and the special use airspace (U.S. Department of the Navy, 2013). Appendix A of the HSTT EIS/OEIS includes a list of potential testing and training activities that the Navy may perform within these areas. The Navy is currently preparing an update to the HSTT EIS/OEIS, which is scheduled for 2018.

4.5.1.2 Rim of the Pacific Exercise

The biennial Rim of the Pacific Exercise (RIMPAC) exercise, which occurs off the coasts of Hawaii and Southern California and includes over 29 nations has been occurring since 1968 (U.S. Department of the Navy, 2002). RIMPAC 2016 is the 25th version of this exercise. It occurred from 30 June to 4 August 2016 and is “the world's largest international maritime exercise” (Commander Naval Surface Force, 2016).

4.5.1.3 At-Sea Law Enforcement

U.S. Coast Guard operates within the U.S. economic exclusion zone. The U.S. Coast Guard has the following 11 statutory missions (U.S. Coast Guard, 2014):

- Ports, waterways, and coastal security
- Drug interdiction
- Aids to navigation
- Search and rescue
- Living marine resources
- Marine safety
- Defense readiness
- Migrant interdiction
- Marine environmental protection
- Ice operations
- Other law enforcement

Living marine resources includes conducting operations to enforce all applicable laws and regulations that safeguard fisheries and marine protected resources. The U.S. Coast Guard provides a consistent at-sea law enforcement presence and assists natural resource agencies with responding to events such as strandings and entanglements (U.S. Coast Guard, 2016). In addition, U.S. Coast Guard also often trains with the Navy at sea (Commander, U.S. Third Fleet, 2013), which includes participating in the biennial RIMPAC exercise.

4.5.1.4 Official Protraction Diagram Blocks (NH10-03; NH10-02, NH11-01; NI10-12; and NI11-10)

Offshore oil and gas production, which is administered by the Bureau of Ocean and Energy Management (BOEM), is listed as another dominant use in the area (marinecadastre.gov, 2016). BOEM has gridded the ocean into Official Protraction Diagram blocks. The landing area is located within NH10-03 (Valero Basin) block, and the sonic boom may be heard within the NH10-02, NH11-01 (Bushnell Knoll), NI10-12 (Patton Ridge), and NI11-10 (San Clemente Island) blocks. There are no active or proposed oil and gas leases within these blocks. In May 2016, BOEM
completed a programmatic EA to use well stimulation treatment on the Pacific outer continental shelf; however, this activity was limited to existing facilities (Argonne National Laboratory, 2016).

4.5.1.5 Maritime Traffic

Maritime traffic includes pleasure crafts, cargo shipping, cruise ships/marine tourism, and other vessels at sea. A Notice to Mariners would be issued before the Proposed Action would occur, to avoid overlap between boost-back landing activities in the Iridium Landing Area and other maritime traffic.

4.5.1.6 Commercial and Recreational Fishing

There are 11 ports in Southern California that commercial and commercial passenger fishing vessels use in the open ocean areas of the SOCAL range complex (U.S. Department of the Navy, 2009). Recently the overall number of commercial fishing vessels has decreased. This change has been attributed to increases in fishing regulations, changes in environmental conditions, and changes in market forces (California Department of Fish and Game, 2008a, 2008b).

4.5.2 Alternative 1 (Proposed Action)

4.5.2.1 Air Quality and Climate

Air emissions from other projects listed in Table 4-10 would be localized and short term in nature, except for the HSTT EIS/OEIS, which is anticipated to continue at the rates given in the 2013 EIS/OEIS until it is renewed in 2018. Long-term emissions from the projects are not anticipated to increase. Cumulative emissions from Proposed Action combined with other concurrent projects and activities would not exceed the significance thresholds and would not produce any significant cumulative air quality impacts. The incremental contribution of the Proposed Action to GHG emissions is extremely small relative to global emissions and therefore would not have a significant impact to cumulative GHG emissions or climate change. This determination was made by reviewing the total emission impact of this project with the cumulative emissions from all planned concurrent projects (Table 4-10). Therefore, implementation of the Proposed Action in conjunction with other past, present, or reasonably foreseeable projects would not result in cumulative impacts to air quality or climate change.

4.5.2.2 Biological Resources

Although the Proposed Action and other concurrent projects may disturb wildlife, the disturbance would be temporary and wildlife would continue to use habitat in the ROI. Boost-back and landing is a short and infrequent operation (up to six events per year) and would not be expected to have residual effects past each operation. Compliance with the Falcon 9 Boost-Back EA consultations and implementation of environmental protection measures as described in Section 2.3.3.1 (Biological Resources – 4 [Bio–4]) would minimize impacts to special-status species. Therefore, implementation of the Proposed Action in conjunction with other past, present, or reasonably foreseeable projects would not result in cumulative impacts to biological resources.
4.5.2.3 Water Resources

Cumulative impacts to water resources could occur if concurrent projects were to inadequately address water resources in the ROI. Compliance with all state and Federal regulations and implementation of proper management of materials and wastes (as described in Sections 4.8, Hazardous Materials and Waste Management; and 4.9, Solid Waste Management, of the Falcon 9 Boost-Back EA [USAF, 2016]) would minimize impacts to water resources as a result of the Proposed Action. Therefore, implementation of the Proposed Action in conjunction with other past, present, or reasonably foreseeable projects would not result in cumulative impacts to water resources.

4.5.2.4 Coastal Zone Management

The Proposed Action would not adversely affect the Coastal Zone, CZMA, or CCA policies. The cumulative projects identified in Table 4-10 that may impact coastal zone resources include the HSTT EIS/OEIS and future oil and gas development. Compliance with all state and Federal regulations and the submittal of a negative determination for the boost-back and landing within the Iridium Landing Area to the California Coastal Commission would show that the Proposed Action would have minimal impacts to coastal zone resources. Therefore, implementation of the Proposed Action in conjunction with other past, present, or reasonably foreseeable projects would not result in cumulative impacts to coastal zone resources.
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Kephart, B. 2016. Letter to Mr. Will Stelle. 2 August 2016. Includes attachment: Description and Assessment of Essential Fish Habitat.


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APPENDIX A: California Coastal Commission Consultation
All-

See response below from the California Coastal Commission for the Iridium-1 downrange landing location.

Thanks,
Samantha

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From: Simon, Larry@Coastal [mailto:Larry.Simon@coastal.ca.gov]
Sent: Thursday, August 11, 2016 10:44 AM
To: KAISERSATT, SAMANTHA O CIV USAF AFSPC 30 CES/CEIEA <samantha.kaisersatt@us.af.mil>
Subject: RE: Change in Landing Location

Samantha,

On August 31, 2015, the Commission's Executive Director concurred with ND-0027-15 for recurring Falcon 9 rocket launches from SLC-4E, and first stage boost-back landings at SLC-4W or a barge approximately 30 miles offshore of Vandenberg AFB. The Executive Director determined that the proposed project would not adversely affect coastal resources. The proposed revised location of offshore barge landings to a site approximately 140 miles southwest of San Nicolas Island does not raise any new coastal resource issues not previously addressed in our concurrence with ND-0027-17. Thank you for coordinating with the Commission on the project modification. Best regards,

Larry

Larry Simon
Federal Consistency Coordinator
Energy, Ocean Resources and
Federal Consistency Division

https://mail.mantech.com/owa/#viewmodel=ReadMessageItem&ItemID...
Larry,

VAFB received concurrence with a negative determination for the recurring SpaceX Falcon 9 boost-back and landings at Space Launch Complex 4 West and on a barge approximately 50 km off the coast. Due to mission restrictions some of the boost-backs will not be able achieve landing at the locations previously identified. SpaceX is proposing to perform barge landings at sea further south, approximately 140 miles southwest of San Nicolas Island (see attached figure for exact location of barge landing and region of influence).

Please provide feedback in regards to any additional requirements that may be required as a result in the change of landing location.

Thanks,
Samantha

//SIGNED//
Samantha Kaisersatt
Environmental Planner
30 CES/CEIEA
1028 Iceland Ave.
Vandenberg AFB, CA 93437
COMM: 805-605-0392
DSN: 275-0392
samantha.kaisersatt@us.af.mil
APPENDIX B: National Oceanic and Atmospheric Administration, National Marine Fisheries Service Consultation
Beatrice L. Kephart  
30 CES/CEI  
1028 Iceland Avenue  
Vandenberg AFB CA  93437-6010  

William W. Stelle, Jr.  
Regional Administrator  
NOAA Fisheries Service  
Southwest Region  
501 West Ocean Blvd., Ste. 4200  
Long Beach CA  90802-4213  

Dear Mr. Stelle  

Vandenberg Air Force Base (VAFB) requests reinitiation of Endangered Species Act Section 7(a)(2) Concurrency, Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response and Marine Mammal Protection Act for SpaceX Boost-Back and Landing of the Falcon 9 First Stage (#2016/4011). VAFB proposed landing the Falcon 9 First Stage at Space Launch Complex 4 West or on a barge approximately 50 kilometers (km) offshore. An additional barge landing location has now been identified approximately 120 nautical miles (225 km) southwest of San Nicolas Island, hereafter referred to as the Iridium Landing Location (Figure 1). VAFB requests National Marine Fisheries Service (NMFS) concurrence that the new barge landing location may affect, but is not likely to adversely affect, species listed as threatened or endangered or critical habitat designated under the Endangered Species Act of 1973 (ESA). VAFB also requests NMFS concurrence that the project may adversely affect Essential Fish Habitat (EFH); however, only temporary and no more than minimal effects are expected.  

The estimated location of the Iridium landing would be at the following coordinates: 31.295900°, -120.513800°. This landing location would be used during the upcoming SpaceX Iridium launch in October 2016, as well as potential future launches. There would be no additional changes to the project. The rocket, vessels, equipment, and personnel performing this action would be the same as that described during the initial consultation. Therefore, the landing noise, vessel noise, and explosion noise and debris for the Iridium Landing Location would all be similar to what was described in Section 7 Biological Assessment (Kephart 2015a). The primary difference between the original barge landing and the Iridium Landing is the location. As such, this analysis focuses on impacts associated with the Iridium Landing Location and incorporates by reference the following correspondence and reports:  

a. Letter to NMFS dated June 4, 2015 (Kephart 2015b), including its attachment titled "Description and Assessment of Essential Fish Habitat"; and  

b. Letter to NMFS dated June 22, 2015 (Kephart 2015a), including its attachment titled "Section 7 Biological Assessment (June 22, 2015)".
Endangered Species Act

NMFS concurred with VAFB’s determination that this project may affect, but is not likely to adversely affect, the following species:

a. Threatened: Guadalupe fur seal (*Arctocephalus townsendi*), green sea turtle (*Chelonia mydas*), olive Ridley sea turtle (*Lepidochelys olivacea*); and


The proposed modification would include an approximately 9.396-million-acres (3,802 km2; 14,681 miles²) area around the Iridium Landing Location (Figure 1). This action area was extrapolated from the maximum extent that the sonic boom may be heard from the Iridium Landing Location. The same ESA-listed species have the potential to occur within the Iridium Landing Location as the original barge landing and no additional species have been identified that were not previously included in the concurrence request.
Debris Strike

Impacts to ESA-listed marine species known to occur within the action area for the Iridium Landing Location would be similar to the original barge landing. As with the original barge landing, the primary potential affect would be from a debris strike from an explosion. Tables 1 and 2 show the probability that an explosion could impact an individual of a ESA-listed marine species. The density estimates conservatively apply the highest density of the species occurring in the area for the entire action area. Probabilities were calculated using the same methods described in the Section 7 Biological Assessment (June 22, 2015) for the conditional landing area (Kephart 2015a). For those ESA-listed marine species not identified in Tables 1 and 2, the anticipated probability of impacts is the same as that of the original barge landing.

Table 1. Estimated at-sea density of individuals per km2 and probability of direct impact of rocket debris per year.

<table>
<thead>
<tr>
<th>Species</th>
<th>Estimated At-Sea Density (km²)*</th>
<th>Probability of Impact per Event</th>
<th>Probability of Impact per Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guadalupe Fur Seal</td>
<td>0.0083</td>
<td>0.00007</td>
<td>0.00042</td>
</tr>
<tr>
<td>Blue Whale</td>
<td>0.005532</td>
<td>0.00009</td>
<td>0.00054</td>
</tr>
<tr>
<td>Fin Whale</td>
<td>0.008176</td>
<td>0.00007</td>
<td>0.00042</td>
</tr>
<tr>
<td>Gray Whale</td>
<td>0.00000</td>
<td>0.00000</td>
<td>0.00000</td>
</tr>
<tr>
<td>Humpback Whale</td>
<td>0.00192</td>
<td>0.00002</td>
<td>0.00012</td>
</tr>
<tr>
<td>Sei Whale</td>
<td>0.0008</td>
<td>0.00010</td>
<td>0.00060</td>
</tr>
<tr>
<td>Sperm Whale</td>
<td>0.008905</td>
<td>0.000009</td>
<td>0.000054</td>
</tr>
</tbody>
</table>


Table 2. Estimated at-sea density of individuals per km2 and probability of an individual occurring within the impact area for explosion.

<table>
<thead>
<tr>
<th>Species</th>
<th>Estimated At-Sea Density (km²)*</th>
<th>Probability of Animal in Noise Impact Zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guadalupe Fur Seal</td>
<td>0.0083</td>
<td>0.10430</td>
</tr>
<tr>
<td>Blue Whale</td>
<td>0.005532</td>
<td>0.00070</td>
</tr>
<tr>
<td>Fin Whale</td>
<td>0.008176</td>
<td>0.00103</td>
</tr>
<tr>
<td>Gray Whale</td>
<td>0.00000</td>
<td>0.00000</td>
</tr>
<tr>
<td>Humpback Whale</td>
<td>0.00192</td>
<td>0.00024</td>
</tr>
<tr>
<td>Sei Whale</td>
<td>0.008176</td>
<td>0.00103</td>
</tr>
<tr>
<td>Sperm Whale</td>
<td>0.008905</td>
<td>0.00112</td>
</tr>
</tbody>
</table>


The probability of affecting an ESA-listed marine species remain sufficiently low (<0.001) and any potential impact would be temporary and of a short duration. Further, SpaceX would use the same method to collect any debris from an explosion as described for the conditional landing area (Kephart 2015a). As such, VAFB requests NMFS concurrence that the potential explosion generated by the Falcon 9 First Stage during the contingency landing actions at the Iridium Landing Location may affect, but is not likely to adversely affect, the following listed species: Guadalupe fur seal, blue whale, fin whale, gray whale, humpback whale, sei whale, sperm whale, green sea turtle,
Olive Ridley sea turtle, hawksbill sea turtle, loggerhead sea turtle, leatherback sea turtle, steelhead, scalloped hammerhead shark, and green sturgeon.

**Sonic Boom**

Attachment 1 provides the estimated sonic boom overpressure modeling results for the Iridium Landing Location. The sonic boom at the Iridium Landing Location is estimated to be similar to that of actual data measured during the Jason-3 barge landing in January 2016, which had a similar trajectory as the upcoming Iridium landing, measured at 2.3 pounds per square foot (psf) on the barge. Bradley (2016) estimated the sonic boom at the Iridium Landing Location would be up to 3.85 psf, slightly increasing the amount of energy transmitted into the water than what was predicted in the concurrence request (2.0 psf).

In the case of a sonic boom, it is likely that acoustic energy would transmit through the air-water interface and propagate some distance into the water column; however, exceptionally little sound would be transmitted between the air-water interface (Godin, 2008). For example, Sohn et al. (2000) performed field measurements of sonic boom penetration into the ocean, and found that boom pressures exhibit a frequency-dependent decay with depth, with low frequencies penetrating significantly farther than high frequencies. All of the boom pressure signals measured in this experiment decayed to ambient levels in all frequency bands by 40–50 meters. Additionally, a sonic boom of 2.0 psf (approximately 133.6 dB re 20 μPa) at the surface was noted to decay to approximately 152 dB re 1 μPa at a depth of 7 meters. By 22 meters, the received level was approximately 140 dB re 1 μPa and by 37 meters; the acoustic wave had been subsumed by ambient noise levels. All of these levels are below the peak SPL criteria for physiological effects from acoustics. Increasing the psf to 3.85 psf (approximately 139.29 dB re 20 μPa) would slightly increase the amount of energy transmitted into the water. However, it is expected that the decay rates would be similar to those reported in Sohn et al. (2000) and would not exceed peak SPL criteria for physiological effects from acoustics. The range to potential behavioral change (160 dB re 1 μPa) increases, but is anticipated to decay to levels less than 160 dB within the first 10 meters of the water column. For in-air, there is no established criterion threshold for PTS (injury). However, the behavioral threshold for harbor seals is 90 dB re 20 μPa and all other pinnipeds is 100 dB re 20 μPa. Therefore, any pinniped at the water surface where the ground signature is greater than 0.04 psf (for non-harbor seals) or 0.013 (for harbor seals) would be in the region where the behavioral thresholds are exceeded. As a result, any pinniped at the water surface underneath nearly the entire boom footprint would be considered in excess of the behavioral threshold. However, any impact would be temporary and of a short duration. As noted in the concurrence letter, the sonic boom associated with the barge landing would be less than an explosion on the barge (blast injury and barotrauma is measured following exposure to an explosion) and would be less than what is estimated at the water’s surface generated by the Falcon First Stage during the barge landing.

For these reasons, VAFB requests NMFS concurrence that the sonic boom generated by the Falcon 9 First Stage during the contingency landing actions at the Iridium Landing Location may affect, but is not likely to adversely affect, the following seven ESA-listed marine mammals: blue whale, fin whale, gray whale, humpback whale, sei whale, sperm whale, and Guadalupe fur seal. Similarly, even with increases in pressure, all received levels would remain below the peak SPL criteria for physiological effects from acoustics on sea turtles. As a result, VAFB requests NMFS concurrence that the sonic boom generated by the Falcon 9 First Stage during the contingency landing actions at the Iridium Landing Location may affect, but is not likely to adversely affect, the five ESA-listed sea turtles: green sea turtle, loggerhead sea turtle, olive Ridley sea turtle, hawksbill sea turtle, and leatherback sea turtle.
Magnuson Stevens Fishery Conservation and Management Act

NMFS determined that the barge landing offshore of VAFB would adversely affect EFH and provided an EFH consultation response pursuant to Section 305(b)(4)(A) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA), 16 U.S.C. § 1855(b)(4)(A) (2014), and comments in accordance with the Fish and Wildlife Coordination Act (FWCA), 16 U.S.C. §§ 661-667e (2014) (Stelle 2016). Pursuant to 50 C.F.R. § 600.920(l), agencies must reinitiate EFH consultation with NMFS if the proposed action is substantially revised in a way that may adversely affect EFH, or if new information becomes available that affects the basis for NMFS’ EFH Conservation Recommendations.

Enclosed is a Description and Assessment of EFH for the Iridium Landing Location (Attachment 2), which incorporates by reference the Description and Assessment of EFH that was submitted via letter dated June 4, 2015 (Kephart 2015b). VAFB requests your concurrence that the project may adversely affect EFH; however, only temporary and no more than minimal effects are expected. As described in the attached, VAFB and SpaceX remain committed to implementing the conservation measures recommended in your concurrence letter (Stelle 2016).

Marine Mammal Protection Act

SpaceX has requested an amendment from NMFS’ Office of Protected Resources to the Incidental Harassment Authorization for this action, which is currently under review.

Please contact me at (805) 605-7924 if you have any questions.

Sincerely

BEATRICE L. KEPHART
Chief, Installation Management Flight

2 Attachments:
1. Map of Sonic Boom Overpressure Modeling Results for the Iridium Landing Location
2. Description and Assessment of Essential Fish Habitat – Iridium Landing Location
Literature Cited


Kephart, B. 2015b. Letter to Mr. Will Stelle. 04 June 2015. Includes attachment: Description and Assessment of Essential Fish Habitat.


Attachment 1. Sonic Boom Overpressure Modeling Results for the Iridium Landing Area
Description of Essential Fish Habitat

The Magnuson-Stevens Fishery Conservation and Management Act (MSA) (16 U.S.C. §§ 1801-1882) requires the delineation and description of essential fish habitat (EFH) by regional fishery management councils, in conjunction with the National Marine Fisheries Service (NMFS), in fishery management plans (FMPs) for all Federally-managed fish species. EFH is defined as "those water and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" (16 U.S.C. § 1802[10]). Actions that occur outside of EFH, that might affect the habitat, must also be taken into account. Federal agencies must prepare an EFH Assessment for every action that may adversely affect EFH (50 C.F.R. § 600.920[e][1]). In addition to EFH designations, areas called Habitat Areas of Potential Concerns (HAPs) are also designated by the regional fishery management councils. These areas are discrete subsets of EFH that are particularly important for ecological function, particularly vulnerable to degradation, or particularly rare (50 C.F.R. §§ 600.805-600.815). Regional fishery management councils may designate a specific habitat area as an HAP based on one or more of the following considerations:

i. The importance of the ecological function provided by the habitat.
ii. The extent to which the habitat is sensitive to human-induced environmental degradation.
iii. Whether, and to what extent, development activities are, or will be, stressing the habitat type.
iv. The rarity of the habitat type.

(67 Fed. Reg. 2343, codified at 50 C.F.R. Part 600). The intent of designating an HAPC is to identify those areas that are in need of additional protection. Although designated HAPCs are not afforded any additional regulatory protection under MSA, federal projects with potential adverse impacts to HAPC will be more carefully scrutinized during the consultation process.

The Iridium Landing Area is within the jurisdiction of the Pacific Fisheries Management Council (PFMC). The PFMC has designated EFH and HAPC for Pacific Groundfish (Pacific Fisheries Management Council 2016c), Pacific Coast Salmon (Pacific Fisheries Management Council 2016d), Coastal Pelagic Species (Pacific Fisheries Management Council 2016a), and Highly Migratory Species (Pacific Fisheries Management Council 2016b). EFH for the Pacific Coast Groundfish is located over 43 nautical miles from the Iridium Landing Location as is HAPC for groundfish (Figure 1). However, the proposed Iridium Landing Location does occur within EFH for various federally managed fish species within the Coastal Pelagic Species and Highly Migratory Species Fishery Management Plans (FMPs).

Pacific Groundfish species include rockfish (Scorpaenidae), sablefish (Anoplopoma fimbria), flatfish (Pleuronectiformes), and Pacific whiting (Merluccius productus) that are often (but not exclusively) found on or near the ocean floor or other structures (Pacific Fisheries Management Council, 2016c). The EFH for Pacific Groundfish species
includes all waters and substrates in areas less than or equal to 3,500 meters (1,914 fathoms) in depth extending to the mean high water level or the upriver extent of salt water intrusion (to salinity levels of 0.5) (Figure 1). HAPC designated for groundfish include all waters, substrates, and associated biological communities falling within estuaries, canopy kelp or kelp forests, seagrasses, rocky reefs, and other habitat areas of interest (Pacific Fisheries Management Council, 2016c). Rocky reefs are submerged rock outcrops occurring from the intertidal zone to deep water. The rocky reef designation also includes seamounts, which force deep nutrient rich water to the surface. Off the coast of California, these include, Gumdrop Seamount, Pioneer Seamount, Guide Seamount, Taney Seamount, Davidson Seamount, and San Juan Seamount, as well as Mendocio Ridge, Cordell Bank, and Monterey Canyon.

Coastal Pelagic Species include finfish, such as Pacific sardine (Sardinops sagax), Pacific chub mackerel (Scomber japonicus), northern anchovy (Engraulis mordax), jack mackerel (Trachurus symmetricus) and market squid. The EFH for Coastal Pelagic Species includes all marine and estuary water from the coasts of California, Oregon, and Washington to the limits of the Exclusive Economic Zone (i.e., approximately 200 nautical miles from shore) and above the thermocline, where sea surface temperatures seasonally range between 50° and 70° Fahrenheit (F) (10° and 26° Celsius [C]) (Pacific Fisheries Management Council 2016a). A thermocline is an area in the water column where water temperatures change rapidly with depth. Water temperature is typically colder below the thermocline and warmer above the thermocline. The southern boundary of EFH for Coastal
Pelagic Species is the United States and Mexico maritime boundary. The northern boundary of EFH for coastal pelagic species is variable and is defined as the position of the 50°F (10°C) isotherm, which varies seasonally and annually, but even during the warmest times would be located north of the landing site (Pacific Fisheries Management Council 2016a). There are no HAPC designated for coastal pelagic species.

Highly Migratory Species include five species of tuna (Thunnus and Katsuwonus pelamis) and five species of shark (Alopias and Isurus oxyrinchus, Prionace glauca) as well as the striped marlin (Tetrapturus audax), swordfish (Xiphias gladius), and Dorado or Dolphinfish (Coryphaena hippurus) (Pacific Fisheries Management Council, 2016b). These are pelagic species that are listed in an annex to Article 64 of the United Nations Convention on the Law of the Sea. The EFH extends between 3 and 200 nm from shore and is bounded by the maritime boundaries of the United States and Canada to the north and United States and Mexico to the south. There are no HAPCs designated at this time for Highly Migratory Species.

Analysis of Effects

As described in Kephart (2015) and Stelle (2016), which are incorporated herein and by reference, an explosion of the Falcon 9 First Stage or the barge could release petroleum-based contaminants (i.e., fuel) or kill or injure individual fish, which may later be susceptible to predation. Adverse effects to EFH species and their prey associated with petroleum-based contaminants can range from acute toxicity at high levels of exposure to chronic sub-lethal toxicity (Khan et al 2007, Seuront 2011). However, the first stage booster uses RP-1, characterized as a “Very Light Oil” that has a low viscosity, low specific gravity, and is highly volatile. In addition, the anticipated amount of residual fuel during an unsuccessful landing attempt would be limited to 50-150 gallons and would most likely be released onto the barge deck upon impact. In the event the first stage booster misses the barge entirely and the fuel is released into the ocean, the RP-1 would be expected to evaporate quickly and would completely dissipate within one to two days after a spill. Clean up of very light oil spills are usually not possible, especially with such small quantities. Given the small quantity and composition of the fuel that may be released, any adverse impacts from a spill of petroleum-based contaminants to EFH would be minimal.

An unsuccessful barge landing would result in a projectile range of up to 1,250 feet (381 miles). SpaceX has experience performing at-sea recovery operations after water and unsuccessful barge landings. This experience, in addition to the debris catalog that identifies floating debris, has revealed that approximately 25 pieces of debris remain floating after a water landing or unsuccessful barge landing. The surface area impacted with debris would be less than 114 acres (0.46 kilometers$^2$), and the vast majority of 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-Over Pressure Vessels (COPVs), the Liquid Oxygen 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 or water landing would result in a small debris field, making recovery relatively straightforward and efficient. Given the location of the Iridium Landing Area and SpaceX’s recovery actions, it is unlikely that this debris would wash ashore along the California coastline. In the unlikely event that debris were to wash ashore, which would only occur during high westerly winds coupled with specific seasonal or tidal conditions, attempts would be made to recover the
debris without affecting sensitive biological resources along the coastline. These activities would be monitored by a qualified biologist. All debris recovered offshore would be transported back to Long Beach Harbor.

Denser debris that would not float on the surface is anticipated to sink relatively quickly and is composed of inert materials that would not change the characteristics of the bottom substrate. Although the debris is inert, it could still result in adverse impacts. For instance, debris may be ingested by, or entangle marine organisms and alter the benthic invertebrate community within the area (Stelle 2016). Marine debris can also become snagged on and/or damage sensitive habitats, such as reefs, though this would only occur under a specific set of conditions as noted in the EFH action area section.

The rate of deposition would vary with the type of debris; however, none is so dense or large that benthic habitat would be degraded. The area that would be impacted by a piece or pieces of sinking debris would be very small. The Iridium Landing Area is not located within habitat that is particularly important for ecological function, particularly vulnerable to degradation, or particularly rare. The closest HAPC (rocky reef for groundfish) is over 43 nautical miles from the Iridium Landing area. The Iridium Landing Area is also outside the Southern California Bight, which extends from Point Conception to U.S. Mexico Border and as far west as the Patagonia Escarpment, also known as the "Continental Borderland" (Givens 2014, Figure 1).

Our determination, for which we request your concurrence, is that the Iridium Landing Location may adversely affect Essential Fish Habitat; however, only temporary and no more than minimal effects are expected.

**Proposed Conservation Recommendation**

SpaceX would continue to follow the EFH Conservation Recommendation NMFS initially proposed for the barge landing (Stelle 2016). Although the majority of Falcon 9 First Stage landings are expected to occur on land, an unsuccessful barge landing attempt at sea would result in the discharge of unrecoverable marine debris. Given that up to six launches would occur annually, the potential for multiple discharges of marine debris could result in cumulative impacts to ocean floor habitats. VAFB coordinated with NMFS to develop an appropriate compensatory mitigation plan to offset these impacts (U.S. Air Force 2016).
References


Kephart, B. 2015. Letter to Mr. Will Stelle. 5 August 2015. Includes attachment: Description and Assessment of Essential Fish Habitat.


August 2, 2016

Jordan Carduner
NOAA Fisheries Office of Protected Resources
1315 East West Highway
Line 2
Silver Springs, MD 20910

Subject: Taking Marine Mammals Incidental to Boost-Backs and Landings of Rockets at Vandenberg Air Force Base.

Mr. Carduner:

SpaceX recently received an IHA from your office dated 5/19/16 covering take of Marine Mammals related to Boost-Backs and Landings of Rockets from Vandenberg Air Force Base. Due to mission restrictions some of the future Missions from Vandenberg utilizing Falcon 9 rockets will not be able to achieve Boost-Back and Landing at the same location as identified in the IHA (Vandenberg A.F.B. and the Northern Channel Islands). SpaceX is proposing to perform a droneship landing at sea (similar to the offshore landing option covered in the IHA) further south off the coast of Vandenberg (see attached figure for exact location). Results of the sonic boom model performed (also shown on the attached figure) for this mission show no impact to any islands or California coastline where potential haul outs for marine mammals would be located.

SpaceX is requesting that your office review this submittal and provide us feedback in regards to any additional requirements that may be required as a result of moving the landing location further south.

Please do not hesitate to contact John Hauenstein at (310) 363-6345 or john.hauenstein@spacex.com if you have any questions about this submittal.

Sincerely,

[Signature]

David Levine
Director, Launch Operations, Vandenberg Air Force Base.
Space Exploration Technologies
Figure 2-1. Sonic Boom Overpressure Modeling Results for the Iridium Landing Area.
FYI

From: John Hauenstein <John.Hauenstein@spacex.com>
Sent: Wednesday, August 3, 2016 11:33 AM
To: KEPHART, BEATRICE L CIV USAF AFSPC 30 CES/CEA (beatrice.kephart@us.af.mil); KAISERSATT, SAMANTHA O CIV USAF AFSPC 30 CES/CEANC (samantha.kaisersatt@us.af.mil)
Cc: DE VENOGE, THOMAS P GS-14 USAF AFSPC 30 CES/CEAN (thomas.devenoge.1@us.af.mil); Matthew Thompson; La Bonte, John Paul
Subject: FW: Change in Landing Location

Bea and Samantha,

Please see response below to our request to NMFS on re-evaluating our IHA for the Iridium-1 downrange landing location. I have attached the document we submitted to them so you can see our exact request.

We can discuss tomorrow at the 1pm meeting if you have any questions.

Regards,

John.

From: Jordan Carduner - NOAA Federal [mailto:jordan.carduner@noaa.gov]
Sent: Wednesday, August 03, 2016 11:27 AM
To: John Hauenstein <John.Hauenstein@spacex.com>
Subject: Re: Change in Landing Location

Hi John,
Thanks for this info. Based on the information provided, we don't think take of marine mammals is likely to occur as a result of Falcon 9 boost-backs and landings at the new landing location as shown on the map attached to your email dated 8/02/2016. Therefore no revision of SpaceX's existing IHA is warranted, and there are no additional requirements on the part of SpaceX with respect to MMPA incidental take authorization. If the planned action should change again, such that the modeled sonic boom footprints may be different than those previously considered, please contact us.

Please let me know if you need further info or have any questions.

Best,
Jordan
On Tue, Aug 2, 2016 at 4:07 PM, John Hauenstein <John.Hauenstein@spacex.com> wrote:

Forgot to send figure. Here you go.

From: John Hauenstein
Sent: Tuesday, August 02, 2016 1:03 PM
To: 'Jordan Carduner - NOAA Federal' <jordan.carduner@noaa.gov>
Subject: Change in Landing Location

Jordan,

Please see attached request. Thanks for your time.
August 29, 2016

In response, refer to:
2016/5369:DDL

Ms. Beatrice L. Kephart
30 CES/CEI
1028 Iceland Ave
Vandenberg Air Force Base, California 93437-6010

Re: Endangered Species Act Section 7(a) (2) Concurrence Letter, Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response, and Marine Mammal Protection Act for the SpaceX Boost-Back and Landing of the Falcon 9 First Stage

Dear Ms. Kephart:

On August 2, 2016, NOAA’s National Marine Fisheries Service (NMFS) received your request for a written concurrence that the Vandenberg Air Force Base (VAFB) SpaceX Boost-Back and landing of the Falcon 9 First Stage (project) is not likely to adversely affect (NLAA) species listed as threatened or endangered or critical habitats designated under the Endangered Species Act (ESA). On August 5, 2015, and January 26, 2016, NMFS provided Letters of Concurrence for this same proposed action with some adjustments to specific project details and consideration of potential impacts to ESA-listed species. This Letter of Concurrence replaces all previous letters that have been issued for this project and any previous letters that have been issued are no longer in effect. This response to your request was prepared by NMFS pursuant to section 7(a)(2) of the ESA, implementing regulations at 50 CFR 402, and agency guidance for preparation of letters of concurrence.

NMFS also provides preliminary comments concerning potential effects on whales, dolphins, porpoises, seals, and sea lions which are protected under the Marine Mammal Protection Act (MMPA). See 16 U.S.C. § 1361 et seq. Under the MMPA, it is generally illegal to “take” a marine mammal without prior authorization from NMFS. “Take” is defined as harassing, hunting, capturing, or killing, or attempting to harass, hunt, capture, or kill any marine mammal. Except with respect to military readiness activities and certain scientific research conducted by, or on behalf of, the Federal Government, “harassment” is defined as any act of pursuit, torment, or annoyance which has the potential to injure a marine mammal in the wild, or has the potential to disturb a marine mammal in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering.

This letter underwent pre-dissemination review using standards for utility, integrity, and objectivity in compliance with applicable guidelines issued under the Data Quality Act (section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554). The concurrence letter will be available through NMFS’ Public Consultation Tracking System [https://pcts.nmfs.noaa.gov/pcts-web/homepage.pcts]. A complete record of this consultation is on file at the NMFS West Coast Regional Office.
Proposed Action and Action Area

SpaceX proposes up to six launches per year of the Falcon 9 rocket. The Falcon 9 is a two-stage rocket designed and manufactured by SpaceX which delivers payloads to space aboard the Dragon spacecraft or inside a composite fairing. Falcon 9 First Stage incorporates 9 Merlin engines and aluminum-lithium alloy tanks containing liquid oxygen and rocket-grade kerosene (RP-1) propellant. The rocket carries landing legs which will land the rocket back on Earth after take-off. Under the proposed action for the Falcon 9 First Stage Boost-back and landing, SpaceX proposes to return the Falcon 9 First Stage to a landing pad at SLC-4 West (W) on VAFB in California for potential reuse. Although, the SLC-4W is the preferred landing location, SpaceX identified the need for contingency landing locations. During previous consultations on this project, SpaceX has identified contingency landing locations on land and offshore VAFB. The August 2, 2016 letter indicates that SpaceX is proposing to modify the potential options for contingency landing locations again, and has now identified a location approximately 120 nautical miles (225 km) southwest of San Nicolas Island to serve as a contingency landing location, hereafter referred to as the Iridium Landing Location, in addition to the contingency landing location 31 miles (50 kilometers) offshore of VAFB that was previously proposed and analyzed in the January 26, 2016 Letter of Concurrence (see Figure 1 and 2). Consistent with previous consultations, the proposed project considers the possibility of a maximum of six contingency landings annually, including potential impacts resulting from unsuccessful barge landings, with contingency landings occurring at either offshore site on a case-by-case basis. No other changes to the proposed action as described and analyzed during previous consultations have been identified or proposed.

After launch of the Falcon 9, the boost-back and landing sequence begins when the First Stage separates from the Falcon 9 and the Merlin engines of the First Stage cut off. After First Stage engine cutoff, rather than dropping the First Stage in the Pacific Ocean, exoatmospheric cold gas thrusters would be triggered to flip the First Stage into position for 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 in the correct angle to land. Once the First Stage is in position and approaching its landing target, the three engines would be 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 site.
Figure 1. Contingency landing location for the First Stage at Vandenberg Air Force Base (SLC-4W) and on a barge on the Pacific Ocean located 31 miles (50 kilometers) off of Vandenberg Air Force Base, California.

**Barge Landing**

Three vessels would be required to support a contingency barge landing, if such a landing is required: a barge/landing platform (300 ft long and 150 ft wide); a support vessel (165 ft long research vessel); and an ocean tug (120 ft long open water commercial tug). The barge was modified to accommodate the First Stage landing by increasing the width of the vessel and installing a dynamic positioning system and a redundant communications and command and control system. The support vessel is capable of housing the crew, instrumentation and communication equipment, and supporting debris recovery efforts. The tug will tow the barge into position at the landing site, after the First Stage lands, it will be secured onto the barge and the tug will tow the barge and the rocket back to Long Beach, California where it will be transported for off-load and transport back to the SLC-4W pad. The three vessels would be at sea for approximately 72 hours, including the 24 hours to transit to either contingency landing site, 12 hours for pre-launch activation, 12 hours to secure the First Stage
and equipment for return trip, and 24 hours to transit back to Long Beach Harbor. The majority of the transit time would occur in Federal waters as it is expected that less than one hour of transit time would be within 3 nm miles from shore in California state waters.

Figure 2. Contingency landing location for the First Stage on the Pacific Ocean located 120 miles (225 kilometers) southwest of San Nicholas Island, California. Figure also describes area expected to be impacted by the sonic boom associated with a contingency landing at this location.

In the event of an unsuccessful barge landing, the First Stage would explode upon impact with the barge. The explosive equivalence with maximum fuel and oxidizer is 503 pounds of trinitrotoluene (TNT) which is capable of a maximum projectile range of 384 m (1,250 ft) from the point of impact. Approximately 25 pieces of debris are expected to remain floating in the water and expected to impact less than 0.46 km² (114 acres), and the majority of debris would be recovered. All other debris is expected to sink. These 25 pieces of debris are primarily made of Carbon Over Pressure Vessels (COPVs), the LOX fill line, and carbon fiber constructed legs. During previous landing
attempts in other locations, SpaceX has performed successful debris recovery. All of the recovered debris would be transported back to Long Beach Harbor for proper disposal. Most of the fuel (estimated 50-150 gallons) is expected to be released onto the barge deck at the location of impact. In cases where the First Stage booster misses the barge entirely, it would be assumed that the 50-150 gallons of fuel would be released into the ocean.

Agency’s Effects Determination

VAFB has determined that the proposed project is not likely to adversely affect threatened: Guadalupe fur seals (*Arctocephalus townsendi*), green sea turtles (*Chelonia mydas*), olive ridley sea turtles (*Lepidochelys olivacea*); and endangered: blue whales (*Balaenoptera musculus*), fin whales (*B. physalus*), gray whales (*Eschrichtius robustus*; Western North Pacific stock), humpback whales (*Megaptera novaeangliae*), sei whales (*B. borealis*), sperm whales (*Physeter macrocephalus*), hawksbill sea turtles (*Eretmochelys imbricata*), loggerhead sea turtles (*Caretta caretta*), leatherback sea turtles (*Dermochelys coriacea*), steelhead (*Oncorhynchus mykiss*), green sturgeon (*Acipenser mediros*), and scalloped hammerhead sharks (*Sphyrna lewini*).

Their reasoning for the above determinations include the low density of animals potentially present in the proposed project area, the low likelihood that the proposed project’s impacts at the water’s surface would reach a submerged animal, and the short duration of the proposed activity. In addition, VAFB determined that the addition of the Iridium Landing Location as a contingency site did not substantially alter previous assessments of risk for ESA-listed species.

Consultation History

Previously, NMFS and VAFB have been engaged in extensive communication and discussion about the project, as detailed in previous Letters of Concurrence (most recent dated January 26, 2016). For the purposes of this consultation request, VAFB sent a letter describing the proposed addition of the Iridium Landing Location as a contingency site, along with an assessment of the potential impacts this change would have on ESA-listed species in context with what had previously been analyzed. The determination made by VAFB and the analysis contained in this Letter of Concurrence are built upon the analyses contained in previous Letters of Concurrence for this project and the information provided by VAFB in the August 2, 2016, consultation request.

ENDANGERED SPECIES ACT

Effects of the Action

Under the ESA, “effects of the action” means the direct and indirect effects of an action on the listed species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action (50 CFR 402.02). The applicable standard to find that a proposed action is not likely to adversely affect listed species or critical habitat is that all of the effects of the action are expected to be discountable, insignificant, or completely beneficial. Beneficial effects are contemporaneous positive effects without any adverse effects to the species or critical habitat. Insignificant effects relate to the size of the impact and should never reach the scale where take occurs. Discountable effects are those extremely unlikely to occur.

The proposed contingency actions associated with the proposed project include three potential impacts that may cause adverse effects on ESA-listed marine mammals, sea turtles, and fish species that occur in the vicinity of the contingency landing site. These include potential debris strike,
acoustic impacts, and interactions with expended materials. In general, the potential exposure and likely response and overall risk associated with the proposed project for ESA-listed species are similar at both offshore contingency landing locations that have been proposed. Where applicable, we distinguish and consider where differences in exposure for ESA-listed species may be expected.

Debris Strike

Although the resulting explosion could reach a maximum impact area of 0.46 km² (114 acres), based on engineering analysis from SpaceX’s Texas Rocket Development Facility, the debris would likely only impact 0.000706 km² of the 0.46 km² impact area. Using the United States Navy’s analytical approach to estimate the probability of impact (U.S. Department of the Navy 2014), and assuming a dynamic scenario in which the width of the footprint is enhanced by a factor of 5 to reflect momentum created by the explosion, the probability of impact with a single marine mammal was calculated. SpaceX proposes to conduct six contingency offshore landings per year, which could result in 0-6 First Stage explosions and we therefore conservatively use the maximum number of six for our calculations. Based on the estimated marine mammal density per km² and assuming that animals are at the surface at all times, the estimated number of impacts per year for any ESA-listed marine mammal is <0.001 (VAFB 2015 and 2016). The density estimates used for this analysis represent coastwide estimates that are considered representative of expected densities that may occur in the vicinity of either offshore contingency landing location. As a result of this analysis, we have determined that it would be extremely unlikely that any of the seven ESA-listed marine mammals would be struck by debris as a result of the proposed Falcon 9 First Stage landings. As a result, we conclude the risk of potential debris strike from the First Stage explosion for ESA-listed marine mammals is discountable.

The probability of impact with an ESA-listed sea turtle can be estimated using the same approach presented above for marine mammals, but the calculations are limited by the lack of similar density data for most ESA-listed sea turtles in the action area. However, there is density information for leatherback sea turtles in Central California that can be used to analyze potential impacts for the contingency landing location 31 miles offshore VAFB (0.0036 animals per km²; U.S. Department of the Navy 2014). In this location, we expect that leatherback sea turtles are the most common or likely sea turtle to be present based on the known distribution of the other 4 sea turtle species in the area, and thus we can use the we use the leatherback sea turtle density information as a conservative surrogate for the density of other sea turtles in this area. Based on the expected density of leatherback sea turtles, the estimated probability of debris impact with a leatherback sea turtle 31 miles offshore VAFB is 0.0003 leatherbacks per km² (VAFB 2015). This is then used to calculate an estimated annual number of takes of 0.0019 leatherback sea turtles at this location. We know that the density of the other 4 ESA-listed sea turtles likely to be in this impact area is less than what is expected for a leatherback sea turtle as calculated above, therefore, the estimated annual number of takes for the green sea turtle, loggerhead sea turtle, olive ridley sea turtle, and hawksbill sea turtle at this location is <0.0019 for each species (VAFB 2015).

However, at the Iridium Landing Location offshore San Nicholas in the Southern California Bight, other species of sea turtles are expected to be more common than they are in areas further north toward Central California; and likely more common in the proposed action area than leatherback sea turtles. Further away from Central California in the Southern California Bight where expected leatherback densities are less, we can expect that the likelihood of a debris strike for leatherback sea turtles at the Iridium Landing Location is also less than what was estimated for the area offshore VAFB. However, it is not appropriate to use estimated leatherback densities from Central California as a conservative surrogate for potential impacts to other sea turtle species in the Southern California
Bight. Based on historical fisheries bycatch data (NMFS 2013) and recent aerial surveys of the Southern California Bight, including the area offshore San Nicholas Island (SWFSC unpublished data), juvenile loggerhead sea turtles are likely the most common sea turtles that may be found in offshore areas of the Southern California Bight, at least seasonally during periods of warmer waters, including El Niño years. Unfortunately, no density data exist for loggerheads in this area at this time.

Recently, Seminoff et al. (2014) estimated loggerhead densities of 0.65 individuals per km² in coastal areas of Baja California Sur where juvenile loggerheads are known to congregate and forage in large numbers for extended periods of time. Compared to density values of leatherback turtles used in previous analyses, this value represents essentially 2 orders of magnitude higher density than the estimated leatherback density value off of Central California. However, the density of loggerhead turtles in the offshore environment in the Southern California Bight is not expected to be nearly as high as the coastal area in Baja. In 2013, NMFS concluded that loggerheads presence and abundance in U.S. waters off the coast of Southern California was significantly less compared those coastal foraging areas in Baja, and this area did not warrant designation of critical habitat (NMFS 2013). As a result, loggerhead density at the Iridium Landing Location is expected to be significantly less than what may be expected in Baja. Without any ability to quantitatively estimate the probability of debris striking a loggerhead sea turtle in this area similar to marine mammal species, we qualitatively have determined that the probability is likely very small given the relatively small size of the anticipated debris field in concert with the relative presence and abundance of loggerheads that can generally be expected in this area. From there we can also assume therefore, the estimated probability of debris strike for green sea turtles, olive ridley sea turtles, and hawksbill sea turtles at the Iridium Landing Location is even less than for loggerheads as these species are less likely than loggerheads to be present in abundance in this area.

Considering the relative probabilities of sea turtle presence within the debris field at both offshore contingency landing locations as described above, we have determined that it would be extremely unlikely that any of the ESA-listed sea turtles would be struck by debris as a result of the proposed Falcon 9 First Stage landings. As a result, we conclude the risk of potential debris strike from the First Stage explosion for ESA-listed sea turtles is discountable.

Sufficient density data are not available to conduct a debris strike analysis for ESA-listed fish species at either offshore contingency landing location in the manner conducted above for marine mammals and sea turtles. However, it is assumed that ESA-listed fish species likely to be in the area would be rare because of their known distribution in the area and likely swimming below the surface at all times. Should debris hit the water, it is expected that the initial impact at the water’s surface or even slightly below the surface, would absorb much of the energy from that impact. If they were present at either location, ESA-listed fish would be expected to be below this initial area of impact, and therefore unaffected by the debris. Although previous consultations only analyzed the potential impact to steelhead and scalloped hammerhead shark because of the higher likelihood that they may inhabit the impact area, NMFS and VAFB assumed that a similar evaluation and analysis would pertain to the green sturgeon, although the potential contingency landing locations are south of its primary range. As a result, we conclude the risk of potential debris strike from the First Stage explosion for ESA-listed fish is discountable.

**Acoustic Impacts**

Impulse sounds may include a sonic boom from the First Stage boost-back or an explosion of the First Stage landing from an unsuccessful barge landing. Non-impulse noise would include engine noise from the First Stage landing and vessel noise from the barge, tug, and support vessel. Acoustic
exposure to loud sounds may result in a temporary or permanent loss of hearing (termed a temporary (TTS) or permanent (PTS) threshold shift) depending upon the location of the marine mammal in relation to the source of the sound. Some marine mammal behavioral responses vary by individual, species, and circumstances. Some sounds may not cause any response, while others may result in minor to significant changes in a variety of behaviors, such as diving, surfacing, vocalizing, feeding, and/or mating, and flushing into the water from land. However, not all changes in behavior are cause for concern. Some marine animal responses are momentary inconsequential reactions, such as the turn of a head while other responses are within natural variation, such as a change in dive time. NOAA has developed new comprehensive guidance on sound characteristics likely to cause injury and behavioral disruption in the context of the MMPA, ESA, and other statutes. However, until this formal guidance becomes widely accessible and used by the public, NMFS will continue to use conservative thresholds of received sound pressure levels from broad band sounds that may cause behavioral disturbance and injury referenced herein as current. These conservative thresholds are applied in both MMPA permits and ESA Section 7 consultations for marine mammals to evaluate the potential for sound effects. The criterion levels specified here are specific to the levels of harassment as defined under the MMPA. Level A criterion for in-water PTS (injury), excluding tactical sonar and explosives, is 190 dB\text{Root Mean Square (rms)} re 1 \mu Pa for pinnipeds and 180 dB\text{rms} re 1 \mu Pa. Level B criterion for in-water for behavioral disruption for impulsive noise, is 160 dB\text{rms} re 1 \mu Pa; Level B criterion for in-water for behavioral disruption for non-pulse noise is 120 dB\text{rms} re 1 \mu Pa. There is no threshold established for Level A criterion for in-air PTS (injury), but for the Level B criterion in-air for harbor seals it is 90 dB\text{rms} and for all other pinniped species, it is 100 dB\text{rms}. We evaluated the proposed project activities using the above acoustic thresholds. In the ESA context, these thresholds are informative as the thresholds at which we might expect either behavioral changes or physical injury to an animal to occur, but the actual anticipated effects would be the result of the specific circumstances of the action (as further explained below).

**Sonic Boom**

A separate analysis is provided for the effects of a sonic boom on ESA listed species that are in the air above the water and for those underwater.

**In-air**

Guadalupe fur seals are the only ESA-listed marine mammal expected to haul out of the ocean onto the rocks within the proposed project area. They are found along the west coast of the United States, but are considered uncommon in Southern California. On San Miguel Island, California, one to several male Guadalupe fur seals had been observed annually between 1969 and 2000 (DeLong and Melin 2000) and juvenile animals of both sexes have been seen occasionally over the years (Stewart et al. 1987). Guadalupe fur seals display a high site fidelity to Point Bennett, on San Miguel Island, but SpaceX Boost-Back sonic boom impacts associated with activity offshore VAFB are expected to occur on the opposite side of San Miguel Island, away from Point Bennett. Guadalupe fur seals haul out in rocky habitat which provides them with protection and creates an environment that would deflect any potential loud noise stimuli (e.g., the wave action would dampen noise and the rocks would deflect any sound waves away from the animals and back towards the sound source). Therefore, should a Guadalupe fur seal react to any stimulus, it is expected that they would not flush

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into the water (*i.e.*, leave the haul out and move to or into the water) because of their typical rocky habitat. Thus, there is little to no threat of trampling of any age class, especially pups.

Sonic booms may potentially result in a short-duration startle response, which would not rise to the level of hearing damage to Guadalupe fur seals. NOAA Fisheries current in-air acoustic threshold for pinnipeds (except for harbor seals) is 100RMS dBA and all of the boom pressure signals measured in Sohn *et al.* (2000) experiment decayed to ambient levels in all frequency bands by 40-50 m (131-164 ft). Therefore, the amount of pressure that would damage hearing will decay to non-harmful levels prior to reaching Guadalupe fur seals hauled out on San Miguel Island. Results of monitoring during prior VAFB rocket launch operations have shown that reactions to sonic booms are correlated to the level of the sonic boom. Low energy sonic booms (<1.0 pounds psf) have resulted in little to no behavioral responses from harbor seals (*Phoca vitulina*) and California sea lions (*Zalophus californianus*). Any observed behavioral response has included a raise of the head or brief alert response, but animals returned to normal behavior shortly after the stimulus. VAFB monitoring reports from prior rocket launch operations indicate that more powerful sonic booms (>1.0 psf) have flushed harbor seals from their haul out sites, but have not resulted in any mortality or any sustained decrease in the total number of individuals following a stimulus and within 24 hours of a launch event (but more often it was within minutes), individuals returned to their pre-launch status. Guadalupe fur seals are considered to be less likely to be disturbed by sonic booms because when compared to harbor seals or California sea lions they are rarely observed showing any kind of behavioral reaction even when harbor seals or California sea lions have reacted (Jeff Harris, NMFS, pers. comm. 2015). Based on previous monitoring of rocket launches, harbor seals and California sea lions have resulted in little to no response. Also, VAFB’s previous monitoring showed that only a portion of the pinnipeds present reacted (most often the most extreme reaction was for harbor seals to flush into the water, although sometimes an individual California sea lion or elephant seal would flush, but the majority would react with a head alert) to the sonic boom and that after all launches, all pinnipeds returned to their normal behavior. The same number of pinnipeds returned to their respective haul out sites within 24 hours of a launch event, but more often they returned to their haul out site within minutes.

During previous consultations on this proposed project, modeling was conducted for sonic boom impacts greater than 2 pounds per square foot (psf), in order to cover sonic booms that could occur at or slightly above 3.0 pounds psf, as the SpaceX data analysis concluded at the time was possible from the Boost-Back and landing of rockets. Actual data measured during the recent Jason-3 barge landing in January 2016, measured at 2.3 pounds psf. Based on this information, Bradley (2016) estimated the sonic boom at a contingency landing location could be up to 3.85 psf, slightly increasing the amount of energy transmitted into the water than what was predicted during previous consultations on this project. Based on the modeling, sonic boom impacts greater than 2 pounds psf are still expected to impact a very small area similar to what has been considered previously.

Based on the modeling, sonic boom impacts greater than 2 pounds psf are expected to impact a very small area, which is likely to be offshore (See Figure 3) but does includes San Miguel Island. If such a sonic boom were to occur and reach San Miguel Island near the Point Bennet area, it is unlikely that a hauled out Guadalupe fur seal would detect it, based on the protection afforded by their rocky habitat as described above. In addition, based upon prior behavioral observations by Guadalupe fur seal experts, if the sonic boom was detected, the likelihood that a Guadalupe fur seal would be disturbed in excess of a startle or head response is minimal. Due to the low number of Guadalupe fur seals on San Miguel Island and their anticipated behavior during and following other types of human disturbance (including noise), in-air impacts from sonic booms are extremely unlikely and therefore discountable.
At the Iridium Landing Location, potential impacts from the sonic boom are likely to be completely offshore and away from any of the Channel Islands and potential haul out sites for Guadalupe fur seals (see Figure 2 above). Given the location of the Iridium Landing Location, there is no expectation of any ESA-listed species being hauled out of the water during any contingency landings there, and no risk of in-air impacts associated with the sonic boom.

Air to Underwater

It is likely that any noise associated with the sonic boom would transmit from the air to water and propagate some distance in the water column. A sonic boom at the surface of 2 pounds psf decayed to approximately 152 dB re 1µPa at a depth of 7 m (23 ft). By 22 m (72 ft), the received levels were approximately 140 dB re 1 µPa and at 37 m (121 ft), it was equal to ambient noise levels. All of these sound pressure levels are below the current NMFS threshold for potential permanent injury (190 dB$_{rms}$ re 1 µPa sound pressure level for pinnipeds and 180 dB$_{rms}$ re 1 µPa sound pressure level for cetaceans) and potential behavioral change or temporary injury (160 dB$_{rms}$ re 1 µPa sound pressure level). The information provided to NMFS did not indicate the point at which underwater sound pressure levels would equal or exceed 160 dB$_{rms}$ re 1 µPa, but we estimate this would likely occur at less than 7 m which could be at or near the surface level of the water based on the decay rate provided above at a depth of 7m. An ESA-listed marine mammal or sea turtle would only be within the <7 m range for an extremely short time to either breathe or break the surface of the water at the conclusion a feeding event (i.e., humpback whales breaking through the surface of the water after they congregate and feed on their prey). The onset of physical injury to fish would be expected if the peak levels exceed 206 dB re 1 µPa (Stadler and Woodbury 2009). As a result, the sonic boom associated with the contingency landing would be less than an explosion on the barge (blast injury and barotrauma is measured following exposure to an explosion) and would be less than what is estimated above at the water’s surface generated by the Falcon 9 First Stage during the contingency barge landing.
Figure 3: Example of a sonic boom impact area if a sonic boom reaches San Miguel Island, CA. In the model, all impacts greater than 2 pounds psf occur offshore (red dot and orange contour), and most impacts greater than 1.

Based on the estimated sound levels, the frequency with which the sonic booms may occur over the course of a year and the relative infrequency with which ESA-listed species may be in the immediate
vicinity during those times at either contingency landing location, we conclude that the risk of sonic booms associated with contingency landing actions for ESA-listed species is discountable.

**Explosion**

Noise resulting from an unsuccessful barge landing could introduce impulse sound into the ocean or near the water’s surface. The direct sound from the explosion would last less than a second. These sounds would be in the audible range of most marine mammals, even if the duration is expected to be very short. The six landing attempts would occur each year and likely dispersed over the course of that year. The spacing of the landing attempts would likely reduce the potential for long-term auditory masking. However, because of its intensity, the direct sound from an explosion could cause behavioral or physiological effects. Depending on the amount of fuel left, the intensity of the explosion will likely vary, but we considered the worst-case scenario, the largest possible amount of fuel left that could create the largest explosion. If an estimated 8% loss of energy is included as a result of the explosion occurring on the surface of the water, at a depth of 10 m (33 ft), the estimated received level is 249 dB re 1 µPa and at a depth of 100 m (328 ft), the estimated received level is 230 dB re 1 µPa which is the sound pressure level identified in Southall et al. (2007) for the onset of PTS in cetaceans to “discrete” noise events (either single or multiple exposures within a 24-h period). The onset of a temporary threshold shift (TTS) has been defined as being a temporary elevation of a hearing threshold by 6 dB (e.g., Schlundt et al. 2000), although smaller threshold shifts have been demonstrated to be statistically significant with a sufficient number of samples (e.g., Kastak et al. 1999; Finneran et al. 2005). If we use the TTS threshold for the most sensitive ESA-listed marine mammal species that could be in the proposed project area (Guadalupe fur seal), the µPa and at a depth of 100 m (328 ft), the estimated received level is 230 dB re 1 µPa which is the sound pressure level identified in Southall et al. (2007) for the onset of PTS in cetaceans to “discrete” noise events (either single or multiple exposures within a 24-h period). The onset of a temporary threshold shift (TTS) has been defined as being a temporary elevation of a hearing threshold by 6 dB (e.g., Schlundt et al. 2000), although smaller threshold shifts have been demonstrated to be statistically significant with a sufficient number of samples (e.g., Kastak et al. 1999; Finneran et al. 2005). If we use the TTS threshold for the most sensitive ESA-listed marine mammal species that could be in the proposed project area (Guadalupe fur seal), the threshold for onset of TTS is 212 dB re 1 µPa (Southall et al. 2007), which would occur within a 2,000 m (6,562 ft) radius, if an unsuccessful barge landing occurred in the water, which is extremely unlikely to occur (see below). When working with explosive sound impulses it is more appropriate to use the peak sound pressure level and the 180 dB and 160 dB thresholds are root mean squared values that are not typically applied to explosions.

However, if an explosion occurs as a result of an unsuccessful barge landing, SpaceX expects it would be on the barge and not directly in the water. VAFB provided a response from SpaceX who indicated that they were 100% successful at hitting the barge in two previous attempts when the barge was in place for the landing attempt. Therefore, we will use the analysis provided above as a starting point, because we expect that significantly less energy from the explosion would transmit into the water if an explosion occurs on the barge and the zone of influence (ZOI) would be much less than what was calculated above. An explosion on the barge would cause an in-air blast that would propagate in all directions, including the surface of the water, but the barge itself would act as a barrier and would be expected to minimize the amount of energy directed into the ocean. It is expected that the in-water sound levels would be below the onset of PTS for any marine mammal species or the current NMFS threshold for Level A (in-water of 190 dBrms re 1 µPa sound pressure

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3 Email from Darryl York (VAFB) on behalf of SpaceX to Monica DeAngelis (NMFS) dated July 20, 2015
level for pinnipeds and 180 dB_{rms} re 1 \mu Pa sound pressure level for cetaceans), even though these thresholds are not typically applied to explosive activities. Based on the information provided for the ESA consultation, it seems unlikely that any explosion, should it occur, would have a ZOI surrounding the barge area that would extend much farther beyond that area in the vicinity of the barge’s footprint that would correspond to the current NMFS threshold for potential behavioral change or temporary injury (in-water 160 dB_{rms} re 1 \mu Pa sound pressure level; or in-air for harbor seals it is 90 dB_{rms} and for all other pinniped species, it is 80 dB_{rms}) based on the source level of the explosion, the distance the sound would travel, and considering that the barge would act as a barrier to any sound produced. Disruption and disturbance of any marine mammal may occur, if they can detect the explosive event, but any disruption or disturbance caused by an explosion would be temporary (e.g., an explosion is expected to last less than a second). Using the same analytical approach for the probability of debris strike above, analysis indicates that the probability of each ESA-listed marine mammal species occurring within the ZOI of an explosion at the water’s surface in excess of NMFS thresholds for potential behavioral change is <0.002 for cetaceans and 0.1 for Guadalupe fur seals (VAFB 2015). The expected behavioral response by an animal exposed to the sound produced by an explosion could be relocation to an area away from the barge, disruption in feeding, or a change in dive pattern or respiration rate. Although there is a small chance that a marine mammal could be present in the acoustic ZOI in excess of NMFS thresholds for potential behavioral change, any behavioral response is not expected to reduce the fitness of that individual animal because the duration of the disturbance or avoidance response is expected to be very short, and will occur at most only a few times over the course of a year. Any marine mammal that may occur in this ZOI is expected to resume any behaviors that may be disrupted shortly after the exposure. As described above, the barge is expected to reduce the one second, one time acoustic impact of an explosion during unsuccessful barge landing; the resultant acoustic impact is not expected to disrupt the behavior pattern in ways that reduce the fitness of ESA-listed marine mammal individuals. As a result, we conclude any exposure to the explosion ZOI will be insignificant for ESA-listed marine mammals.

Since the onset for injury from sound pressure levels are evaluated in the same way for sea turtles as they are for marine mammals, a sea turtle would be expected to experience physiological impacts if it is within the 2000 m (6,562 ft) of an explosion that occurs at the water’s surface. Beyond 2000 m (6,562 ft), it is unlikely that physiological impacts would occur, but possible behavioral responses could include relocation to an area away from the barge, disruption in feeding, or a change in dive pattern or respiration rate. Although there is a very small chance that a sea turtle could be present in this ZOI, any behavioral response is not expected to reduce the fitness of that individual animal because the duration of the disturbance or avoidance response is expected to be very short, and will occur at most only a few times over the course of a year. Any sea turtle that may occur in this ZOI is expected to resume any behaviors that may be disrupted shortly after the exposure. Similar to marine mammals, an explosion on the barge resulting from an unsuccessful landing would result in significantly less acoustic energy transmitting into the water than has been assumed. Using the Central California leatherback density as a surrogate for the contingency landing locations 31 miles offshore VAFB and same methodology applied to marine mammals, the estimated number of sea turtle occurring within the ZOI would be less than 0.0044 (VAFB 2015). For the Iridium Landing Location, there is no quantified estimate for the probability or number of sea turtles expected to occur in the ZOI in excess of NMFS thresholds for potential behavioral change at that location. Based on the analysis for the debris strike above, we have determined it is unlikely that any sea turtles will be within this ZOI at this location. Although there is a small chance that a marine mammal could be present in this acoustic ZOI at either contingency landing location proposed, any behavioral response is not expected to reduce the fitness of that individual animal because the duration of the disturbance or avoidance response is expected to be very short, and will occur at most only a few times over the
course of a year. Any sea turtle that may occur in this ZOI is expected to resume any behaviors that may be disrupted shortly after the exposure. Ultimately, as described above, the barge is expected to reduce the one second, one time acoustic impact of an explosion during unsuccessful barge landing; the resultant acoustic impact is not expected to disrupt the behavior patterns in ways that reduce the fitness of ESA-listed sea turtles. As a result, we conclude any exposure to the explosion ZOI will be insignificant for ESA-listed sea turtles.

A conservative estimate of 10% mortality was estimated for fish with swim bladders potentially occurring in the contingency landing location would be 214 m (702 ft) (for a 1 pound fish). The estimated range in which injury could occur to fish with swim bladders (> 2 grams) would be 815 m (2,674 ft). Therefore, the area of potential impact to fish species with swim bladders is an approximately 815 m (2,674 ft) radial area around the surface of the water. The density of the fish killed by a surface water explosion would be density dependent and highly variable. As indicated above, NMFS does not expect that the ESA-listed fish species commonly occur in either contingency landing location proposed. In addition, an explosion on the barge resulting from an unsuccessful landing would result in significantly less acoustic energy transmitting into the water and the ZOI would be less, as discussed above. Behavioral disturbance thresholds for fish are lower than for mammals (150db), and similar to our assessment for mammals and turtles we do not expect behavioral disruption, to affect fitness of the exposed fish, in the unlikely event it occurs. As a result, we conclude any exposure to the explosion ZOI will be insignificant for ESA-listed fish.

**Landing Noise**

The Falcon 9 First Stage will generate landing noise up to 110 dB (well below the ESA and MMPA thresholds) for a short duration (minutes). Should a marine mammal be at the water’s surface at the time of the landing, the sound could elicit a response such as an alert, avoidance, or other behavioral reactions such as diving and moving away from the source, but any response is expected to be temporary, if it occurs at all. The landing noise is not expected to have an effect on submerged animals or those that spend a considerable amount of time submerged, such as large whales or sea turtles. Disturbance to landing noise would be unlikely to cause long-term impacts to marine mammals. As a result, we conclude that any exposure to the landing noise generated by the Falcon 9 First Stage during contingency landings will be insignificant for ESA-listed marine mammals or sea turtles.

Fish at or near the surface of the water would potentially experience behavioral disturbance, but in the unlikely event that a fish is near enough to the water’s surface at the time of the landing to detect the noise, any response is expected to be temporary due to the short duration of the landing noise and the sound levels transmitted into the water would be far below injury or disturbance levels. As a result, we conclude that any exposure to the landing noise generated by the Falcon 9 First Stage during contingency landings will be insignificant for ESA-listed fish.

**Vessel Noise**

Vessel noise does have the potential to disturb marine mammals by eliciting an alert, avoidance, or other behavioral reactions such as diving and moving away from the source. Marine mammals and sea turtles in the proposed zone of influence at either contingency landing location may be exposed to project-related vessels and vessel noise. However, it may be difficult for the animals to discern vessel noise associated with the proposed activities as additional to that which is already present due to research, ecotourism, commercial or private vessels, or government activities. As a result, we
conclude that any exposure to vessel noise generated by the support vessels required to support the contingency landing actions will be insignificant for ESA-listed marine mammals and sea turtles.

Vessel noise has the potential to create in-water sound that could disturb ESA-listed fish species, which could result in behavioral (e.g., avoidance) or physiological responses (e.g., stress, increased heart rate). While vessel movements have the potential to expose ESA-listed fish species occupying the water column to noise and general disturbance, potentially resulting in short-term behavioral or physiological responses, such responses would not be expected to compromise the health, condition, or fitness of individual fish because the impacts from vessel noise would be temporary, infrequent, and localized. As a result, we conclude that any exposure to vessel noise generated by the support vessels required to support the contingency landing actions will be insignificant for ESA-listed fish.

Expended Materials and Fluids

Debris

Approximately 25 pieces of debris remain floating after a water landing or an unsuccessful barge landing with a potentially impacted surface area of less than 0.46 km$^2$ (114 acres), and the vast majority of debris would be recovered. All other debris is expected to sink to the bottom of the ocean. Depending on the type of materials involved, amount of debris, density, and other factors, the potential risks posed by the debris that was not collected are: degradation of water quality, substrate or habitat, which in turn would affect the listed species which use them. Since the area that would be impacted by falling debris is very small, the likelihood of adverse effects to ESA-listed marine mammals, fish, or sea turtles is very low. Furthermore, denser debris that would not float on the surface is anticipated to sink relatively quickly and is composed of inert materials which, by nature of their composition, would not affect water quality or bottom substrate or benthic habitat potentially used by ESA-listed marine mammals and sea turtles. 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. As a result, we conclude the risk associated with debris from an unsuccessful barge landing or water landing that enters the ocean environment at either contingency landing location for ESA-listed species is discountable.

Rocket Propellant

In the event of an unsuccessful landing attempt, the First Stage would explode upon impact with the barge or water. 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 (estimated to be between 50 and 150 gallons) would be released into the ocean. 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). Due to its high volatility, RP-1 evaporates quickly when exposed to the air, and would completely dissipate within one to two days after a spill in the water. Clean-up following a spill of very light oil is usually not necessary or not possible, particularly with such a small quantity of oil that would enter the ocean in the event of a water landing (U.S. Fish and Wildlife Service 1998). Therefore, no attempt would be made to boom or recover RP-1 fuel from the ocean. RP-1 on the water’s surface would move with the water flow, being transported due to the velocities in the surface layer. Given the offshore location of the contingency landing locations RP-1 is unlikely to reach any shoreline or any nearshore habitats (e.g., kelp beds). The ESA-listed fish species, steelhead, green sturgeon, and scalloped hammerhead shark, are typically below the surface and would not be expected to interact with surface of the water frequently, making them unlikely to
be exposed to RP-1 on the ocean surface during the one to two day period during which it would dissipate. “Very light oil” is not known to cause injury or harm to animals that are directly exposed to it and the spilled fuel from an unsuccessful barge landing or a water landing that enters the ocean environment at either contingency landing location is expected to evaporate quickly when exposed to the air, and would completely dissipate within one to two days after a spill in the water. As a result, we conclude the risk associated with exposure to rocket propellant for ESA-listed species is discountable.

**Conclusion**

Based on this analysis, NMFS concurs with VAFB and SpaceX that the proposed action is not likely to adversely affect the subject listed species. Critical habitat has not been designated or proposed for ESA-listed marine mammals, ESA-listed fish, green sea turtles, loggerhead sea turtles, olive ridley sea turtles, and hawksbill sea turtles in the action area; therefore, none was analyzed. Critical habitat for leatherback sea turtles is designated in the action area where the contingency landing location 31 miles offshore VAFB is located. Prey is an essential feature of leatherback critical habitat and the preferred prey of leatherbacks off the California coast is jellyfish, with other gelatinous prey, such as salps (a pelagic tunicate), considered of lesser importance (77 FR 4170). Based on the information provided and analyses of the proposed action conducted above, there is no indication that the proposed project activities could impact prey or the critical habitat of leatherback sea turtles offshore VAFB. The proposed addition of the Iridium Landing Location is outside of leatherback critical habitat. As a result, NMFS concludes that the proposed action is not likely to adversely affect critical habitat for leatherback sea turtles. Critical habitat for steelhead does exist on the mainland within the VAFB, but the proposed project’s action area will not overlap with the designated critical habitat.

**Reinitiation of Consultation**

Reinitiation of consultation is required and shall be requested by VAFB or by NMFS, where discretionary Federal involvement or control over the action has been retained or is authorized by law and (1) new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered; (2) the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in this concurrence letter; or if (3) a new species is listed or critical habitat designated that may be affected by the identified action (50 CFR 402.16). This concludes the ESA portion of this consultation.

**MARINE MAMMAL PROTECTION ACT**

Although several marine mammal species are listed as federally endangered or threatened under the ESA, the Marine Mammal Protection Act of 1972 (MMPA) is the principal Federal legislation that guides marine mammal species protection and conservation. Under the MMPA, "take" of a marine mammal is permitted by NMFS under an Incidental Harassment Authorization (IHA) when the specified activity is incidental, but not intentional, of a small number of marine mammals.

As discussed in detail under the ESA section of this letter, sounds introduced into the sea by man-made devices could have a deleterious effect on marine mammals by causing stress or injury, interfering with communication and predator/prey detection, and changing behavior. Acoustic exposure to loud sounds may result in a temporary or permanent loss of hearing (termed a temporary (TTS) or permanent (PTS) threshold shift) depending upon the location of the marine mammal in relation to the source of the sound. As mentioned above, NMFS has recent published new guidance
for determining safety criteria for marine species exposed to underwater sound. However, pending regular implementation and adoption of these guidelines for use in MMPA processes that is still under development, we have preliminarily determined, based on past projects, consultations with experts, and published studies, that 180 dB_{rms} re 1 μPa (190 dB_{rms} re 1 μPa for pinnipeds) is the impulse sound pressure level that can be received by marine mammals without injury. Marine mammals have shown behavioral changes when exposed to impulse sound pressure levels of 160 dB_{rms} re 1 μPa and when exposed to non-impulse sound pressure levels of 120 dB_{rms} re 1 μPa. Based on the estimated noise levels expected to be produced by the proposed project, Space X applied for authorization from NMFS under the MMPA for Level B harassment, specifically for the potential for behavioral harassment as a result of the proposed project activities. On May 19, 2016, NMFS issued Space X an IHA for the incidental harassment of marine mammals (81 FR 34984). Due to the proposed modification of the contingency landing locations, SpaceX has requested an amendment of the IHA for this action, which is currently under review by NMFS' Office of Protected Resources. At this time, we have no further guidance to provide other than compliance with the conditions of the IHA as issued by NMFS.

Thank you for coordinating with NMFS regarding this project. We appreciate your efforts to comply with Federal regulations and to conserve and protect marine mammals, sea turtles, and fish. Please direct questions regarding ESA and MMPA to Dan Lawson, 562-980-3209, Dan.Lawson@noaa.gov.

Sincerely,

[Signature]

William W. Stelle, Jr.
Regional Administrator

cc: Darryl York, Chief, Conservation 30 CES/CEIE Vandenberg AFB
Administrative File: 151422WCR2015PR00190
References


VAFB 2016. ESA and EFH Consultation request submitted by VAFB to NMFS, August 2, 2016.
APPENDIX C: Notice of Availability for Public Review, Proof of Delivery/Publication, Comments Received on Final Draft, and Responses
MEMORANDUM FOR ALL INTERESTED GOVERNMENT AGENCIES, PUBLIC OFFICIALS, ORGANIZATIONS, AND INDIVIDUAL PARTIES

FROM: 30 CFS/CFI
1028 Iceland Avenue
Vandenberg AFB CA 93437-6010

SUBJECT: Final Draft Supplemental Environmental Assessment (SEA) and Finding of No Significant Impact (FONSI) for the Boost-Back and Landing of the Falcon 9 Full Thrust First Stage at Iridium Landing Area Vandenberg Air Force Base (VAFB), California

1. Attached as public and agency notification, to comply with the National Environmental Policy Act of 1969, and the President’s Council on Environmental Quality’s implementing regulations, is the Final Draft SEA and FONSI for the Boost-Back and Landing of the Falcon 9 Full Thrust First Stage at Iridium Landing Area Vandenberg Air Force Base (VAFB), California.

2. This Draft SEA supplements the Final Environmental Assessment (EA) Boost-Back and Landing of the Falcon 9 Full Thrust First Stage at SLC-4 West at Vandenberg Air Force Base, California and Offshore Landing Contingency Option (2016), which is available at:


and at the San Diego Public Library, 330 Park Blvd, San Diego, California. The Proposed Action is Space Exploration Technologies Corporation’s (SpaceX’s) proposal to use an alternate conditional landing area for the Falcon 9 First Stage (referred to as the Iridium Landing Area) in addition to the landing areas proposed in the Falcon 9 Boost Back EA. The Iridium Landing Area may be used up to six times per year and would require performing boost-back and landings on an autonomous barge. The barge would be located southwest of San Nicolas Island within the United States Exclusive Economic Zone. This contingency action would be used for heavy payloads that are unable to return near VAFB and perform a boost-back and landing. Resources analyzed in this Draft SEA include air quality and climate, biological resources, water resources, and coastal zone management. This Draft SEA concludes that there will be no significant environmental impacts resulting from the Proposed Action.

3. The public comment period for this Final Draft SEA/FONSI will be from 2 Sep 16 through 16 Sep 16. Comments may be sent to the above address attention of Samantha Kaisersatt, e-mailed to samantha.kaisersatt@us.af.mil, or faxed to (805) 606-6137. If you have any questions, please contact Ms. Samantha Kaisersatt at (805) 605-0392.

BEATRICE L. KEPHART
Chief, Installation Management Flight

Attachment:
Final Draft SEA and FONSI for the Boost-Back and Landing of the Falcon 9 Full Thrust First Stage at Iridium Landing Area Vandenberg Air Force Base (VAFB), California.
Distribution Instructions: Please distribute NEPA documents, including the corresponding notice of availability (NOA), to the following points of contact (POCs) as indicated below. Send NOA only when indicated. Distribute hard copies to the libraries via personal delivery and obtain signed receipt. Please inform VAFB of any “return to sender” issues with any of the listed POCs or change of preference for document type or delivery. Finally, please inform VAFB of any POC that would like to be removed from this list.

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California Coastal Commission - Energy, Ocean Resources and Federal Consistency Division
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45 Fremont Street, Suite 2000
San Francisco, CA 94105-2219
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Jordan Carduner
NOAA Fisheries Office of Protected Resources
Permits and Conservation Division
1315 East West Highway, Silver Spring MD 20910
Electronic Copy
September 1, 2016

Re: Receipt of Delivery of Final Draft Supplemental Environmental Assessment for Boost-Back and Landing of the Falcon 9 Full Thrust First Stage at Iridium Landing Area (31 August 2016) and Final Environmental Assessment for Boost-Back and Landing of the Falcon 9 Full Thrust First Stage at SLC-4 West (25 April 2016)

The signature below represents proof of in-person delivery of hard copy documents of the above referenced titles.

[Signature]

Reference Librarian, San Diego Public Library
330 Park Boulevard
San Diego, California 92101

Gary Klockenga (go:ut:.docs)
Bill To:
ManTech International Corporation - CU00559262
420 Stevens Ave
Ste 300
Solana Beach, CA 92075-2080

STATE OF ILLINOIS
COUNTY OF Cook

The Undersigned, declares under penalty of perjury under the laws of the State of California: That he/she is and at all times herein mentioned was a citizen of the United States, over the age of twenty-one years, and that he/she is not a party to, nor interested in the above entitled matter; that he/she is Chief Clerk for the publisher of

San Diego Union-Tribune

a newspaper of general circulation, printed and published daily in the City of San Diego, County of San Diego, and which newspaper is published for the dissemination of local news and intelligence of a general character, and which newspaper at all the times herein mentioned had and still has a bona fide subscription list of paying subscribers, and which newspaper has been established, printed and published at regular intervals in the said City of San Diego, County of San Diego, for a period exceeding one year next preceding the date of publication of the notice hereinafter referred to, and which newspaper is not devoted to nor published for the interests, entertainment or instruction of a particular class, profession, trade, calling, race, or denomination, or any number of same; that the notice of which the annexed is a printed copy, has been published in said newspaper in accordance with the instruction of the person(s) requesting publication, and not in any supplement thereof on the following dates, to wit:

September 2, 2016; September 3, 2016

I certify under penalty of perjury under the laws of the State of California that the foregoing is true and correct.

Dated in the City of Chicago, State of Illinois on this 6th of September 2016.

[Signature]

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FINAL DRAFT
SUPPLEMENTAL
ENVIRONMENTAL
ASSESSMENT AND
FINDING OF NO SIG-
IFICANT IMPACT
BOOST-BACK AND
LANDING OF THE
FALCON 9 FIRST
STAGE AT IRIDIUM
LANDING AREA
VANDENBERG AIR
FORCE BASE, CALI-
FORNIA

The U.S. Air Force
and Space Explora-
tion Technologies
Corporation (SpaceX)
has prepared a Draft
Supplemental Environ-
mental Assessment
(SEA) and Finding of
No Significant Impact
(FONSI) that evalu-
ates the potential en-
vironmental impacts
of the boost-back and
landing of the Falcon
9 First Stage on an
autonomous barge
within a contingency
landing area, which
is referred to as the
Iridium Landing Area.
This Draft SEA sup-
plements the Final
Environmental As-
essment Boost-Back
and Landing of the
Falcon 9 Full Thrust
First Stage at SLC84
West at Vandenberg
Air Force Base, Cali-
fornia and Offshore
Landing Contingency
Option (2016). The
Iridium Landing Area
is located approxi-
mately 120 nautical
miles southwest of
San Nicholas Island,
within the United
States Exclusive Eco-
nomic Zone. SpaceX
would use the Iridium
Landing Area up to
six times per year for
heavy payloads that
are unable to perform
a boost-back and
landing and return
near VAFB. Resour-
ces analyzed in this
Draft SEA include air
quality and climate,
biological resources,
water resources, and
Coastal Zone man-
agement. This Draft
SEA concludes that
there will be no sig-
nificant environmental
impacts resulting
from the Proposed
Action.

The Final Draft SEA/
FONSI is available
for review at the San
Diego Public Library,
located at 330 Park
Blvd, San Diego, Cali-
fornia. The public
comment period for
this Final Draft SEA/
FONSI is 2 September
2016 through 16 Sept-
ember 2016. Com-
ments may be sent
to the 30 CES/CEEA,
1028 Iceland Avenue,
Vandenberg AFB, CA
93437 to the atten-
tion of Samantha Kals-
satt, e-mailed to saman-
thakaipersatt@usmil, or
taxed to (805) 606-6137.
If you have any ques-
tions, please contact Ms.
Samantha Kalsatt at
(805) 605-0392.
Bill To:
ManTech International Corporation - CU00559262
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Ste 300
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STATE OF ILLINOIS:
COUNTY OF Cook

The Undersigned, declares under penalty of perjury under the laws of the State of California: That he/she is and at all times herein mentioned was a citizen of the United States, over the age of twenty-one years, and that he/she is not a party to, nor interested in the above entitled matter; that he/she is Chief Clerk for the publisher of

San Diego Union-Tribune

a newspaper of general circulation, printed and published daily in the City of San Diego, County of San Diego, and which newspaper is published for the dissemination of local news and intelligence of a general character, and which newspaper at all the times herein mentioned had and still has a bona fide subscription list of paying subscribers, and which newspaper has been established, printed and published at regular intervals in the said City of San Diego, County of San Diego, for a period exceeding one year next preceding the date of publication of the notice hereinafter referred to, and which newspaper is not devoted to nor published for the interests, entertainment or instruction of a particular class, profession, trade, calling, race, or denomination, or any number of same; that the notice of which the annexed is a printed copy, has been published in said newspaper in accordance with the instruction of the person(s) requesting publication, and not in any supplement thereof on the following dates, to wit:

September 4, 2016

I certify under penalty of perjury under the laws of the State of California that the foregoing is true and correct.

Dated in the City of Chicago, State of Illinois on this 6th of September 2016.

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FINAL DRAFT
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STAGE AT IRIDIUM
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FORCE BASE, CALI-
FORNIA

The U.S. Air Force and Space Exploration Technologies Corporation (SpaceX) has prepared a Draft Supplemental Environmental Assessment (SEA) and Finding of No Significant Impact (FONSI) that evaluates the potential environmental impacts of the boost-back and landing of the Falcon 9 First Stage on an autonomous barge within a contingency landing area, which is referred to as the Iridium Landing Area. This Draft SEA supplements the Final Environmental Assessment Boost-Back and Landing of the Falcon 9 Full Thrust First Stage at SLC-4 West at Vandenberg Air Force Base, California and Offshore Landing Contingency Option (2016). The Iridium Landing Area is located approximately 120 nautical miles southwest of San Nicholas Island, within the United States Exclusive Economic Zone. SpaceX would use the Iridium Landing Area up to six times per year for heavy payloads that are unable to perform a boost-back and landing and return near VAFB. Resources analyzed in this Draft SEA include air quality and climate, biological resources, water resources, and Coastal Zone management. This Draft SEA concludes that there will be no significant environmental impacts resulting from the Proposed Action.

The Final Draft SEA/FONSI is available for review at the San Diego Public Library, located at 330 Park Blvd, San Diego, California. The public comment period for this Final Draft SEA/FONSI is 2 September 2016 through 16 September 2016. Comments may be sent to the 30 CES/CEIEA, 1028 Iceland Avenue, Vandenberg AFB, CA 93437 to the attention of Samantha Kaisersatt, e-mailed to samantha.kaisersatt@us.af.mil, or faxed to (805) 606-6137. If you have any questions, please contact Ms. Samantha Kaisersatt at (805) 605-0392.