Federal Aviation Administration

Final Environmental Assessment and Finding of No Significant Impact for Issuing a Reentry License to SpaceX for Landing the Dragon Spacecraft in the Gulf of Mexico

August 2018

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AGENCIES: Federal Aviation Administration (FAA), lead Federal agency; National Aeronautics and Space Administration, cooperating agency; United States Air Force, cooperating agency.

DEPARTMENT OF TRANSPORTATION, FEDERAL AVIATION ADMINISTRATION: The FAA is evaluating Space Exploration Technologies Corp.'s (SpaceX's) proposal to conduct landings of the Dragon spacecraft (Dragon) in the Gulf of Mexico, which would require the FAA Office of Commercial Space Transportation to issue a reentry license. SpaceX has two versions of Dragon: Dragon-1 and Dragon-2. Dragon-1 is used for cargo missions to the International Space Station (ISS), and SpaceX intends that Dragon-2 will eventually be used to transport astronauts to the ISS. Under the Proposed Action, the FAA would issue a reentry license to SpaceX, which would authorize SpaceX to conduct up to six Dragon landing operations per year in the waters of the Gulf of Mexico. Each landing operation would include orbital reentry, splashdown, and recovery.

The Final EA evaluates the potential environmental impacts from the Proposed Action and No Action Alternative on air quality; climate; noise and noise-compatible land use; Department of Transportation Act, Section 4(f); biological resources (including aquatic plants and animals and special status species); coastal resources; water resources; natural resources and energy supply; and hazardous materials, solid waste, and pollution prevention. Potential cumulative impacts are also addressed in this EA.

PUBLIC REVIEW PROCESS: In accordance with the applicable requirements, the FAA initiated a public review and comment period for the Draft EA. The 30-day public comment period began with the issuance of the Notice of Availability in the *Federal Register* on April 5, 2018 and ended on May 4, 2018. The FAA received one public comment submission (refer to Appendix D of this Final EA).

CONTACT INFORMATION: Questions regarding the Final EA can be addressed to Mr. Daniel Czelusniak, Environmental Protection Specialist, Federal Aviation Administration, 800 Independence Avenue, SW, Suite 325, Washington, DC 20591; email Daniel.Czelusniak@faa.gov.

This environmental assessment becomes a federal document when evaluated, signed, and dated by the responsible FAA official.

Responsible FAA Official:

Date: Aug. 14, 2018

Kelvin Coleman
Acting Associate Administrator for Commercial Space Transportation

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DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

Office of Commercial Space Transportation

Finding of No Significant Impact

for

Issuing a Reentry License to SpaceX for Landing the Dragon Spacecraft in the Gulf of Mexico

Summary

The Federal Aviation Administration (FAA) prepared the attached Final Environmental Assessment (EA) to analyze the potential environmental impacts of issuing a reentry license to Space Exploration Technologies Corp. (SpaceX) to conduct landings of the Dragon spacecraft (Dragon) in the Gulf of Mexico. The EA was prepared in accordance with the National Environmental Policy Act of 1969, as amended (NEPA; 42 United States Code [U.S.C.] § 4321 et seq.); Council on Environmental Quality NEPA implementing regulations (40 Code of Federal Regulations [CFR] parts 1500 to 1508); and FAA Order 1050.1F, *Environmental Impacts: Policies and Procedures*.

After reviewing and analyzing available data and information on existing conditions and potential impacts, the FAA has determined the Proposed Action would not significantly affect the quality of the human environment. Therefore, the preparation of an Environmental Impact Statement (EIS) is not required, and the FAA is issuing this Finding of No Significant Impact (FONSI). The FAA has made this determination in accordance with applicable environmental laws and FAA regulations. The Final EA is incorporated by reference into this FONSI.

For any questions or to request a copy of the EA, contact the following FAA Environmental Protection Specialist. A copy of the EA may also be obtained from the FAA's website: https://www.faa.gov/about/office_org/headquarters_offices/ast/environmental/nepa_docs/review/launch/.

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Purpose and Need

The purpose of FAA's Proposed Action is to fulfill the FAA's responsibilities as authorized by Executive Order 12465, *Commercial Expendable Launch Vehicle Activities* (49 FR 7099, 3 CFR, 1984 Comp., p. 163) and the Commercial Space Launch Act (51 U.S.C. Subtitle V, ch. 509, §§ 50901-50923) for oversight of commercial space launch activities, including licensing and regulating launch and reentry activities. The need for FAA's Proposed Action results from the statutory direction from Congress under the Commercial Space Launch Act, 51 U.S.C 50901(b) to, in part, "protect the public health and safety, safety of property, and national security and foreign policy interests of the United States" while "strengthening and [expanding] the United States space transportation infrastructure, including the enhancement of United States launch sites and launch-site support facilities, and development of reentry sites, with Government, State, and private sector involvement, to support the full range of United States space-related activities."

Proposed Action

The FAA's Proposed Action is to issue a reentry license to SpaceX that would authorize SpaceX to conduct up to six Dragon landing operations per year in the Gulf of Mexico. SpaceX is currently authorized to conduct Dragon landing operations in the Pacific Ocean and Atlantic Ocean. The Gulf of Mexico would act as a contingency landing site in the event of hazardous conditions in either the Pacific Ocean or Atlantic Ocean. Each landing operation would include orbital reentry, splashdown, and recovery. After completing its mission in space, Dragon would complete a deorbit burn, reenter the atmosphere, and be tracked to a splashdown zone in the Gulf of Mexico. Following splashdown, a recovery vessel would transport Dragon to a port on the Gulf Coast or the Port of Cape Canaveral. Crew and/or cargo would be transported via helicopter from the splashdown location to the nearest airport.

Alternatives

Alternatives analyzed in the EA include (1) the Proposed Action and (2) the No Action Alternative. Under the No Action Alternative, the FAA would not issue a reentry license to SpaceX for Dragon reentry and splashdown in the Gulf of Mexico. SpaceX would conduct Dragon landing operations in the Pacific Ocean or Atlantic Ocean, as authorized by an FAA reentry license. The No Action Alternative provides the basis for comparing the environmental consequences of the Proposed Action. The No Action Alternative would not satisfy the purpose of and need for the Proposed Action.

Public Involvement

On April 5, 2018, the FAA published a Notice of Availability of the Draft EA in the *Federal Register*. The public comment period ended on May 4, 2018. The FAA received one comment submission (see Appendix D of the Final EA for the comment and FAA's response). No substantive changes to the EA were made as a result of the comment.

Environmental Impacts

The potential environmental impacts from the Proposed Action and No Action Alternative were evaluated in the attached Final EA for each environmental impact category identified in FAA Order 1050.1F. Chapter 3 of the Final EA describes the affected environment and regulatory setting. In addition, Chapter 3 identifies those environmental impact categories that are not analyzed in detail, explaining why the Proposed Action would have no potential effect on those impact categories. Those impact categories include biological resources (aquatic vegetation, and terrestrial vegetation and wildlife); farmlands; historical, architectural, archaeological and cultural resources; land use; socioeconomics, environmental justice, and children's environmental health and safety risks; visual effects; and water resources (wetlands, floodplains, inland surface waters, groundwater, and wild and scenic rivers).

Chapter 4 of the Final EA provides evaluations of the potential environmental consequences of each alternative for each of the environmental impact categories analyzed in detail, and documents the finding that no significant environmental impacts would result from the Proposed Action. In addition, Chapter 4 addresses the requirements of applicable special purpose laws, regulations, and executive orders.

A summary of the documented findings for each impact category analyzed in detail, including requisite findings with respect to relevant special purpose laws, regulations, and executive orders, is presented below.

- **Air Quality**, Final EA Section 4.1. Air pollutant emissions under the Proposed Action would not result in violations of Federal or State air quality standards because they would represent a negligible percentage of regional emissions and would not cause an exceedance of any National Ambient Air Quality Standards. As shown in Table 4.1-2 of the EA, estimated emissions from the Proposed Action are well below the General Conformity Rule *de minimis* thresholds and would represent a small percentage of local emissions. Therefore, the FAA has determined there would be no significant air quality impacts.
- **Biological Resources (Marine Wildlife)**, Final EA Section 4.5. The Proposed Action would result in a minor increase in noise along a portion of the Gulf coast of Texas, Louisiana, Mississippi, Alabama, or Florida due to the sonic boom generated during Dragon reentry. The noise from the sonic boom would be similar to the sound of a clap of thunder. Due to the low magnitude of the sonic boom, significant attenuation at the air/water interface, and exponential attenuation with water depth, marine species beneath the water's surface would not be affected. Dragon is designed to retain residual propellant. Any propellant remaining in Dragon is not expected to be released into the ocean. In the event of a leak, the risks of exposure to marine organisms is negligible due to the limited area and the time fuels would be present before being diluted and buffered by seawater or oxidizing into harmless byproducts. Given the small area of potential impact on the water during Dragon splashdown, it is unlikely marine species would be adversely affected. Parachutes would be recovered, preventing the risk of entanglement or ingestion. If parachutes cannot be recovered due to poor sea or weather conditions, they would not easily degrade into small digestible pieces and would be expected to sink rapidly, thereby minimizing the risk of ingestion by marine species. The FAA consulted with the National Marine Fisheries Service (NMFS) regarding potential impacts to species listed under the Endangered Species Act (ESA). NMFS concurred with the FAA's determination that the Proposed Action is not likely to adversely affect federally listed species or adversely modify designated critical habitat (See Appendix B of the Final EA). Therefore, the FAA has determined there would be no significant biological resource impacts.

- **Climate**, Final EA Section 4.2. The Proposed Action would generate small increases in greenhouse gas (GHG) emissions from vessel and helicopter activities. Mobile source activities would be limited on an annual basis, and their incremental contributions to global emissions would not be of such magnitude to make a direct correlation with climate change. The primary combustion products of propellants used in the Dragon propellant system are nitrogen gas and water. Thus, no criteria pollutants or GHG emissions are associated with operation of this system. Therefore, the FAA determined there would be no significant climate impacts.
- **Coastal Resources**, Final EA Section 4.6. The Proposed Action does not include any coastal construction or seafloor disturbing activities. Dragon splashdown would occur outside State coastal zones (at least 15 nautical miles offshore). Landing and recovery operations would not take place in intertidal areas, salt marshes, estuaries, and coral reefs. National Marine Sanctuaries in the Gulf of Mexico would be avoided through precision landings. Therefore, the FAA has determined there would be no significant impacts on coastal resources.
- **Department of Transportation Act, Section 4(f)**, Final EA Section 4.4. The FAA determined the Proposed Action would not result in a physical use, direct taking, or temporary occupancy of any Section 4(f) property. Noise associated with the Proposed Action would not result in a constructive use of any Section 4(f) property. Therefore, the FAA determined there would be no significant impacts on Section 4(f) properties.
- **Hazardous Materials, Solid Waste, and Pollution Prevention**, Final EA Section 4.9. All hazardous materials and wastes would be handled in accordance with all applicable Federal, State, and local laws and regulations. The Proposed Action would not increase hazardous waste production, and continued implementation of existing handling and management procedures for hazardous materials and wastes would limit the potential for exposure. Hazardous materials, substances, and wastes used and generated as part of recovery operations would be collected, stored, and disposed of using practices that minimize the potential for accidental releases or contact with storm or marine water in accordance with applicable spill prevention plans and Federal regulations. Accidental spills would be cleaned up quickly and appropriately in accordance with applicable laws and established emergency response plans. Notifications would be issued 3–6 days before Dragoon landing operations to avoid collisions with marine vessels. Therefore, the FAA has determined there would be no significant impacts related to hazardous materials, solid waste, and pollution prevention.

- **Natural Resources and Energy Supply**, Final EA Section 4.8. The Proposed Action would require the use of fuels for reentry and recovery activities. The demand for both types of fuel would be met without difficulty. Therefore, the FAA has determined there would be no significant impacts related to natural resources and energy supply.
- **Noise and Noise-Compatible Land Use**, Final EA Section 4.3. The noise from Dragon reentries, splashdowns, and recovery operations would be similar to noise already occurring regularly in the Gulf of Mexico, including noise from helicopters and ships. A sonic boom would generated during Dragon reentry. It would most likely only impact the ocean's surface. A portion of the Gulf coast of Texas, Louisiana, Mississippi, Alabama, or Florida could experience the boom, depending on the location of the landing site. There would be a maximum of six sonic booms per year and each boom would occur in a different location. Given the size of the splashdown and recovery zone, it is unlikely one location would be exposed to more than one boom per year. An overpressure of 0.4 pounds per square foot (psf) could be expected approximately 19 miles from the landing site and 0.35 psf approximately 50 miles from the landing site. Therefore, because it is possible for Dragon to land approximately 50 miles from the coast, overpressures could impact land and oil platforms. However, it would be at an overpressure of approximately 0.4 psf. For comparison, an overpressure of 1 psf is similar to a clap of thunder. No structural damage would occur. The maximum sonic boom generated during Dragon reentry would be less than a day-night average noise level of 40 C-weighted decibels. Therefore, the FAA has determined there would be no significant noise impacts.
- **Water Resources (Ocean Waters)**, Final EA Section 4.7. The Dragon is designed to retain residual propellant, and any propellant remaining in the Dragon is not expected to be released into the ocean. In the event of a leak, the propellant would rapidly disperse and does not represent a source of substantial environmental degradation to water quality. All vessel operations would be conducted in accordance with the International Convention for the Prevention of Pollution from Ships prohibiting certain discharges of oil, garbage, and other substances. Therefore, the FAA has determined there would be no significant water resource impacts.

Please refer to Chapter 4 of the Final EA for a full discussion of the determination for each environmental impact category.

Chapter 5 of the Final EA provides an analysis of the potential cumulative impacts of the Proposed Action when added to other past, present, and reasonably foreseeable future actions. The FAA has determined the Proposed Action would not result in significant cumulative impacts to any environmental impact category.

Conditions and Mitigation

As prescribed by 40 CFR § 1505.3, the FAA shall take steps as appropriate to the action, through mechanisms such as the enforcement of licensing conditions, and shall monitor these as necessary to ensure SpaceX implements avoidance, minimization, and/or mitigation measures as set forth in Chapter 4 of the Final EA under the various impact categories. These avoidance, minimization, and mitigation measures include:

- Those avoidance and minimization measures, as well as reporting requirements, identified in the ESA consultations with NMFS (see Appendix B of the Final EA); and
- Handling hazardous materials, hazardous wastes, and solid wastes in accordance with all relevant Federal, State, and local regulations pertaining to these substances.

Agency Finding and Statement

The FAA has determined no significant impacts would occur as a result of the Proposed Action and, therefore, preparation of an EIS is not warranted and a FONSI in accordance with 40 CFR § 1501.4(e) is appropriate.

After careful and thorough consideration of the facts contained herein, the undersigned finds that the proposed Federal action is consistent with existing national environmental policies and objectives as set forth in Section 101 of NEPA and other applicable environmental requirements and will not significantly affect the quality of the human environment or otherwise include any condition requiring consultation pursuant to Section 102(2)(C) of NEPA.

APPROVED: ______________________ DATE: Aug. 24, 2018

Kelvin Coleman

Acting Associate Administrator for Commercial Space Transportation

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List of Exhibits

Acronyms and Abbreviations

AGL	above ground level
CCAFS	Cape Canaveral Air Force Station
CCP	Commercial Crew Program
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
COTS	Commercial Orbital Transportation Services
dB	decibel
dBA	A-weighted decibels
DNL	day-night average noise level
DOT	Department of Transportation
EA	Environmental Assessment
EFH	Essential Fish Habitat
EO	Executive Order
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
FAA	Federal Aviation Administration
FONSI	Finding of No Significant Impact
FR	*Federal Register*
GHG	greenhouse gases
HAPs	hazardous air pollutants
ISS	International Space Station
KSC	Kennedy Space Center
LAS	Launch Abort System
LEO	Low Earth Orbit
LOA	Letter of Agreement
mg/m^3	milligrams per cubic meter
$\mu g/m^3$	micrograms per cubic meter
MARPOL	International Convention for the Prevention of Pollution from Ships
MMH	monomethylhydrazine
MMPA	Marine Mammal Protection Act
MSATs	Mobile Source Air Toxics
MT	metric tonnes
N_2	nitrogen
NAAQS	National Ambient Air Quality Standards
NASA	National Aeronautics and Space Administration
NEPA	National Environmental Policy Act
NIOSH	National Institute for Occupational Safety and Health
NMFS	National Marine Fisheries Service
NO_2	nitrogen dioxide
NO_x	nitrogen oxide
NOAA	National Oceanic and Atmospheric Administration
NOTAM	Notice to Airmen
NOTMAR	Notice to Mariners
NPDES	National Pollutant Discharge Elimination System
NTO	nitrogen tetroxide
NWR	National Wildlife Refuge
O_2	oxygen
OSHA	Occupational Safety and Health Administration
Pb	lead
PM	particulate matter
$PM_{2.5}$	particulate matter less than or equal to 2.5 microns in diameter
PM_{10}	particulate matter less than or equal to 10 microns in diameter
Ppb	parts per billion
Ppm	parts per million
RCRA	Resource Conservation and Recovery Act
RCS	Reaction Control System
RHIB	rigid hulled inflatable boat
RLV	reusable launch vehicle
ROI	Region of Influence
SEL	Sound Exposure Level
SLC-40	Space Launch Complex 40
SO_2	sulfur dioxide
SpaceX	Space Exploration Technologies Corp.
U.S.	United States
USAF	United States Air Force
U.S.C.	United States Code
USFWS	U.S. Fish and Wildlife Service

1.0 INTRODUCTION

Space Exploration Technologies Corp. (SpaceX) proposes to conduct orbital reentries, splashdowns, and recoveries of the Dragon spacecraft (Dragon) in the waters of the Gulf of Mexico (Exhibit 1). To conduct these operations, the Federal Aviation Administration (FAA) Office of Commercial Space Transportation must issue a reentry license to SpaceX as described in 51 United States Code (U.S.C.) Subtitle V, ch. 509, § 50906 of the Commercial Space Launch Act of 2011.

Issuing a reentry license is considered a major Federal action subject to environmental review under the National Environmental Policy Act (NEPA) of 1969, as amended (NEPA; 42 U.S.C. § 4321 et seq.). The FAA has prepared this Final Environmental Assessment (EA) in accordance with NEPA, Council on Environmental Quality (CEQ) NEPA implementing regulations (40 Code of Federal Regulations [CFR] Parts 1500 to 1508), and FAA Order 1050.1F, *Environmental Impacts: Policies and Procedures*, to evaluate the potential environmental impacts of activities associated with issuance of this license (see Section 2.1). The National Aeronautics and Space Administration (NASA) and the United States Air Force (USAF) are cooperating agencies in the development of this EA.

The successful completion of the environmental review process does not guarantee that the FAA would issue a reentry license to SpaceX. The Proposed Action must also meet all FAA safety, risk, and financial responsibility requirements per 14 CFR Part 400. Additional environmental analyses would be required for future SpaceX-proposed activities not addressed in this EA or in previous environmental documentation.

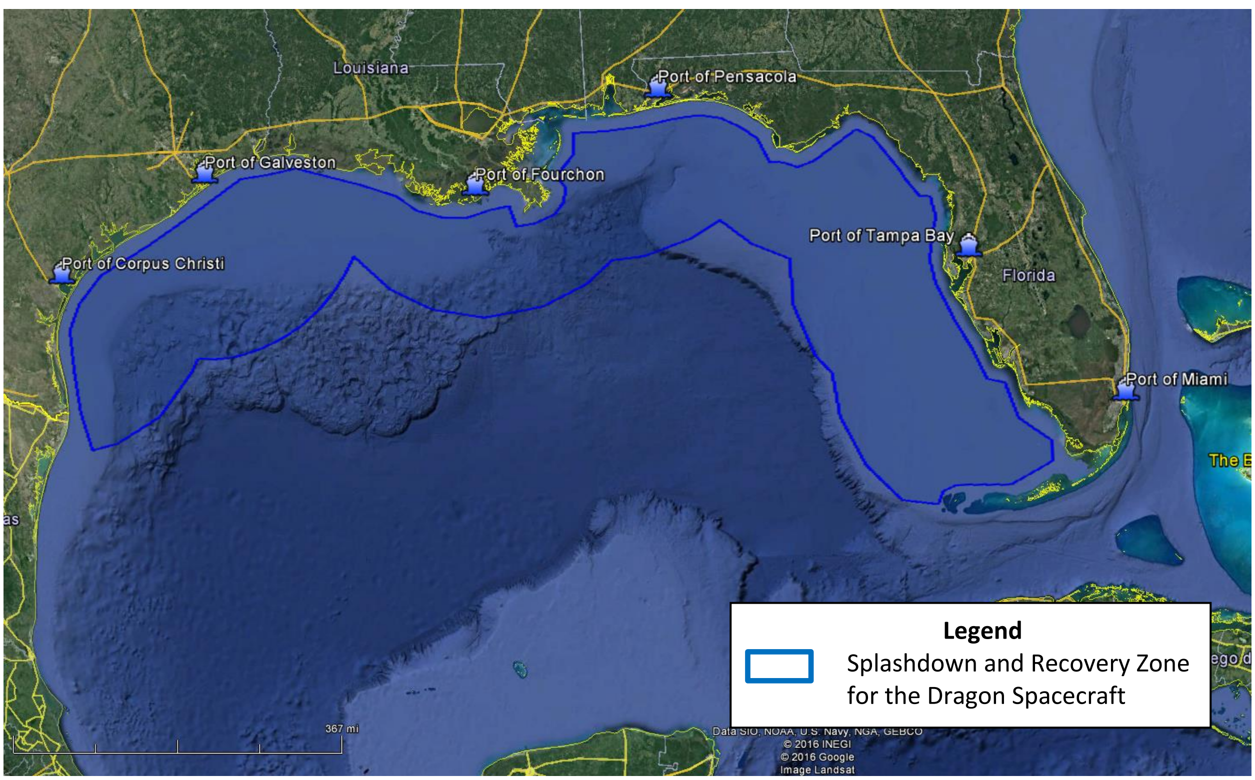


Exhibit 1: Dragon Spacecraft Landing and Recovery Zone

1.1 Background

SpaceX, founded in 2002, is a commercial space transportation company headquartered in Hawthorne, California. SpaceX developed the Dragon to deliver cargo and people to orbiting destinations. There are two versions of the Dragon: Dragon-1 is used for cargo missions to the International Space Station (ISS), and SpaceX intends that Dragon-2 will eventually be used to transport astronauts to the ISS. Since 2010, SpaceX has successfully launched the Dragon-1 under an FAA license from Space Launch Complex-40 (SLC-40) at Cape Canaveral Air Force Station and LC-39A at Kennedy Space Center 16 times (see Table 1-1 below). In 2006, NASA awarded SpaceX a Commercial Orbital Transportation Services (COTS) contract to design and demonstrate a launch system to resupply cargo to the ISS. Later, NASA also awarded SpaceX a contract to develop and demonstrate a human-rated Dragon spacecraft as part of its Commercial Crew Development program to transport crew to the ISS. On May 31, 2012, SpaceX successfully completed the COTS 2/3 mission that made Dragon-1 the first commercial spacecraft to visit the ISS, as well as the first commercial cargo resupply vehicle to return to Earth from the ISS.

SpaceX's Dragon program has been designed to create a free-flying spacecraft that is able to safely and efficiently deliver both cargo and people to orbiting destinations. SpaceX's goal of the Dragon program is to reduce the cost of space travel by utilizing reusable launch vehicles (RLVs) which would land nearby and shorten delays between launches due to standard water landings. The Dragon-2 is similar to the Dragon-1 used in all missions to date (refer to Section 2.1.1).

The Commercial Space Launch Act of 2011 (51 U.S.C. Subtitle V, ch. 509, §§ 50901-50923) declares that the development of commercial launch vehicles, reentry vehicles, and associated services would enable the United States (U.S.) to retain its competitive position internationally, contributing to the national interest and economic well-being of the U.S. The Act authorizes the Secretary of Transportation to oversee and coordinate the conduct of commercial launch and reentry operations, issue commercial licenses authorizing those operations, and protect the public health and safety, safety of property, and national security and foreign policy interests of the United States. Within the Department of Transportation, the Secretary of Transportation's authority has been delegated to the FAA.

Table 1.1. Successful Dragon Launch History at SLC-40 and LC-39A

Flight Number	*Vehicle*	*Flight Name/Reason**	*Date*
1	Falcon 9 with Dragon	NASA COTS Demo-1	December 8, 2010
2	Falcon 9 with Dragon	NASA COTS Demo-2/3	May 22, 2012
3	Falcon 9 with Dragon	NASA ISS Resupply Flight 1	October 7, 2012
4	Falcon 9 with Dragon	NASA ISS Resupply Flight 2	March 1, 2013
5	Falcon 9 with Dragon	NASA ISS Resupply Flight 3	April 18, 2014
6	Falcon 9 with Dragon	NASA ISS Resupply Flight 4	September 21, 2014
7	Falcon 9 with Dragon	NASA ISS Resupply Flight 5	January 10, 2015
8	Falcon 9 with Dragon	NASA ISS Resupply Flight 6	April 14, 2015
9	Falcon 9 with Dragon	NASA ISS Resupply Flight 8	April 8, 2016
10	Falcon 9 with Dragon	NASA ISS Resupply Flight 9	July 18, 2016
11	Falcon 9 with Dragon	NASA ISS Resupply Flight 10	February 19, 2017
12	Falcon 9 with Dragon	NASA ISS Resupply Flight 11	June 3, 2017
13	Falcon 9 with Dragon	NASA ISS Resupply Flight 12	August 14, 2017
14	Falcon 9 with Dragon	NASA ISS Resupply Flight 13	December 15, 2017
15	Falcon 9 with Dragon	NASA ISS Resupply Flight 14	April 2, 2018
16	Falcon 9 with Dragon	NASA ISS Resupply Flight 15	June 29, 2018

Note: *COTS = Commercial Orbital Transportation Services, ISS = International Space Station

1.2 Federal Agency Roles

1.2.1 FAA Role

1.2.1.1 Office of Commercial Space Transportation

As the lead Federal agency, the FAA is responsible for analyzing the potential environmental impacts of the Proposed Action. The issuance of an FAA reentry license to SpaceX would allow the activities described in this EA to be conducted in the Gulf of Mexico.

As authorized by Executive Order (EO) 12465, *Commercial Expendable Launch Vehicle Activities* (49 Federal Register 7099, 3 CFR, 1984 Comp., p. 163), and chapter 509 of Title 51 of the U.S. Code, the FAA licenses and regulates U.S. commercial space launch and reentry activity, as well as the operation of non-Federal launch and reentry sites. The FAA's mission is to ensure public health and safety and the safety of property while protecting the national security and foreign policy interests of the United States during commercial launch and reentry operations. In addition, Congress directed the FAA to encourage, facilitate, and promote commercial space launches and reentries.

1.2.1.2 Air Traffic Organization

The FAA's Air Traffic Organization is responsible for providing safe and efficient air navigation services to 30.2 million square miles of airspace, including all of the United States and the northern Gulf of Mexico. As part of the licensing process, the FAA entered into a Letter of Agreement (LOA) with SpaceX in May 2016 regarding airspace use for reentry operations in the FAA-controlled airspace within the Gulf of Mexico. This LOA outlines general procedures for notification, including the issuance of Notices to Airmen (NOTAMs) and the scheduling of reentry operations, and addresses the responsibilities of all domestic entities that control or manage airspace in the Gulf of Mexico. The temporary airspace changes under the LOA would not be expected to have significant environmental impacts, but could be reevaluated in a future Written Re-evaluation, if warranted.

1.2.2 NASA

NASA provides special expertise with respect to potential environmental impacts from operation of reusable suborbital rockets, which are intended to help foster the development of the commercial reusable suborbital transportation industry. NASA's partnerships with commercial suppliers and private enterprises are expanding, and for these reasons, NASA requested to be a cooperating agency in the development of this EA. NASA will typically be the customer for all or most of the missions in which Dragon lands in the Gulf of Mexico. As described in Section 1.5 below, launches of the Falcon 9, for missions where Dragon would land in the Gulf of Mexico, have been addressed in prior NEPA documents. However, it is possible that NASA may re-evaluate individual launches, as needed.

1.2.3 USAF

The United States Air Force (USAF) provides support to the United States government and commercial entities for low-cost and reliable access to space. USAF's partnerships with commercial suppliers and private enterprises are expanding and for these reasons, USAF requested to be a cooperating agency in the development of this EA. It is possible that missions with a Gulf of Mexico landing could use USAF assets during the mission. These assets could include the use of USAF wharfs such as Poseidon Wharf and the use of USAF transportation networks.

1.3 Purpose and Need

1.3.1 FAA's Purpose and Need

The purpose of FAA's Proposed Action is to fulfill the FAA's responsibilities as authorized by EO 12465 and chapter 509 of Title 51 of the U.S. Code for oversight of commercial space launch activities, including licensing launch activities. The need for FAA's Proposed Action results from the statutory direction from Congress under the U.S. Commercial Space Launch Competitiveness Act of 2015 to, in part, "promote commercial space launches and reentries by the private sector; facilitate Government, State, and private sector involvement in enhancing U.S. launch sites and facilities; and protect public health and safety, safety of property, national security interests, and foreign policy interests of the United States." Pub. L. 114-90, § 113(b). Additionally, Congress has determined the Federal Government is to "facilitate the strengthening and expansion of the United States space transportation infrastructure, including the enhancement of United States launch sites and launch-site support facilities, and development of reentry sites, with Government, State, and private sector involvement, to support the full range of United States space-related activities." 51 U.S.C. § 50901(b)(4).

The FAA must review all applications for licenses and determine whether to issue a license. Actions described in SpaceX's application for a license that fall outside the scope of the analysis in this EA would require additional environmental review.

1.3.2 SpaceX's Purpose and Need

NASA's Commercial Crew Program (CCP) was formed to facilitate the development of a U.S. commercial crew space transportation capability with the goal of achieving safe, reliable, and cost-effective access to and from the ISS and low-Earth orbit (LEO). SpaceX is actively working towards certification of its Dragon-2 spacecraft that will enable the company to meet the established CCP goals.

SpaceX is currently servicing the ISS under the NASA Commercial Resupply Services contract using the Dragon-1. Under this contract, SpaceX provides cargo delivery services to the ISS, disposal of unneeded cargo, and the return of research samples and other cargo from the station back to NASA. During the return portion of these missions, Dragon detaches from the ISS and descends to Earth before splashing down under parachutes into the Pacific Ocean. Certain criteria need to be met in order for the return portion of the mission to be initiated. These criteria include weather conditions and sea state at the anticipated splashdown location (point at which Dragon comes into contact with the ocean and then floats on the ocean surface before being recovered). Unfavorable conditions at the splashdown location can therefore result in delays to spacecraft departure. Although the return of the cargo is time sensitive, delays in spacecraft return do not result in critical concern for human life or health.

With the introduction of the CCP, the ability to return crew to Earth in a safe and timely manner is extremely important, particularly in cases where human life or health may be in jeopardy. The purpose of the Proposed Action is to therefore establish an additional Dragon-2 splashdown option. The Proposed Action is needed as the additional option further ensures that a secondary splashdown option is available to missions planned to splashdown in either the Pacific or Atlantic Oceans, which would provide the returning crew with a timely and safe return to Earth.

1.4 Public Involvement

In accordance with NEPA, CEQ NEPA implementing regulations, and FAA Order 1050.1F, the FAA initiated a 30-day public review and comment period for the Draft EA by publishing a Notice of Availability in the *Federal Register* on April 5, 2018. The public review and comment period ended on May 4, 2018. The FAA received one public comment submission. This comment and the FAA's response are included in Appendix D of this Final EA. No substantive changes to the EA were made as a result of the comment.

1.5 Prior Environmental Analyses

The USAF, NASA, and FAA have previously analyzed the environmental effects of Dragon landings in the Atlantic and Pacific oceans. The information and analyses contained in these documents were used in the development of this EA and are summarized and incorporated by reference where appropriate.

In November 2007, the USAF published the Environmental Assessment for the Operation and Launch of the Falcon 1 and Falcon 9 Space Vehicles at Cape Canaveral Air Force Station, Florida (USAF 2007; hereafter abbreviated as 2007 USAF EA). The USAF issued a Finding of No Significant Impact (FONSI) in December 2007. The FAA was a cooperating agency in the preparation of the 2007 USAF EA, and issued its own FONSI in January 2009. The 2007 USAF EA analyzed the potential environmental impacts of constructing support facilities and operating the Falcon 1 and Falcon 9 launch vehicles, payloads, and Dragon at SLC-40. The 2007 USAF EA also included USAF leasing land and facilities to SpaceX, and supported cooperating agency actions for NASA to contract with SpaceX for launch services, and for the FAA to issue launch licenses for the Falcon 1 and Falcon 9 vehicles and a reentry license for reentry of the Dragon. Three recovery locations for Dragon were considered in the EA: the Atlantic Ocean off the east coast of Florida, the Pacific Ocean off the coast of California, and the equatorial Pacific near the Marshall Islands.

Additionally, in July 2013, the USAF published the Supplemental Environmental Assessment to the November 2007 Environmental Assessment for the Operation and Launch of the Falcon I and Falcon 9 Space Vehicles at Cape Canaveral Air Force Station Florida (USAF 2013; hereafter abbreviated as 2013

USAF Supplemental EA). The FAA was a cooperating agency in the preparation of the 2013 USAF Supplemental EA, which assessed the potential environmental impacts of the Falcon 9 Block 2 vehicle, also referred to as Version 1.1 (v1.1), launch operations at SLC-40. These launch operations included Dragon reentry with a landing in the Pacific Ocean, in addition to other payloads for 2013 and beyond. The USAF published a FONSI in September 2013. The FAA adopted the 2013 USAF Supplemental EA and issued its own FONSI/Record of Decision in October 2013.

In November 2013, NASA published the Final Environmental Assessment for Multi-Use of Launch Complexes 39A and 39B John F Kennedy Space Center (NASA, 2013; hereafter abbreviated as 2013 NASA EA). NASA published the FONSI in February 2014. The FAA was a cooperating agency in the preparation of the 2013 NASA EA. The FAA adopted the 2013 NASA EA and issued its own FONSI in November 2016. The 2013 NASA EA assessed the potential environmental impacts of enhancing Kennedy Space Center (KSC) spaceport capabilities by modifying LC-39A and LC-39B to facilitate the processing and launch of a variety of vertical launch vehicles (including Falcon 9) from either complex by both commercial and governmental entities.

Both Dragon-1 and Dragon-2 will be launched as payloads on Falcon 9. The environmental impacts of Falcon 9 launches at CCAFS and KSC were analyzed in the 2007 USAF EA, 2013 USAF Supplemental EA, and 2013 NASA EA. Those EAs have been adopted by the FAA and are incorporated by reference in this EA. Therefore, the scope of operations analyzed in this EA is limited to the reentry and splashdown of the Dragon in the Gulf of Mexico, as well as associated Dragon post-landing safing and transport operations.

2.0 PROPOSED ACTION AND ALTERNATIVES

2.1 Proposed Action

Under the Proposed Action, the FAA would issue a reentry license to SpaceX, which would authorize SpaceX to conduct up to six Dragon landing operations per year in the waters of the Gulf of Mexico. The launch of the Falcon vehicles carrying Dragon would be licensed by the FAA. Landing Dragon in the Gulf of Mexico would not result in an increase in the number of Falcon launches. As explained in section 1.5 above, these launch operations have been addressed in previous environmental analyses which are incorporated by reference. At the time the previous environmental analyses were prepared, Dragon landings in the Gulf of Mexico were not yet reasonably foreseeable and therefore were not included in the analyses. Each landing operation would include orbital reentry, splashdown, and recovery; each of these operations are explained in more detail in Section 2.1.2 below. The Dragon spacecraft are similar in make up with the primary differences being limited to the additional propellant load on the Dragon-2, the crew capsule abort capabilities of the Dragon-2, the landing guidance system on the Dragon-2, and the life support system on the Dragon-2. The Gulf of Mexico would act as a contingency landing site in the event of hazardous conditions in either the currently utilized Pacific Ocean landing site or the recently approved Atlantic Ocean landing site.

Under the FAA reentry license program (implemented in accordance with 14 CFR Parts 431, 433, and 435), the FAA issues mission-specific and operator reentry licenses to commercial launch operators. A mission-specific license authorizes a licensee to "launch and reenter, or otherwise land, one model or type of RLV from a launch site approved for the mission to a reentry site or other location approved for the mission. A mission-specific license authorizing an RLV mission may authorize more than one RLV mission and identifies each flight of an RLV authorized under the license." Under the Proposed Action, the mission-specific reentry license would authorize up to six reentries of the Dragon in the waters of the Gulf of Mexico per year. The FAA could renew the reentry license if requested, in writing, by SpaceX at least 90 days before the license expires.

2.1.1 Dragon Spacecraft

Structure

Dragon is composed of the capsule for pressurized crew and cargo, the unpressurized cargo module or "trunk," and a nosecone (Exhibit 2). Other primary structures include a welded aluminum pressure vessel, primary heat shield support structure, and back shell thermal protection system support structure. This structure supports secondary structures including the SuperDraco engines (for Dragon-2), propellant tanks, pressurant

Exhibit 2: Dragon-2 Structure

tanks, parachute system, and necessary avionics. The pressurized section consists of the welded pressure vessel, forward hatch, side hatch, docking tunnel, docking adapter, and windows. A docking adapter compatible with the International docking system standard and a conical tunnel mounted on the forward bulkhead provide the structural attachment to the ISS. The primary heat shield support structure transfers aerodynamic loads during reentry and landing. In addition, a compression-only support between the primary heat shield carrier structure and the pressure vessel aft bulkhead allows the primary heat shield to help carry capsule internal pressure load. Dragon-1's dry weight could range from 8,000 to 15,000 pounds depending on its cargo and configuration. Dragon-2 weighs approximately 16,976 pounds without cargo, with a height of approximately 2,317 feet (including the trunk) and a base width of 13 feet. Each pair of SuperDraco engines (eight total engines) are mounted to a monolithic aluminum bracket. This bracket is connected to the pressure vessel with three mounts in a minimally constrained fashion.

<u>Propulsion System</u>

The Dragon propulsion system assembly consists of both a reaction control system (RCS) and an integrated launch abort system (LAS). There are 18 Draco RCS engines and 8 SuperDraco LAS engines (two in each for the four modules) on the Dragon-1. There are 16 Draco RCS engines and 8 SuperDraco LAS engines (two in each of the four modules) on Dragon-2. The propulsion system includes four self-contained modules (quads) with independent sets of propellant tanks for system redundancy. The propulsion system uses nitrogen tetroxide (NTO) and monomethylhydrazine (MMH) propellant combination because of its hypergolic ignition and long term in-orbit storage benefits. The Dragon-2 could contain up to 4,885 pounds of propellant which includes 3,004 pounds of NTO and 1,881 pounds of MMH.[1] The pressurization subsystem, which uses gaseous helium, is separated between the oxidizer and fuel to prevent propellant migration reactions. The Dragon propellant storage is designed to retain residual propellant preventing release into seawater upon splashdown.

2.1.2 Dragon Landing Operations

Up to six Dragon landing operations in the Gulf of Mexico would be conducted annually under a reentry license. All Dragon spacecraft would contain multiple types of cargo, including NASA science experiments and NASA hardware. Dragon would typically weigh between 19,840 and 33,070 pounds based on the mission specific profile. Dragon-2 would also have the capability of returning astronauts to Earth. The weight differential between a cargo and crew mission would be negligible.

Orbital reentry, splashdown, and recovery are the three elements in a Dragon landing operation. After completion of its mission, the Dragon1/Dragon-2 would complete a deorbit burn and reenter the atmosphere.

The trunk supports the capsule during the mission and contains a truss structure to hold unpressurized cargo. At the conclusion of each Dragon-2 mission, the trunk would be left in orbit. For cargo (Dragon-1) missions, the trunk falls through Earth's atmosphere and burns up. Dragon would reenter Earth's atmosphere at a pre-planned trajectory and would be tracked to a splashdown zone within the recovery zone (Exhibit 1). The splashdown zone is a circle with a radius of approximately 5.4 nautical miles. The

[1] The Dragon-2 could contain approximately 40 percent more propellant than the Dragon-1.

recovery zone is positioned in deeper waters at least 15 to as much as 140 nautical miles off the Gulf of Mexico coastline from southern Texas to southern Florida and is completely within the U.S. exclusive economic zone. The splashdown zone would be encompassed completely by the recovery zone and would never extend outside its borders. Dragon has been designed to perform precision landings in order to minimize the size of the splashdown zone and recovery time. The landing ellipse would be developed in accordance with FAA safety regulations and would not contain any existing structures that represent potential collision risk such as oil platforms. SpaceX would maintain a large overall splashdown zone in order to maximize operational flexibility and therefore the safety of the crew. In order to ensure public safety, SpaceX would coordinate with the U.S. Coast Guard, and issue a Notice to Mariners (NOTMAR) 3-6 days prior to all reentry, splashdown, and recovery efforts.

During reentry and prior to splashdown, Dragon's velocity would be slowed by two drogue parachutes and three or four main parachutes. Drogue parachutes are thin parachutes deployed during reentry to gain control of the spacecraft at speeds that would destroy larger parachutes and therefore are deployed before the larger and thicker main parachutes. For both versions of Dragon, the vehicle is rigged with two drogue parachutes. Each drogue parachute has a diameter of 19 feet with 72 feet of risers/suspension and are made of variable porosity conical ribbon. The drogues typically land within one to two kilometers from Dragon.

Shortly after the drogue parachutes are deployed, they are released and the main parachutes are deployed. The main parachutes would slow Dragon to a speed of approximately 13 miles per hour allowing for a "soft" splashdown in a designated area in the Gulf of Mexico. For both versions of Dragon, the main parachutes are made of Kevlar and nylon and have a diameter of 116 feet with 147 feet of risers/suspension. Dragon-1 is rigged with three main parachutes, while Dragon-2 is rigged with four main parachutes.

Dragon is designed to float after splashdown. Dragon would be briefly submerged in the water (approximately 3 feet) upon splashdown and then immediately float on the water's surface for recovery. Debris related to parachute deployment would include the parachute doors and frangible nuts. These items would not be recoverable and would sink to the ocean floor. Recovery activities are limited to surface waters and do not involve any seafloor-disturbing activities.

Following splashdown, an electronic locator beacon on Dragon would allow it to be located and recovered by a pre-positioned recovery vessel. The recovery vessel is a 160-foot ship equipped with a helideck. Two pre-positioned rigid-hulled inflatable boats (RHIB) would arrive at the Dragon's location first to assess Dragon's condition. This assessment would include checking for hypergol vapors, which can be fatal if inhaled, and ensuring the spacecraft is floating in an upright and stable position.

The recovery vessel would then arrive and recovery personnel would lower a hydraulic lift mechanism into the water in order to prepare for pickup of the spacecraft. The lift would bring the spacecraft gently out of the water and onto the deck of the recovery vessel. If the spacecraft contains crew, once the spacecraft is safely secured on-deck, recovery personnel would prepare the spacecraft for crew egress.

While the spacecraft is loaded on to the recovery vessel, the RHIB would recover all parachutes deployed by Dragon, as possible, including the two drogue and three/four main parachutes. The main parachutes are designed to float. Recovery of the drogue parachute assembly is attempted if the recovery team can get a visual fix on the splashdown location. However, because the drogue parachute assembly is deployed at a high altitude, it is difficult to locate. In addition, based on the size of the assembly and the density of the material, the drogue parachute assembly becomes saturated within approximately one minute of splashing down and begins to sink. This makes recovering the drogue parachute assembly difficult and unlikely. This EA assumes all drogue parachute assemblies are not recovered. SpaceX would implement operational controls and contingency planning in an attempt to recover all of the parachutes. These measures would likely include:

- Mobilizing additional recovery resources – most likely one team per parachute;
- Land, ocean, and airborne visual monitoring of the operation; and
- The use of a buoy marking system – attaching appropriately sized buoys immediately upon contact with the parachute would aid in the tracking and retrieval of the parachute.

With Dragon secured in the on-deck hangar, egress equipment would be positioned in front of the spacecraft, capsule pressure would be equalized, and the side hatch would be opened. Crew egress would begin. Crew would be helped from the spacecraft into shipboard medical evaluation quarters. Medical assessment would begin in private medical quarters. The crew and cargo would be transported via helicopter (e.g., Erickson S-64E or H-47 Chinook) to the nearest airport. In some instances, two helicopters could be used to return larger crews.

A commercially available port/wharf on the Gulf Coast may be used for the offloading operations. SpaceX would be responsible for coordinating local approvals with the relevant state and local agencies including the Port Authority. If a local port is not used, the recovery vessel would travel to SpaceX facilities located at the Port of Cape Canaveral or a CCAFS-located wharf. Upon arriving at a port, the spacecraft would be offloaded and transported by truck to a SpaceX facility for further post-flight processing. In accordance with U.S. Department of Transportation (DOT) requirements as outlined in SpaceX's DOT permit regarding the transport of hazardous waste, SpaceX would ensure all pressurized tanks are vented to a DOT-mandated maximum pressure prior to transport.

2.2 No Action Alternative

Under the No Action Alternative, the FAA would not issue a reentry license to SpaceX for the reentry and splashdown of Dragon in the waters of the Gulf of Mexico. SpaceX would continue to conduct reentries and splashdowns of Dragon in the Pacific Ocean authorized under an FAA reentry license. SpaceX could use the reentry area recently licensed in the Atlantic Ocean for future missions. NEPA requires agencies to consider a "no action" alternative in their NEPA analyses and to compare the effects of not taking action with the effects of the action alternative(s). Thus, the No Action Alternative serves as a baseline to compare the impacts of the Proposed Action.

The No Action Alternative would not satisfy the purpose and need for the Proposed Action. With the introduction of the CCP, the ability to return crew to Earth in a safe and timely manner is extremely important, particularly in cases where human life or health may be in jeopardy. The purpose of the Proposed Action is to therefore establish an additional Dragon-2 splashdown option. The Proposed Action is needed as the additional option further ensures that a splashdown option is available which will be able to provide the returning crew with a timely and safe return to Earth.

2.3 Alternatives Considered but Not Carried Forward

NEPA's implementing regulations provide guidance on the consideration of alternatives to a proposed action. These NEPA regulations require rigorous exploration and objective evaluation of reasonable alternatives. The only alternatives that require detailed analysis are those that are determined to be reasonable and that meet the purpose and need. Potential alternatives that meet the purpose and need were evaluated against the following screening factors:

- Must provide favorable weather conditions and sea state at the anticipated splashdown location
- Must allow for the quick return of time sensitive cargo
- Must allow for the return of crew to Earth in a safe and timely manner

The following alternative was considered, but not carried forward for detailed analysis in this EA as it did not meet the purpose and need for the project and satisfy the alternative screening factors listed above. Consideration was given to landing Dragon in the central portion of the Gulf of Mexico. Dragon landings in the Gulf's central portion meet the first screening factor, but not the second and third screening factors. Both crew and time sensitive cargo are transported via helicopter from the recovery vessel to the nearest airport because they must be quickly and safely returned to appropriate facilities for processing in accordance with the NASA Commercial Resupply Services contract. Therefore, suitable reentry and splashdown sites are limited to the recovery zone along the Gulf of Mexico coastline shown in Exhibit 1.

3.0 AFFECTED ENVIRONMENT

This chapter provides a description of the environmental resources that would be affected by the Proposed Action, as required by the CEQ regulations for implementing NEPA (40 CFR Parts 1500 to 1508) and FAA Order 1050.1F, *Environmental Impacts: Policies and Procedures*. In accordance with paragraph 6-2.1.e of FAA Order 1050.1F, the data and analyses in this section are presented in detail commensurate with the importance of the impact.

The geographic area potentially affected by the Proposed Action is referred to as the Region of Influence (ROI). Each resource area discussed in this chapter has a distinct ROI, which is further described in each section.

3.1 Resources Not Analyzed in Detail

The level of detail provided in this chapter is commensurate with the importance of the impact on these resources (40 CFR § 1502.15). Those environmental resource areas not analyzed in detail in this EA include:

Biological Resources (Aquatic Vegetation, and Terrestrial Vegetation and Wildlife) – Submerged aquatic vegetation, or seagrass, typically grows in estuaries and coastal marine waters that are shallow enough for light to reach plants. The Proposed Action does not involve any coastal construction or seafloor disturbing activities. Dragon landing operations and recovery activities would occur in deeper waters at least 15 nautical miles off the Gulf Coast, and the recovery vessel would remain in deep waters during the transport of the recovered Dragon to Port Canaveral, a CCAFS-based wharf facility, such as Poseidon Wharf, or a commercially available wharf on the Gulf Coast. Therefore, no impacts to aquatic vegetation would occur.

The Proposed Action does not involve any vegetation clearing/cutting or earth/soil disturbing activities. Therefore, no impacts to terrestrial vegetation and wildlife would occur. Potential impacts to marine wildlife are discussed in Sections 3.7 and 4.6.

Farmlands – The Proposed Action does not involve land-disturbing activities and would not convert farmland (i.e., prime farmland, unique farmland, and land of statewide or local importance) to nonagricultural use. Therefore, no impact to farmlands would occur.

Historical, Architectural, Archaeological, and Cultural Resources – The Proposed Action would not require any construction or ground-disturbing activities, and there are no historic or tribal sites of significance in the study area. Because the Dragon would land via parachute in the Gulf of Mexico, reentry operations would not have the potential to affect historical, architectural, archaeological, and cultural resources. Therefore, the Proposed Action would not affect architectural, archaeological, or other cultural resources, and the FAA has no further obligations under Section 106 of the National Historic Preservation Act.

Land Use – The Proposed Action does not involve any land-disturbing activities. Port Canaveral, a CCAFS-based wharf facility such as Poseidon Wharf, or a commercially available wharf on the Gulf Coast would be used for the transport and offloading of Dragon. This action would be consistent with the ongoing vessel movement and cargo offloading at these facilities. The transport of the spacecraft by truck to a

SpaceX facility would be consistent with ongoing cargo transport on highways/roadways. Therefore, no impact to land use would occur.

Visual Effects – The Proposed Action does not involve facility development or the introduction of any permanent light sources. Therefore, no impact to visual effects would occur.

Coastal Resources (Coastal Barrier Resources and Coastal Zone Management Plans) – The Coastal Barrier Resources Act prohibits, with some exceptions, Federal financial assistance for development within the Coastal Barrier Resources System that contains undeveloped coastal barriers along the Atlantic and Gulf coasts and Great Lakes. Undeveloped coastal barriers are geologic features that experience wave, tidal, and wind energies; and protect landward aquatic habitats from direct tidal waves. The Proposed Action does not involve development on or modification to any coastal barriers. Therefore, no impact to coastal barrier resources would occur.

The Coastal Zone Management Act provides for management of the nation’s coastal resources, including the Great Lakes. The distance from the shore that coastal zone management protected areas extend into the Gulf varies for each state with the longest distance of 9 nautical miles for Florida and Texas. Dragon landing operations and recovery activities would occur at least 15 nautical miles off the Gulf Coast outside of coastal zone management protected areas. Therefore, the Proposed Action does not have the potential be inconsistent with relevant state coastal zone management plans.

Water Resources (Wetlands, Floodplains, Inland Surface Waters, Groundwater, and Wild and Scenic Rivers) – The Proposed Action does not involve any discharge of material into waters of the United States, occupancy or modification of floodplains, land-disturbing activities, or withdrawal of groundwater. Therefore, no impact to wetlands, floodplains, inland surface waters, groundwater, and wild and scenic rivers would occur. Potential impacts to ocean waters are discussed in Sections 3.9 and 4.8.

Socioeconomics, Environmental Justice, Children’s Environmental Health and Safety Risks – The Proposed Action does not involve onshore activities that could adversely affect economic activity and income, employment, population and housing, and public services and social conditions. Six Dragon off-loadings per year at Port Canaveral, a CCAFS-based wharf facility (such as Poseidon Wharf), or a commercially available wharf on the Gulf Coast would contribute positively to economic conditions in the port region. Landing operations in the Gulf of Mexico would not affect the oil and gas industry because oil and gas platforms would be avoided when establishing splashdown zones (see Section 4.8). Issuing a notice to mariners to avoid the splashdown zone for six landing operations per year would result in a negligible effect to commercial fishing.

Reentry and landing activities would not take place on land near any populated communities. Recovery offloading activities would be limited to an existing commercial/industrial port, such as Port Canaveral, a CCAFS-based wharf facility, or a commercially available wharf on the Gulf Coast. Therefore, the Proposed Action would not result in disproportionately high and adverse human health or environmental effects on minority and low-income populations, nor would it result in environmental health risks or safety risks that may disproportionately affect children.

3.2 Air Quality

The Earth's atmosphere consists of five main layers: the troposphere, stratosphere, mesosphere, ionosphere, and exosphere. For the purposes of this EA, the lower troposphere is defined as at or below 3,000 feet above ground level (AGL), which the U.S. Environmental Protection Agency (EPA) accepts as the nominal height of the atmosphere mixing layer in assessing contributions of emissions to ground-level ambient air quality under the Clean Air Act (EPA 1992). Typically, temperature and density decrease with altitude in the atmosphere up to the mixing height. However, at the mixing height, the temperature begins to increase with altitude and creates an inversion, which prevents a parcel of air from spontaneously rising past the mixing height (Visconti 2001). Although Dragon emissions from operations at or above 3,000 feet AGL would occur, these emissions would not result in appreciable ground-level concentrations due to this inversion.

The proposed reentry, splashdown and recovery operations would primarily occur in the Gulf of Mexico and to a very limited extent in Port Canaveral, FL as explained in Section 2.1.2. Therefore, the ROI for air quality is the Gulf of Mexico and the administrative/regulatory boundary of Brevard County, FL. Brevard County is located within the Central Florida Intrastate Air Quality Control Region as designated by the EPA.

3.2.1 National Ambient Air Quality Standards

Under the Clean Air Act, the EPA established National Ambient Air Quality Standards (NAAQS) (40 CFR Part 50) for criteria pollutants. Criteria pollutants include carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), ozone, particulate matter less than or equal to 10 microns in diameter (PM_{10}), particulate matter less than or equal to 2.5 microns in diameter ($PM_{2.5}$), and lead (Pb). CO, SO_2, Pb, nitrogen oxides, and some particulates are emitted directly into the atmosphere from emissions sources. Ozone, NO_2, and some particulates are formed through atmospheric chemical reactions that are influenced by weather, the ultraviolet component of sunlight, and other atmospheric processes.

The NAAQS represent the maximum levels of pollution that are considered acceptable, with an adequate margin of safety, to protect public health and welfare. Short-term standards (1-, 3-, 8-, and 24-hour periods) are established for pollutants contributing to acute health effects, while long-term standards (quarterly and annual averages) are established for pollutants contributing to chronic health effects. The Florida Department of Environmental Protection, Division of Air Resource Management has exclusively adopted the NAAQS. The Florida and EPA established ambient air quality standards are presented in Table 3.1-1.

Based on measured ambient criteria pollutant data, the EPA designates all areas of the U.S. as having air quality better than the NAAQS (attainment), worse than the NAAQS (nonattainment), or unclassifiable (40 CFR Part 81, Subpart C, Section 107). The designation of attainment for any NAAQS is based on the evaluation of ambient air quality monitoring data collected through federal, state, and/or local monitoring networks. According to the EPA, Brevard County, Florida is in attainment for all federal and state criteria pollutants (EPA 2016b).

No federal agency may engage in, support in any way, or provide financial assistance for, license or permit, or approve any activity which does not conform to an applicable implementation plan (i.e., the State Implementation Plan [SIP]). Conformity determination is the process by which a federal agency demonstrates that the action conforms to the SIP, and is required only in nonattainment and maintenance areas. As Florida is in attainment for all federal and state criteria pollutants, no general conformity determination is required. The most recent Annual Air Monitoring Report for the state of Florida was published in 2012. The air monitoring effort concentrated on the six criteria pollutants; carbon monoxide, lead, nitrogen dioxide, ozone, sulfur dioxide, and particle pollution. In 2016, Florida continued to be in attainment for all criteria pollutants, with the exception of Tampa's nonattainment designation for lead, and sulfur dioxide nonattainment areas in Hillsborough County (Tampa area) and Nassau County (Jacksonville area) (EPA 2016b). The state coastal boundaries are part of the same air quality jurisdiction area as the contiguous land area. Coastal waters for most states lie within 3 nautical miles of a shoreline. For Florida, the Atlantic side boundary is also 3 nautical miles, but the Gulf of Mexico side is 9 nautical miles. The coastal boundaries for Texas and Puerto Rico are also 9 nautical miles. Since splashdown and retrieval operations would occur at a minimum of 15 nautical miles from shore, they would be outside of state coastal water jurisdictions.

Existing stationary point sources of air emissions in the Gulf of Mexico include oil platforms. Mobile sources of air emissions include commercial ships, recreational boats, cruise ships, and aircraft.

Table 3.1-1. National and Florida Ambient Air Quality Standards

Pollutant	*Primary/ Secondary*	*Averaging Time*	*Levels*	*Forms*
Carbon monoxide	primary	8 hours	9 ppm	Not to be exceeded more than once per year
		1 hour	35 ppm	
Lead	primary and secondary	Rolling 3 month average	0.15 µg/m3 (1)	Not to be exceeded
Nitrogen dioxide	primary	1 hour	100 ppb	98th percentile of 1-hour daily maximum concentrations, averaged over 3 years
	primary and secondary	1 year	53 ppb (2)	Annual Mean
Ozone	primary and secondary	8 hours	0.070 ppm (3)	Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years
Particle Pollution (PM) 2.5	primary	1 year	12.0 µg/m3	annual mean, averaged over 3 years
	secondary	1 year	15.0 µg/m3	annual mean, averaged over 3 years
Particle Pollution (PM) 10	primary and secondary	24 hours	35 µg/m3	98th percentile, averaged over 3 years
	primary and secondary	24 hours	150 µg/m3	Not to be exceeded more than once per year on average over 3 years
Sulfur Dioxide	primary	1 hour	75 ppb (4)	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
	secondary	3 hours	0.5 ppm	Not to be exceeded more than once per year

Table 3.1-1. National and Florida Ambient Air Quality Standards

Pollutant	Primary/ Secondary	Averaging Time	Levels	Forms

Source: (EPA 2016a)

Notes: mg/m3 = milligrams per cubic meter; µg/m3 = micrograms per cubic meter; ppb = parts per billion; ppm = parts per million; PM10 = particulate matter less than or equal to 10 microns in diameter; PM2.5 = fine particulate matter 2.5 microns or less in diameter

(1) In areas designated nonattainment for the Pb standards prior to the promulgation of the current (2008) standards, and for which implementation plans to attain or maintain the current (2008) standards have not been submitted and approved, the previous standards (1.5 µg/m3 as a calendar quarter average) also remain in effect.

(2) The level of the annual NO2 standard is 0.053 ppm. It is shown here in terms of ppb for the purposes of clearer comparison to the 1-hour standard level.

(3) Final rule signed October 1, 2015, and effective December 28, 2015. The previous (2008) ozone standards additionally remain in effect in some areas. Revocation of the previous (2008) ozone standards and transitioning to the current (2015) standards will be addressed in the implementation rule for the current standards.

(4) The previous SO2 standards (0.14 ppm 24-hour and 0.03 ppm annual) will additionally remain in effect in certain areas: (1) any area for which it is not yet 1 year since the effective date of designation under the current (2010) standards, and (2) any area for which implementation plans providing for attainment of the current (2010) standard have not been submitted and approved and which is designated nonattainment under the previous SO2 standards or is not meeting the requirements of a SIP call under the previous SO2 standards (40 CFR 50.4(3)), A SIP call is an EPA action requiring a state to resubmit all or part of its State Implementation Plan to demonstrate attainment of the require NAAQS.

3.2.2 Hazardous Air Pollutants

In addition to the ambient air quality standards for criteria pollutants, national standards also exist for Hazardous Air Pollutants (HAPs). The National Emission Standards regulate 187 HAPs based on available control technologies (40 CFR Parts 61 and 63). The majority of HAPs are volatile organic compounds.

HAPs emitted from mobile sources are called Mobile Source Air Toxics (MSATs). MSATs are compounds emitted from highway vehicles and non-road equipment that are known or suspected to cause cancer or other serious health and environmental effects. In 2001, EPA issued its first Mobile Source Air Toxics Rule, which identified 21 compounds as being HAPs that required regulation (EPA 2001). A subset of six of these MSATs compounds were identified as having the greatest influence on health and included benzene, 1,3-butadiene, formaldehyde, acrolein, acetaldehyde, and diesel particulate matter. EPA issued a second Mobile Source Air Toxics Rule in February 2007, which generally supported the findings in the first rule and provided additional recommendations of compounds having the greatest impact on health. The rule also identified several engine emission certification standards that must be implemented (EPA 2007).

MSATs would be the primary HAPs emitted by mobile sources during recovery operations. The recovery vessel, RHIB and helicopter used during recovery operations would likely vary in age and have a range of emission controls. It is anticipated that recovery equipment and vehicles would be operated for approximately five days for each recovery operation and would produce negligible ambient pollutant emissions in a widely dispersed area. Hazardous air pollutants from the combustion of fossil fuel, which is the cause of emissions from mobile sources, are anywhere from one to three orders of magnitude less than criteria pollutant emissions from these sources. Because of the small scale of the emissions and in the context of the minimal mobile source operations required by the proposed action, HAP emissions are not considered further in this analysis.

3.3 Climate

The climate of the gulf region varies from tropical to subtropical, with hot, humid summers and distinct wet and dry seasons. Of particular note are the often-devastating hurricanes (tropical cyclones) that strike the region nearly every year. The hurricane season officially runs from June 1 to November 30, during which time meteorological and oceanographic conditions are conducive for hurricanes to develop anywhere in the gulf (Encyclopedia Britannica 2016).

Greenhouse gases (GHG) are gas emissions that trap heat in the atmosphere. These emissions occur from natural processes and human activities. Research has shown there is a direct correlation between fuel combustion and GHG emissions. In terms of U.S. contributions, domestic aviation contributed a little over two percent of total Carbon Dioxide equivalent (CO_2e) emissions in 2014, according to EPA data, with the total transportation sector contributing 26.3 percent and power generation contributing 30.3 percent) (EPA 2016c). The International Civil Aviation Organization estimates that GHG emissions from aircraft account for roughly 2 percent of all anthropogenic GHG emissions globally (ICAO 2010). Climate change resulting from GHG emissions is a cumulative global phenomenon, so the affected environment and ROI is the global climate (EPA 2009). Discussion of the estimated GHG emissions associated with the Proposed Action and the impact analysis can be found in cumulative impact analysis in Section 4.2.

The FAA has developed guidance for considering GHGs and climate under NEPA, as published in the Desk Reference to Order 1050.1F (FAA 2015). Considering GHG emissions for an FAA NEPA review should follow the basic procedure of considering the potential incremental change in CO_2 emissions that would result from the proposed action and alternative(s) compared to the no action alternative for the same timeframe, and discussing the context for interpreting and understanding the potential changes. For FAA NEPA reviews, this consideration could be qualitative (e.g., explanatory text), but may also include quantitative data (e.g., calculations of estimated project emissions).

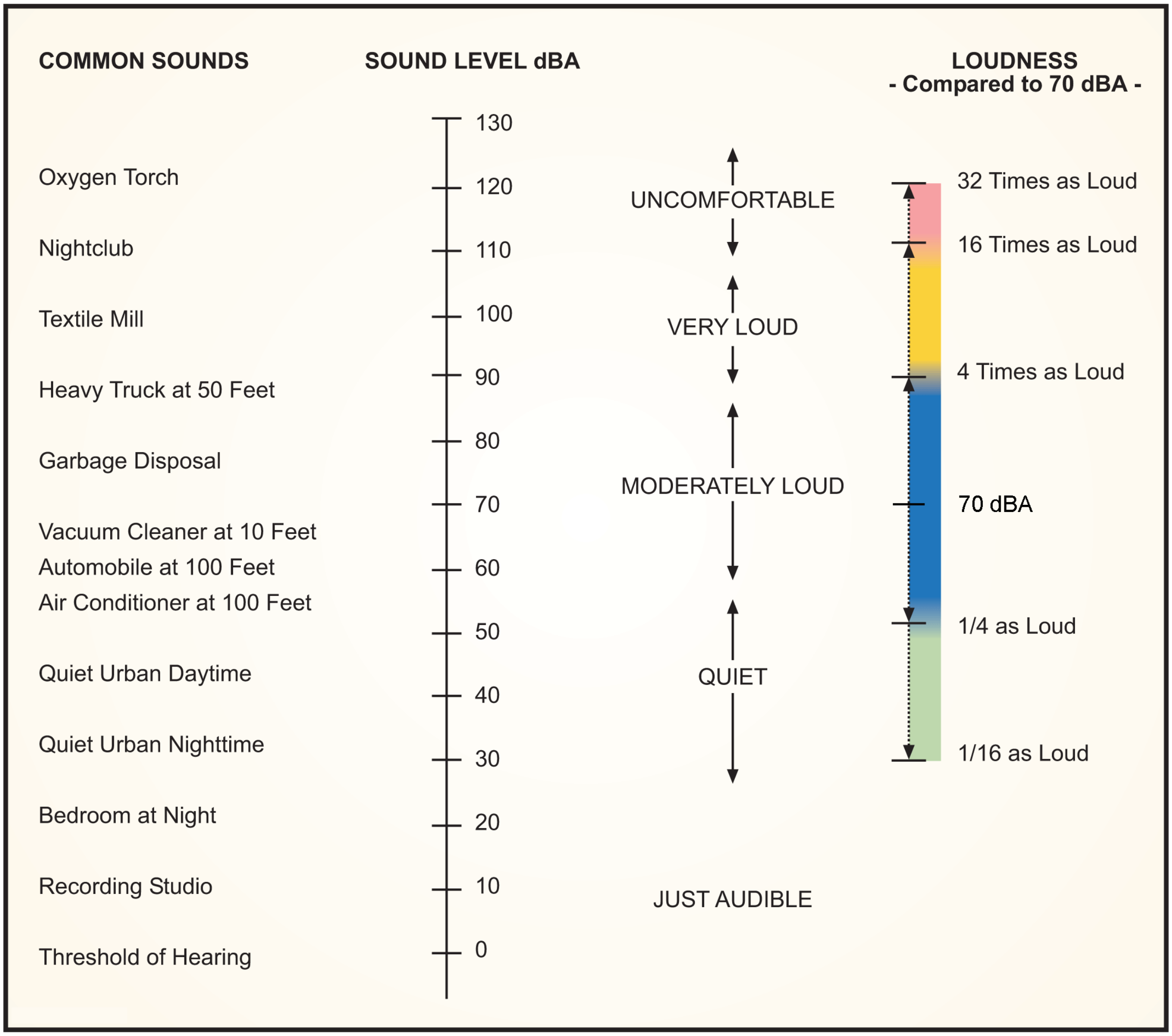
3.4 Noise and Noise-Compatible Land Use

Noise is considered unwanted or annoying sound that interferes with or disrupts normal human activities. Although exposure to very high noise levels can cause hearing loss, the principal human response to noise is annoyance. The response of different individuals to similar noise events is diverse and is influenced by the type of noise, perceived importance of the noise, its appropriateness in the setting, time of day, type of activity during which the noise occurs, and sensitivity of the individual.

The ROI for noise and noise-compatible land use includes the recovery zone positioned between approximately 15 to 140 nautical miles off the Gulf of Mexico coastline from southern Texas to southern Florida where the majority of boat noise would occur (Exhibit 1). This ROI also extends beyond the recovery zone to the Gulf coastline where the effects of sonic boom noise from reentry would occur. Lastly, this ROI includes Port Canaveral, CCAFS, and a commercially available wharf on the Gulf Coast where recovery offloading activities would occur.

3.4.1 Noise Metrics

The decibel (dB) is a ratio that compares the sound pressure level of the sound source of interest (e.g., a launch) to a reference sound pressure level (i.e., the quietest sound that can be heard). A number of factors affect sound, as the human hearing mechanism perceives it. These include the actual level of noise, the frequency content, the time period of exposure to the noise, and changes or fluctuations in noise levels during exposure. In order to correlate the frequency characteristics from typical noise sources to human response, several frequency weighting scales have been developed. The most common frequency scale is the 'A-weighted scale.' Since the human hearing mechanism cannot perceive all frequencies equally well, the A-weighted scale compensates for the human lack of sensitivity to low and high-frequency sounds. A-weighting collapses all of the frequency data associated with a sound to a single value known as the A-weighted decibel, or dBA. Exhibit 3 provides a chart of A-weighted sound levels from typical noise sources. Some noise sources (e.g., air conditioner, vacuum cleaner) generate continuous sounds that maintain a constant sound level for some period of time. Other sources (e.g., automobiles and trucks) produce sound that rises in level, reaches a maximum, and then recedes during the vehicle pass-by. Still other sounds such as sonic booms are referred to as transient or impulse sounds because of their very short duration.



Sources: Derived from Harris 1979 and Federal Interagency Committee on Aviation Noise (FICAN) 1997. Note: dBA = A-weighted decibel

Exhibit 3: A-Weighted Sound Levels from Typical Sound

The day-night average noise level (DNL) is a cumulative noise metric that is an average of noise levels over a 24-hour period with a 10 dB upward adjustment of noise levels during the nighttime (10:00 p.m. to 7:00 a.m.). This adjustment accounts for increased human sensitivity to noise at night. The DNL can be calculated on the basis of the Sound Exposure Level (SEL) and the number of daytime and nighttime noise events. The SEL represents all of the acoustic energy associated with a noise event such as a vehicle pass-by. The SEL normalizes the sound level as if the entire event occurred in 1 second. The SEL is also useful for directly comparing two different noise events with differing maximum noise levels and durations.

FAA Order 1050.1F requires the FAA to assess noise impacts on noise sensitive areas using the DNL metric to determine if significant impacts would occur. A noise sensitive area is an area where noise interferes with normal activities associated with its use. Normally, noise sensitive areas include residential, educational, health, and religious structures and sites, and parks, recreational areas (including areas with wilderness characteristics), wildlife refuges, and cultural and historical sites. There are other Federal agency noise standards that pertain to hearing conservation (e.g., those established by the National Institute for Occupational Safety and Health (NIOSH) and the Occupational Safety and Health Administration (OSHA)).

Noise contour maps of noise metrics are used to assess the noise level and impact of noise on a community. Noise contours depict the area within which a certain noise level occurs, as predicted by a computer model. As stated in Exhibit 4-1 of FAA Order 1050.1F, a significant noise impact would occur if the "action would increase noise by DNL 1.5 dB or more for a noise sensitive area that is exposed to noise at or above the DNL 65 dB noise exposure level, or that will be exposed at or above the DNL 65 dB due to a DNL 1.5 dB or greater increase, when compared to the no action alternative for the same timeframe."

The Gulf of Mexico is approximately 617,800 square miles and has little development in its open surface waters. Potential noise sources include sources that are typical to an open ocean setting, including wave action, wind, boat engines (both recreational and commercial), and oil rig operations.

3.4.2 Noise-Compatible Land Use

Compatible land use means the use of the land is normally compatible with the outdoor noise environment at the location (14 CFR § 150.7). Compatible land use analysis considers the effects of noise on special management areas, such as national parks, national wildlife refuges, and other sensitive noise receptors. The concept of land use compatibility corresponds to the objective of achieving a balance or harmony between the Proposed Action and the surrounding environment.

Within land use, there are certain classifications that are afforded special protection by the DOT, such as Section 4(f) properties, farmlands, and coastal resources. Section 4(f) properties are a special class of public lands or resources whose "use" by agencies in the DOT is restricted unless no feasible and prudent alternative exists. For the purposes of this EA, Section 4(f) properties are described separately in Section 3.5 and Coastal Resources in Section 3.8. The lack of impacts to farmlands is documented in Section 3.1.

Noise compatibility or non-compatibility of land use is determined by comparing the DNL values at a site to the values in the land use compatibility guidelines in FAA Order 1050.1F.

3.5 Department of Transportation Act, Section 4(f)

Section 4(f) properties are publicly owned lands including public parks, recreation areas, wildlife and waterfowl refuges, and public and private historic sites of national, state, and/or local significance. The term historic sites includes prehistoric and historic districts, sites, buildings, structures, or objects listed in, or eligible for listing in, the National Register of Historic Places. Section 4(f) properties are protected under Section 4(f) of the DOT Act, codified and renumbered as 49 U.S.C. § 303(c). In accordance with Section 4(f), the FAA will not approve any program or project that requires the use of a Section 4(f) property unless no feasible and prudent alternative exists to the use of such land and the program or project includes all possible planning to minimize harm resulting from the use.

The ROI for this resource includes the recovery zone positioned between approximately 15 to 140 nautical miles off the Gulf of Mexico coastline from southern Texas to southern Florida (Exhibit 1). This

ROI also extends beyond the recovery zone to the Gulf coastline where sonic booms may be heard (see Section 4.3.1).

Public parks, recreation areas, wildlife and waterfowl refuges, and public and private historic sites may be considered Section 4(f) properties, as defined by the DOT Act. As stated at the beginning of Chapter 3, the Proposed Action would not have the potential to affect historic properties. Therefore historic sites are not considered.

According to the U.S. Fish and Wildlife Service (USFWS) National Wildlife Refuge (NWR) System website, there are over 40 National Wildlife Refuges along the Texas, Louisiana, Alabama, and western Florida coasts which could potentially be exposed to a sonic boom during reentry. Lands within the NWR System are set aside for the conservation of fish, plants, and wildlife. The NWR System includes lands managed by private landowners, non-profit organizations, and state governments under the oversight of the USFWS.

Similar to national parks on land, National Marine Sanctuaries consist of underwater protected areas that range in size from less than one square mile to more than 137,000 square miles (NOAA 2014a). In total, the sanctuary system encompasses more than 150,000 square miles of U.S. Ocean and Great Lakes waters. Sanctuaries protect thriving ecosystems like coral reefs and kelp forests, along with important breeding and feeding areas for marine life like whales, seabirds, sharks, and sea turtles (NOAA 2014a). Two National Marine Sanctuaries exist within the ROI of the Proposed Action.

Flower Garden Banks National Marine Sanctuary is located 70 to 115 miles off the coasts of Texas and Louisiana. The Flower Garden Banks were discovered by snapper and grouper fishermen in the late 1800s. They named the banks after the brightly colored sponges, plants and other marine life they could see on the colorful reefs below their boats. The sanctuary includes underwater communities that rise from the depths of the Gulf of Mexico atop underwater mountains called salt domes (NOAA 2016a).

Florida Keys National Marine Sanctuary supports one of the most diverse assemblages of underwater plants and animals in North America. Although best known for its coral reefs, the shallow waters near shore contain interconnecting and interdependent marine habitats that include fringing mangroves, seagrass meadows, hard bottom regions, patch reefs, and bank reefs. This complex marine ecosystem is the foundation for the tourism and commercial fishing-based economies that are so important to Florida. Encompassing over 3,800 square miles of marine water surrounding the Florida Keys, this sanctuary supports over 6,000 species of marine life and protects shipwrecks and other archeological resources (NOAA 2016b).

3.6 Biological Resources (Marine Wildlife)

Biological resources include plant and animal species and the habitats where they occur. Habitat can be defined as the resources and conditions present in an area that supports the existence of a plant or animal (Hall et al. 1997). Although the existence and preservation of biological resources are intrinsically valuable, these resources also provide aesthetic, recreational, and socioeconomic values to society. Aquatic vegetation and terrestrial vegetation and wildlife would not be impacted by the Proposed Action (see Section 3.1). This analysis focuses on marine wildlife species that are important to the function of the ecosystem, of special societal importance, or are protected under federal law or statute. The ROI for marine wildlife and special-status species includes the recovery zone positioned between approximately 15 to 140 nautical miles off the Gulf of Mexico coastline from southern Texas to southern Florida (Exhibit 1). This ROI also extends beyond the recovery zone to the Gulf coastline where the effects of sonic boom noise from reentry would occur.

3.6.1 Marine Wildlife

Marine wildlife resources include mammals, fish, reptiles, birds and invertebrate species or species groups such as mollusks. The recovery zone of the ROI is composed of pelagic open ocean and provides habitat for a wide range of species. Common fish species found within the ROI include marlins, sailfish, swordfish, tunas, wahoos, bull shark, lemon shark, and blacktip shark (Franks 2005, TPWD 2016). Common invertebrate species found within the ROI include sea nettle, moon jellyfish, longfin squid, arrow squid, blue crab, and many species of krill and plankton (Voss and Brakoniecki 1985). All of the marine mammals present within the ROI are protected under the Marine Mammal Protection Act of 1972 (MMPA) (16 U.S.C. § 1361 et seq.), and all of the reptile species (i.e., sea turtles) present in the ROI are protected under the Endangered Species Act of 1973 (ESA) (16 U.S.C. § 1531 et seq.). As a result, these species are discussed in Section 3.7.2 below.

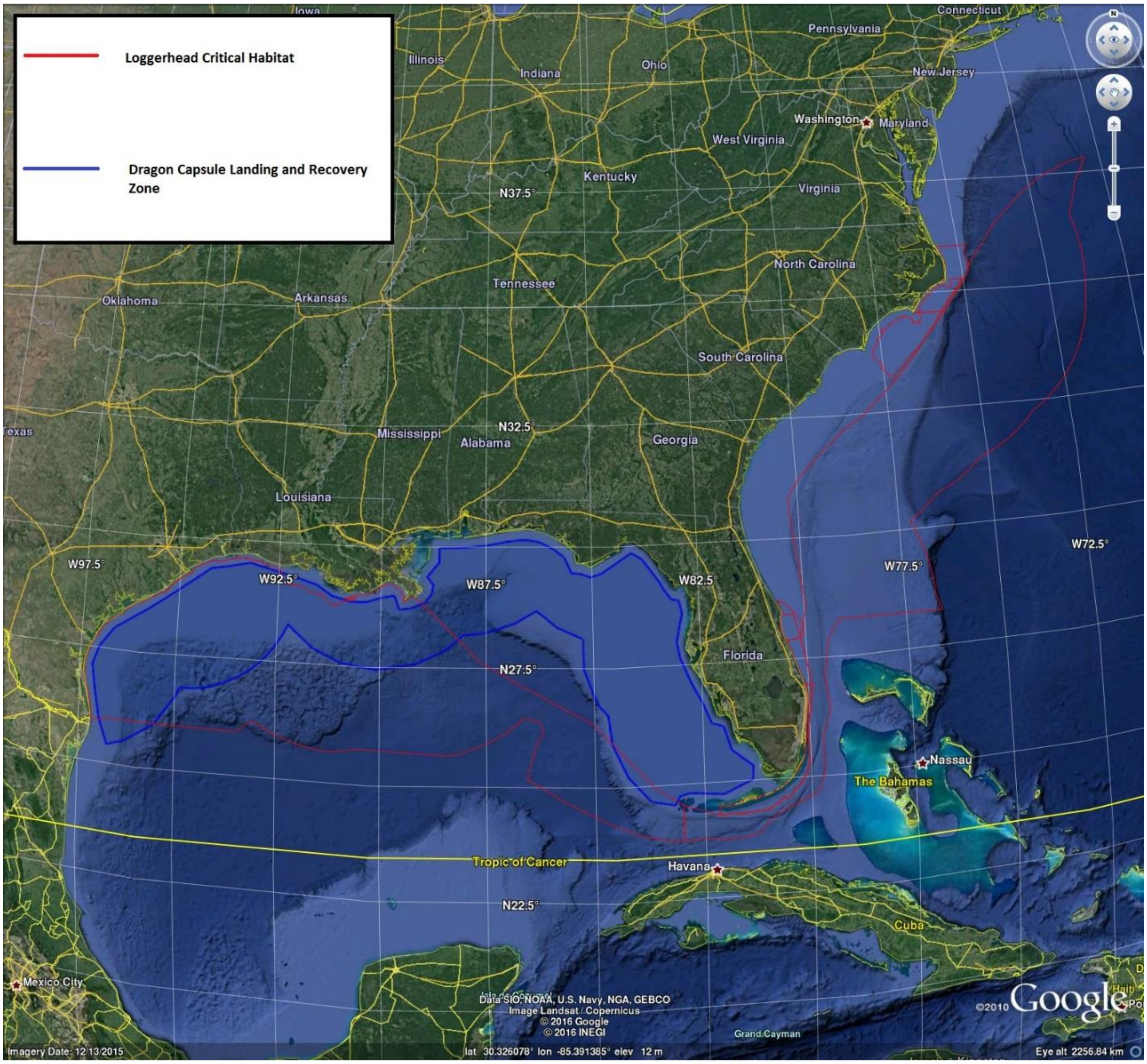
3.6.2 Special Status Species

The MMPA and ESA are the primary federal statutes protecting sensitive marine species in the ROI. The MMPA protects all marine mammals and prohibits the take of marine mammals in U.S. waters and by U.S. citizens on the high seas. Under the MMPA, the NMFS has jurisdiction over whales, dolphins, seals, and sea lions. The ESA and subsequent amendments require the conservation of federally listed threatened and endangered plant and animal species, and the critical habitats in which they are found. A species is considered endangered if it is in danger of extinction throughout all or a significant portion of its range. Threatened species are defined as those that are likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. The National Marine Fisheries Service (NMFS) has jurisdiction under the ESA for marine and anadromous species and designates critical habitat for these species. NMFS and USFWS share jurisdiction over sea turtles, with NMFS responsible for the marine environment and USFWS for nesting beaches. Section 7 of the ESA requires all federal agencies, including the FAA, to consult with the NMFS or USFWS, as applicable, before initiating any action that may affect a listed species or designated critical habitat.

A list of federally threatened and endangered species and marine mammals occurring or potentially occurring in the ROI was developed by reviewing online information from the NMFS Southeast Regional Office website (NMFS 2016a), the NMFS Protected Resources Division website (NMFS 2016b) and the USFWS Environmental Conservation Online System (USFWS 2016). Based on this information, 10 federally listed threatened, and 12 federally listed endangered animal species occur or potentially occur within the ROI (see Table 3.7-1). In addition, 28 marine mammal species protected under the MMPA also occur or potentially occur within the ROI (see Table 3.7-1).

The only federally listed species with designated critical habitat in the ROI is the loggerhead sea turtle (NMFS 2014). This critical habitat is identified as *Sargassum*, which is a genus of large brown seaweed (a type of algae) that floats in island-like masses along miles of ocean surface waters and provides developmental and foraging habitat for young loggerhead sea turtles (NOAA 2014b, 2014c). Exhibit 4 displays the location of critical habitat within the ROI.

The Migratory Bird Treaty Act of 1918 (16 U.S.C. §§ 703-712) protects migratory birds, including their eggs, active nests, and bird parts. The ROI is located within a major spring and fall migratory corridor used by neotropical migrants, waterfowl, raptors, and other birds. The ROI also provides habitat for pelagic bird species. Common examples include the pomarine jaeger, northern gannet, band-rumped storm petrel, Audubon's shearwater, laughing gull and herring gull (Peake and Elwonger 1996). Bald and golden eagles are protected under the Migratory Bird Treaty Act and also under the Bald and Golden Eagle Protection Act (16 U.S.C. §§ 668-668c), which was enacted to provide protection of the bald eagle and golden eagle by prohibiting the take, possession, sale, purchase, barter, offer to sell, purchase or barter, transport, export or import, of any bald or golden eagle, alive or dead, including any part, nest, or egg, unless allowed by permit. Golden eagles are found primarily in mountains, canyonlands, rimrock terrain, and riverside cliffs and bluffs across the western, central and northeastern U.S. and therefore are not found in the ROI (Cornell Lab of Ornithology 2015a). Bald eagles can be found near lakes, reservoirs, rivers, marshes, and coasts across the U.S. and therefore have the potential to be present within the coastal areas along the ROI (Cornell Lab of Ornithology 2015b) where sonic boom noise from reentry would occur.



Source: NMFS 2014.

Exhibit 4: Loggerhead Turtle Critical Habitat in the Northwest Atlantic Ocean

Table 3.7-1. Federally Listed Threatened and Endangered Species Potentially Occurring within the Gulf of Mexico

Common Name (Scientific name)	***Status***	***Critical Habitat in ROI***
	Federal	
Reptiles		
Kemp's Ridley turtle (*Lepidochelys kempii*)	E	NA
Hawksbill turtle (*Eretmochelys imbricata*)	E	N
Green turtle (*Chelonia mydas*)	T	N
Loggerhead turtle (*Caretta caretta*)	T	Y
Leatherback turtle (*Dermochelys coriacea*)	E	N
Birds		
Least Tern (*Sterna antillarium*)	E	NA
Red Knot (*Calidris canutus rufa*)	T	NA
Piping Plover (*Charadrius melodus*)	T	NA
Mammals		
Sperm Whale (*Physeter catodon*)	E, MMPA	NA
Sei Whale (*Balaenoptera borealis*)	E, MMPA	NA
Fin Whale (*Balaenoptera physalus*)	E, MMPA	NA
Blue Whale (*Balaenoptera musculus*)	E, MMPA	NA
Humpback Whale (*Megaptera novaeangliae*)	E, MMPA	N
North Atlantic Right Whale (*Eubalaena glacialis*)	E, MMPA	N
West Indian Manatee (*Trichechus manatus*)	E, MMPA	N
Atlantic Spotted Dolphin (*Stenella frontalis*)	MMPA	NA
Risso's Dolphin (*Grampus griseus*)	MMPA	NA
Cuvier's Beaked Whale (*Ziphius cavirostris*)	MMPA	NA
Bryde's Whale (*Balaenoptera edeni*)	MMPA	NA
Pantropical Spotted Dolphin (*Stenella attenuata*)	MMPA	NA
Clymene Dolphin (*Stenella clymene*)	MMPA	NA
Bottlenose Dolphin (*Tursiops truncatus*)	MMPA	NA
Fraser's Dolphin (*Lagenodelphis hosei*)	MMPA	NA
Rough-toothed Dolphin (*Steno bredanensis*)	MMPA	NA
Spinner Dolphin (*Stenella longirostris*)	MMPA	NA
Striped Dolphin (*Stenella coeruleoalba*)	MMPA	NA
Blainville's Beaked Whale (*Mesoplodon densirostris*)	MMPA	NA
Dwarf Sperm Whale (*Kogia sima*)	MMPA	NA
False Killer Whale (*Pseudorca crassidens)*	MMPA	NA
Killer whale (*Orcinus orca*)	MMPA	N
Melon-headed Whale (*Peponocephala electra*)	MMPA	NA
Gervais' Beaked Whale (*Mesoplodon europaeus*)	MMPA	NA
Minke Whale (*Balaenoptera acutorostrata*)	MMPA	NA
Pygmy Killer Whale (*Feresa attenuata*)	MMPA	NA
Pygmy Sperm Whale (*Kogia breviceps*)	MMPA	NA
Short-finned Pilot Whale (*Globicephala macrorhynchus*)	MMPA	NA
Fish		
Gulf sturgeon (*Acipenser oxyrinchus desotoi*)	T	N
Nassau grouper (*Epinephelus striatus*)	T	NA
Smalltooth sawfish (*Pristis pectinata*)	E	N

Table 3.7-1. Federally Listed Threatened and Endangered Species Potentially Occurring within the Gulf of Mexico

Common Name (Scientific name)	***Status***	***Critical Habitat in ROI***
	Federal	
Invertebrates		
Lobed star coral (*Orbicella annularis*)	T	NA
Mountainous star coral (*Orbicella faveolata*)	T	NA
Boulder star coral (*Orbicella franksi*)	T	NA
Elkhorn coral (*Acropora palmata*)	T	N

Sources: NMFS 2016a, 2016b, USFWS 2016.

Notes: E = endangered, T = threatened, N = No, Y = Yes, NA = non-applicable (i.e., no critical habitat designated), MMPA = Marine Mammal Protection Act. Some species listed above have designated critical habitat outside of the ROI.

3.6.3 Essential Fish Habitat

NMFS is responsible for enforcing the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) (50 CFR § 600.905 *et seq*.) and evaluating potential impacts to Essential Fish Habitat (EFH). EFH is identified for species managed in Fishery Management Plans under the MSFCMA and is the habitat necessary for managed fish to complete their life cycle, thus contributing to a fishery that can be harvested sustainably (NMFS 2016c). EFH applies to each life stage of approximately 1,000 managed species and different life stages of the same species often use different habitats (NMFS 2016c). NMFS has interpreted through regulation that EFH must be described and identified for each federally managed species at all life stages for which information is available (NMFS 2016c). EFH exists in the ROI for red drum, reef fish species, coastal migratory pelagic species, shrimp species, spiny lobster, and coral species.

3.7 Coastal Resources

Executive Order 13089, *Coral Reef Protection* requires Federal agencies to identify any actions that may affect coral reef ecosystems, protect and enhance the conditions of these ecosystems, and ensure that, to the extent permitted by law, the actions carried out, authorized, or funded by Federal agencies will not negatively impact or degrade coral reef ecosystems. The ROI for coastal resources includes the recovery zone positioned between approximately 15 to 140 nautical miles off the Gulf of Mexico coastline from southern Texas to southern Florida (Exhibit 1).

3.7.1 Description

The Gulf of Mexico is located at the southeastern corner of North America and is bordered by Florida, Alabama, Mississippi, Louisiana, and Texas. The Gulf measures approximately 864 nautical miles from east to west, 486 nautical miles from north to south, and has a surface area of 580,000 square miles. If bays and other inland waters are included, the total shoreline increases to over 14,580 nautical miles in the U.S. alone (Moretzohn et al. 2016).

3.7.2 Fisheries

Gulf fisheries are some of the most productive in the world. In 2000, the commercial fish and shellfish harvest from the five U.S. Gulf states was estimated to be 1.7 billion pounds, which represents almost one-fifth (19.4 percent) of the total domestic landings in the United States (O’Bannon 2001). In the same year, commercial catches in the Gulf represented approximately 25 percent of the total U.S. domestic commercial fishing revenue and were valued at over 900 million dollars (O'Bannon 2001). The Gulf also supports a productive recreational fishery. Excluding Texas, U.S. Gulf states accounted for over 40 percent (>104,000 pounds) of the U.S. recreational finfish harvest in 2000 (O'Bannon 2001).

3.7.3 Physical / Mineral

The U.S. economy relies heavily on the ports in the Gulf of Mexico region for the import and export of both foreign and domestic goods (NOAA 2012). All ports are shown in Exhibit 1. The Gulf of Mexico region supports several ports that lead the Nation in total commerce and provides 68 percent of the total U.S. tonnage (USACE 2010).

The Gulf of Mexico holds the largest volume of undiscovered technically recoverable resources on the outer continental shelf. Technically recoverable resources are defined as resources existing in accumulations of sufficient size to be amenable to the application of existing recovery technology (USGS 1995). The Central Gulf of Mexico is estimated to hold close to 31 billion barrels of oil and 134 trillion cubic feet of natural gas that are currently undiscovered and technically recoverable (USDOI 2012a). Gulf of Mexico federal offshore oil production accounts for 17 percent of total U.S. crude oil production and federal offshore natural gas production in the Gulf accounts for 5 percent of total U.S. dry production (USEIS 2016). In FY 2010, oil and gas production from offshore areas supported more than 642,000 American jobs (USDOI 2012b).

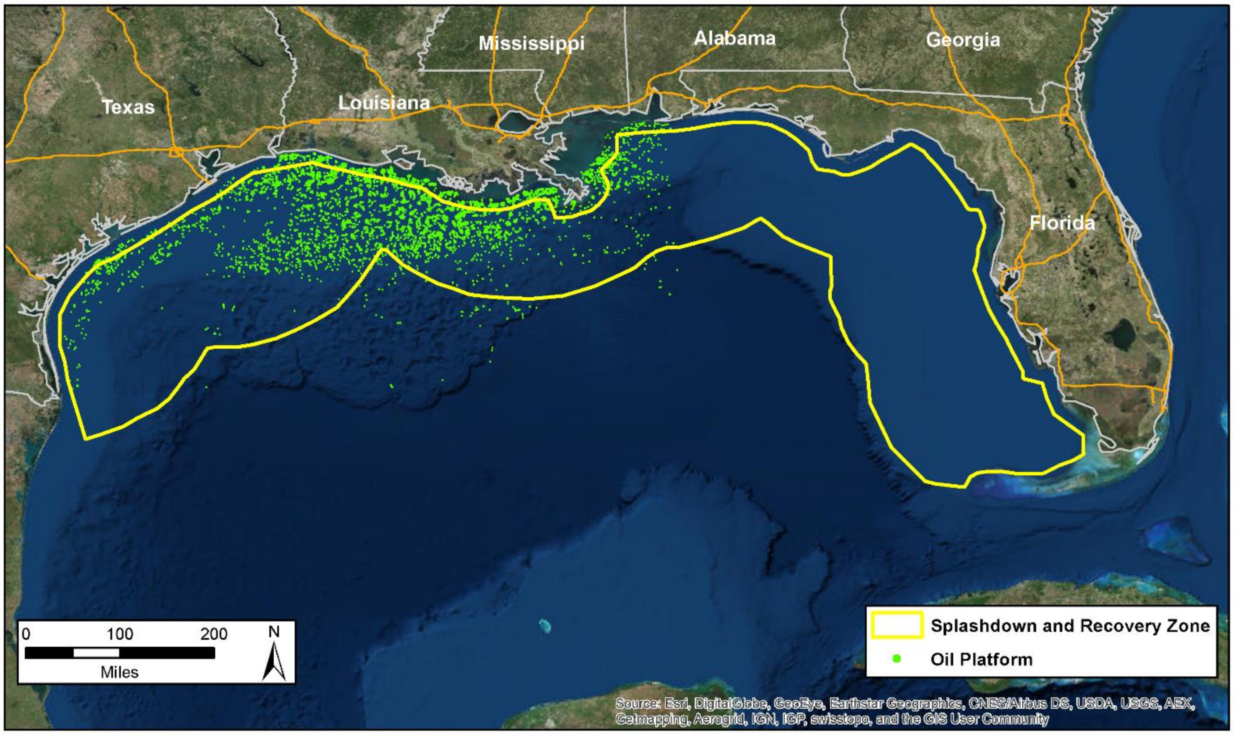
3.8 Water Resources (Ocean Waters)

The ROI for ocean waters is the recovery zone positioned between approximately 15 to 140 nautical miles off the Gulf of Mexico coastline from southern Texas to southern Florida (Exhibit 1). Ocean waters within the ROI include offshore, high salinity waters that are defined by prevailing currents. Water quality in ocean waters may be characterized by temperature, salinity, dissolved oxygen, and nutrient levels. Two water quality issues that are of particular concern in the Gulf of Mexico include hypoxia and oil spills from exploration and extraction activities. Waters in the northern Gulf of Mexico have significant, seasonal occurrences of low dissolved oxygen, or hypoxia. This hypoxia is caused in part by nutrient input from the Mississippi River watershed, as well as salinity stratification of oceanic waters, which reduces the mixing of bottom waters (NOAA 2013a).

3.9 Natural Resources and Energy Supply

As an impact category, natural resources and energy supply provides an evaluation of a project's consumption of natural resources and use of energy supplies. The FAA has not established a significance threshold for natural resources and energy supply. The FAA 1050.1F Desk Reference emphasizes that it is the policy of the FAA to encourage the development of facilities that exemplify the highest standards of design, including principles of sustainability.

The ROI for natural resources and energy supply is the recovery zone positioned between approximately 15 to 140 nautical miles off the Gulf of Mexico coastline from southern Texas to southern Florida (Exhibit 1). The only permanent developments found in the waters of the Gulf of Mexico near the coast are oil platforms. As seen in Exhibit 4, there are several thousand oil platforms along the Gulf coast (BOEM 2016).



Source: BOEM 2016.

Exhibit 5: Oil Well Platforms.

3.10 Hazardous Materials, Solid Waste, and Pollution Prevention

Analysis of the presence, handling, storage, and disposal of hazardous materials, hazardous waste, and solid waste includes an evaluation of potential hazardous materials that could be transported and used during reentry, splashdown, and recovery operations; and applicable pollution prevention strategies.

The handling and disposal of hazardous materials, chemicals, substances, and wastes are governed at various levels ranging from the federal level to the local level. The two federal statutes of most importance to the FAA are the Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 and the Community Environmental Response Facilitation Act of 1992. RCRA governs the generation, treatment, storage, and disposal of hazardous wastes. CERCLA provides for consultation with natural resources trustees and cleanup of any release of a hazardous substance (excluding petroleum) into the environment. The Federal Hazardous Materials Regulations are contained in 49 CFR parts 171 through 180.

The ROI for hazardous materials, pollution prevention, and solid waste is the Gulf of Mexico, the Port of Canaveral and CCAFS wharf facilities, that could be affected by the materials transported, stored, and used; waste generated; or spills/releases that may occur as a result of implementing the Proposed Action.

Hazardous Materials and Waste

Routine operations at Port Canaveral or CCAFS-based wharf facilities, or a commercially available wharf on the Gulf Coast require use of a variety of hazardous materials, including petroleum, oil, and lubricant products, solvents, cleaning agents, paints, adhesives, and other products necessary to perform ship, ground vehicle, and equipment maintenance and repair.

Bulk quantities of fuel are managed in two petroleum tank farms totaling 5 million barrels in capacity. These storage locations and facilities represent potential sources of spills. Petroleum tanks and associated systems and operations at Port Canaveral are managed and permitted in accordance with federal and state regulations.

Dragon could contain up to 20 percent of the maximum propellant load (approximately 300 pounds) of MMH propellant when recovered. MMH is a strong irritant which may damage eyes and cause respiratory tract damage. Repeated exposure to lower concentrations may cause toxic damage to liver and kidneys as well as anemia. In addition, the EPA classifies MMH as a probable human carcinogen. MMH is also flammable and could spontaneously ignite when exposed to an oxidizer.

Operation and maintenance of vessels, vehicles, and equipment used for Dragon recovery operations would generate small quantities of hazardous wastes. These wastes would include, at a minimum, empty containers, spent solvents, waste oil, spill cleanup materials (if used), and lead-acid batteries.

The International Convention for the Prevention of Pollution from Ships (MARPOL) is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes and was adopted at the International Maritime Organization on November 2, 1973. The Convention includes regulations aimed at preventing and minimizing pollution from ships, both accidental pollution and that from routine operations, and currently includes six technical Annexes. Special Areas with strict controls on operational discharges are included in most Annexes. Annex I covers prevention of pollution by oil from operational measures as well as from accidental discharges. Annex II details the discharge criteria and measures for the control of pollution by noxious liquid substances carried in bulk. Annex III contains general requirements for the issuing of detailed standards on packing, marking, labelling, documentation, stowage, quantity limitations, exceptions, and notifications. Annex IV contains requirements to control pollution of the sea by sewage. Annex V deals with different types of garbage and specifies the distances from land and the manner in which they may be disposed of. Annex VI sets limits on sulphur oxide and nitrogen oxide emissions from ship exhausts and prohibits deliberate emissions of ozone depleting substances.

Large commercial vessels routinely discharge ballast water, gray and black water, bilge water, and deck runoff consistent with applicable international and national standards. Discharges of sewage (also known as black water) and gray water, which is the effluent generated from wash basins and showers on board ships, are regulated under MARPOL Annex IV. Discharges of black water are prohibited except for specific conditions stipulated under the Annex. In addition to the international standards established under MARPOL Annex IV, the U.S. regulates vessel discharges of sewage, gray water, bilge water, and a variety of other vessel discharges through the EPA's Clean Water Act National Pollutant Discharge Elimination System (NPDES) Program.

Pollution Prevention

Canaveral Port Authority has conducted a voluntary water quality monitoring program since 1992, regularly analyzing water samples from six stations in the Harbor and five stations in the Barge Canal. This enables the identification of short-term fluctuations and long-term trends in water quality. Water is regularly sampled from Port stormwater outfalls. Efforts to decrease contaminants include sweeping piers after cargo operations, cleaning pipes, installing stormwater treatment boxes and educating tenants on managing potential pollutants.

All new construction projects at Port Canaveral include stormwater retention systems. In addition, the existing stormwater system has been retrofitted to redirect millions of gallons of run-off away from the Banana River, where it could possibly reduce salinity and compromise plant and sea life health, to retention ponds.

The Port also monitors water quality along the beaches south of the Port. In 2005, a study funded by the Port Authority and Brevard County and carried out by the National Oceanic and Atmospheric Administration (NOAA) concluded there was no evidence of a water quality problem in the form of elevated bacteria or nutrient levels along these beaches. However, to increase available data and maintain water quality, additional monitoring stations have been added (Port Canaveral 2016).

In October 2000, the EPA authorized the Florida Department of Environmental Protection to implement the NPDES stormwater permitting program in Florida. This program regulates point source discharges of stormwater into surface waters from municipal facilities, and from industrial and construction activities.

The NPDES permit requires that the City of Cape Canaveral (City) develop/implement strategies for reducing pollutants in stormwater runoff; thereby, improving overall water quality.

The primary method of attaining these goals is through the implementation of Best Management Practices, which include:

- Public Education: Requires the City educate the public concerning stormwater issues;
- Public Involvement/ Participation: Requires the City involve the public in the stormwater management process;
- Illicit Discharges: Requires the City implement a monitoring and enforcement program to identify and eliminate illicit discharges to the storm sewer system;
- Runoff Control – Construction Sites: Requires the City monitor and enforce regulations limiting the amount of stormwater runoff from active construction sites;
- Runoff Control – Post-Construction: Requires the City continue to monitor and enforce regulations limiting the amount of stormwater runoff from completed construction projects; and
- Pollution Prevention: Requires the City monitor and enforce regulations concerning the illegal discharge of pollutants to the storm sewer system.

The City maintains a NPDES permit and continually implements the six required Best Management Practices. To assist in implementation, as well as funding of stormwater improvement projects, a Stormwater Utility was established by the City Council in 2003.

The Stormwater Utility ensures that dedicated funding is available for:

- the management of stormwater runoff; and
- the performance of facility maintenance of the storm sewer system (City of Cape Canaveral 2016a).

Solid Waste

The City of Cape Canaveral's garbage/recycling fees are billed through the City of Cocoa. Waste Pro, Inc. provides solid waste collection under franchise agreement with the City (City of Cape Canaveral 2016b). Solid waste generated in Brevard County is disposed of at the Central Disposal Facility is located on Adamson Road in Cocoa. The property was first used for solid waste disposal in the 1960's. Since then, the County has continued to make improvements operationally and environmentally (Brevard County 2017).

4.0 ENVIRONMENTAL CONSEQUENCES

Both Dragon-1 and Dragon-2 will be launched as payloads on Falcon 9. The environmental impacts of Falcon 9 launches at CCAFS and KSC were analyzed in the 2007 USAF EA, 2013 USAF Supplemental EA, and 2013 NASA EA. Those EAs have been adopted by the FAA and are incorporated by reference in this EA. Therefore, the scope of operations analyzed in this EA is limited to the reentry and splashdown of the Dragon in the Gulf of Mexico, as well as associated Dragon post-landing safing and transport operations.

This chapter presents an analysis of the potential impacts to the environment that could result from implementation of the Proposed Action. To evaluate potential impacts, the analyses presented in this chapter compares the Proposed Action described in Chapter 2 with the No Action Alternative for each environmental resource area presented in Chapter 3. Both direct and indirect impacts of Dragon landing operations are considered in this EA.

The analysis in this chapter considers the FAA's significance thresholds presented in Exhibit 4-1 of FAA Order 1050.1F, as well as the guidance found in the 1050.1F Desk Reference which includes a description of how to analyze impacts for each environmental impact category.

4.1 Air Quality

Potential impacts to air quality could result from the proposed operations of up to six recovery events of Dragon. As stated in Exhibit 4-1 of FAA Order 1050.1F, significant air quality impacts would occur if, "The action would cause pollutant concentrations to exceed one or more of the National Ambient Air Quality Standards (NAAQS), as established by the Environmental Protection Agency under the Clean Air Act, for any of the time periods analyzed, or to increase the frequency or severity of any such existing violations." For most of the United States, the territorial seas extend 12 nautical miles from the coast. For the southern coasts of Alabama, Mississippi and Louisiana, the territorial seas extend 3 nautical miles into the Gulf of Mexico. For Gulf of Mexico coastlines of Texas and Florida, as well as Puerto Rico, the territorial seas extend 9 nautical miles from the coast. Beyond these areas, the Clean Air Act and NEPA do not apply. Air pollutant emissions outside U.S. territorial seas are calculated in the same manner as emissions over territorial waters. These emissions are evaluated under Executive Order 12114, Environmental effects abroad of major Federal actions, as the Clean Air Act does not apply to actions outside of the United States.

4.1.1 Proposed Action

Recovery efforts under the Proposed Action would consist of the use of one 160-foot recovery vessel equipped with a helideck and six RHIB to track down, collect, and transport Dragon to shore and potentially six parachute recovery teams. SpaceX anticipates up to six Gulf of Mexico recovery operations per year that would originate from Port Canaveral, a CCAFS-based wharf facility, or a commercially available wharf on the Gulf Coast and traveling no more than a 2,000 nautical-mile roundtrip.

Emissions associated with the combustion of diesel fuel being consumed by the recovery vessels would have the potential to affect air quality. The primary combustion products of the diesel fuel would be nitrogen (N_2), oxygen (O_2), carbon dioxide (CO_2), water vapor, and pollutant emissions. Common pollutants contained in these emissions would include unburned hydrocarbons, carbon monoxide (CO), nitrogen oxides (NOx), and particulate matter (PM). For this analysis, it was assumed that up to eight RHIB would be deployed from the salvage vessel for Dragon and parachute recovery. The salvage vessel is assumed to be a modern, fuel efficient, dynamic positioning, multi-role construction/intervention vessel similar to the Havila Harmony (MarineTraffic 2018).

Emissions associated with Dragon reentry would be generated by the combustion of the NTO/MMH propellant during the reentry burn but these emissions would occur at elevations well above the 3,000-foot AGL boundary layer and would have no impact on ground level ambient air quality. The combustion of fuel by the helicopter that would potentially transport crew and time critical cargo to Port Canaveral or the closest airport is a source of emissions that would operate below the boundary layer for most or all of its operation time. Any fuel payloads remaining in Dragon would remain in the fuel storage containers until they can be safely transferred and stored.

The use of a helicopter up to six times a year would generate minimal pollutant emissions. Information on the emission factors for the H-47 Chinook, which uses two turboshaft engines of similar horsepower as the ones used on the Erickson S-64E, were used to estimate the helicopter emissions. Helicopter operations include taking off from the recovery vessel, airborne visual monitoring during parachute recovery, and transfer of any crew and critical cargo to the closest airport, which would not exceed 150 miles. For the emissions analysis, it was assumed that the helicopter would operate below 3,000 feet AGL, which is the vertical threshold for assessing ground-level pollutant impacts. Two take-off and landing operations are conservatively assumed per operation; one for the parachute recovery exercise, and one for the transfer of crew and cargo to the nearest airport. The total annual operational emissions, which include the helicopter and recovery vessel operations, are presented in Table 4.1-2. The total annual operation emissions are compared to the General Conformity Rule basic de minimis thresholds, which are 100 tons per year for each of the pollutants. While the General Conformity Rule does not apply because there are no potential impacts in a non-attainment or maintenance area, these values are useful for assessing the scale of the operational emissions. All of the emissions are well below the General Conformity Rule de minimis thresholds, and would therefore be expected to have little or no impact on regional air quality. Additionally, most of the emissions would occur substantially offshore, beyond state boundaries where attainment status is unclassified and the National Ambient Air Quality Standards do not apply.

Table 4.1-2. Estimated Annual Operation Emissions in Tons per Year Compared to Brevard County Emission Inventory

Emissions	***Volatile Organic Compounds***	***Nitrogen Oxides***	***Carbon Monoxide***	***Sulfur Dioxide***	***PM_{10}***	***$PM_{2.5}$***
Helicopter	0.16	0.55	0.45	0.19	0.19	0.19
Boat Operations	1.52	54.48	9.30	0.04	1.47	1.42
Total Annual Operational	1.68	55.03	9.75	0.23	1.66	1.61
GCR de minimis thresholds*	100	100	100	100	100	100
Exceedance?	No	No	No	No	No	No

Table 4.1-2. Estimated Annual Operation Emissions in Tons per Year Compared to Brevard County Emission Inventory

Emissions	*Volatile Organic Compounds*	*Nitrogen Oxides*	*Carbon Monoxide*	*Sulfur Dioxide*	*PM_{10}*	*$PM_{2.5}$*

Source: * 40 CFR 93, Subpart B

Notes: PM_{10} = particulate matter less than or equal to 10 microns in diameter; $PM_{2.5}$ = fine particulate matter 2.5 microns or less in diameter.

The Port of Cape Canaveral, which is where vessels involved in the recovery mission would depart from and return to (note that off load may also occur at a CCAFS-based wharf facility or a commercially available wharf on the Gulf Coast) offload Dragon, is located in Brevard County. Because this is the only known location with localized activities that would be covered under the Clean Air Act, all of the emissions from the operations have been conservatively compared to Brevard County's emission inventory to assess worst-case impacts. In reality, the emissions associated with the recovery missions would occur over a vast area that could include many portions of the Gulf of Mexico, depending on where the mission actually occurs, and including the vessel movements from the Port of Cape Canaveral to the Gulf of Mexico and return. Much if not all of the transport activity would be expected to occur outside of the U.S. territorial seas, but even when within the territorial seas, the emissions would be insignificant for any given locality that the recovery vessels might sail past.

Based on the infrequency and limited scale of the operations, emissions impacts from vessels engaged in SpaceX recovery operations six times per year would represent small percentages of the Brevard County emissions and would not cause an exceedance of any NAAQS. The Proposed Action would therefore not have a significant impact on local or regional air quality.

4.1.2 No Action Alternative

Under the No Action Alternative, the FAA would not issue a reentry license to SpaceX for Dragon landings in in the Gulf of Mexico. Current activities within the Gulf of Mexico would continue and there would be no new effects to these activities as a result of the No Action Alternative.

4.2 Climate

The Proposed Action would involve limited mobile source fuel combustion occurring over a range of years, and as a result would generate small quantities of GHG emissions from these operations. As stated in Exhibit 4-1 of FAA Order 1050.1F, "The FAA has not established a significance threshold for Climate." In keeping with the FAA's Climate Guidance (FAA 2015), emissions were estimated for total carbon dioxide equivalents (CO2e) for annual operations, at 3,815 metric tons CO2e annually. There are no significance thresholds for aviation or commercial space launch GHG emissions, nor has the FAA identified specific factors to consider in making a significance determination for GHG emissions. There are currently no accepted methods of determining significance applicable to aviation or commercial space launch projects given the small percentage of emissions they contribute. There is a considerable amount of ongoing scientific research to improve understanding of global climate change and FAA guidance will evolve as the science matures or if new Federal requirements are established (FAA 2015).

4.2.1 Proposed Action

The Proposed Action would directly and indirectly generate small increases in GHG emissions to the atmosphere as a result of vessel and helicopter activities. The Proposed Action, which involves limited mobile source activities on an annual basis, would incrementally contribute to global emissions, but are not themselves of such magnitude as to make a direct correlation with climate change. The primary combustion products of the propellants MMH and NTO used in the Dragon propellant system are nitrogen gas and water (Stuetzer 2013, Haas 1984); therefore, there are no significant criteria pollutants or GHG emissions associated with the operation of this system.

4.2.2 No Action Alternative

Under the No Action Alternative, the FAA would not issue a reentry license to SpaceX for Dragon landings in in the Gulf of Mexico. The No Action Alternative would not result in the additional emission of any GHG emissions.

4.3 Noise and Noise-Compatible Land Use

Noise impact criteria are based on land use compatibility guidelines and on factors related to the duration and magnitude of noise level changes. Annoyance effects are the primary consideration for most noise impact assessments on humans. Noise impacts on wildlife are discussed in Section 4.6, Biological Resources. As stated in Exhibit 4-1 of FAA Order 1050.1F, a significant impact would occur if, "The action would increase noise by DNL 1.5 dB or more for a noise sensitive area that is exposed to noise at or above the DNL 65 dB noise exposure level, or that will be exposed at or above the DNL 65 dB level due to a DNL 1.5 dB or greater increase, when compared to the no action alternative for the same timeframe."

4.3.1 Proposed Action

Under the Proposed Action, potential noise impacts could occur from proposed reentry and recovery operations of Dragon. Significant impacts to noise would occur if the Proposed Action would increase noise by DNL 1.5 dB or more for a noise sensitive area that is exposed to noise at or above the DNL 65 dB noise exposure level, or that will be exposed at or above the DNL 65dB level due to a DNL 1.5dB or greater increase, when compared to the no action alternative for the same timeframe. There are other Federal agency noise standards that pertain to hearing conservation (e.g., those established by the NIOSH and OSHA). Activities conducted under the Proposed Action would be in compliance with these standards.

The noise analysis assumes a proposed maximum of six reentries, splashdowns, and recovery operations of Dragon. Under the Proposed Action, there would be no Dragon engine noise during reentry/splashdown as the spacecraft would be under parachutes. The only noise associated with the Proposed Action includes noise that regularly occurs in the region from both ship and helicopter engines during the recovery efforts. The noise from helicopters and ships associated with Dragon recovery efforts would be indistinguishable from helicopter and ship noise already occurring regularly in the area. This noise source has not been quantified for this Proposed Action, but is rather discussed qualitatively for purposes of this analysis. The anticipated noise from both sources are considered relatively low, short-term and infrequent. Both noise sources are consistent with current Gulf of Mexico land use which includes heavy helicopter traffic associated with the oil and gas industry and vessel engine noise associated with common maritime operations. No significant impacts from vessel and helicopter activity is therefore anticipated as a result of the Proposed Action.

A sonic boom may be generated during Dragon reentry. It would most likely only impact the ocean's surface. A portion of the gulf coast of Texas, Louisiana, Mississippi, Alabama or Florida could experience the boom, depending on the location of the landing site. There would be a maximum of six sonic booms per year and each boom would occur in a different location. Given the size of the splashdown and recovery zone, it is unlikely one location would be exposed to more than one boom per year. SpaceX conducted a sonic boom analysis for Dragon landings at CCAFS using PCBOOM, which is an FAA-approved model (BRRC 2015; see Appendix C). Based on the analysis and the fact that the reentry trajectories (Mach, altitude, and angle-of-attack profiles) are the same between sites, an overpressure of 0.4 pound per square foot (psf) could be expected approximately 19 miles from the landing site and 0.35 psf approximately 50 miles from the landing site. Therefore, because it is possible for Dragon to land approximately 50 miles from the coast, overpressures could impact land and oil platforms. However, it would be at an overpressure of approximately 0.4 psf. For comparison, an overpressure of 1 psf is similar to a clap of thunder. No structural damage would occur. The PCBOOM results (BRRC 2015) show the maximum sonic boom generated during Dragon reentry at CCAFS would be less than 40 DNL. Therefore, sonic booms generated during Dragon reentry would not result in significant noise impacts.

The effects of the sonic boom generated during Dragon reentry on Gulf waters would most likely occur on the surface of those waters. Due to the low magnitude of the boom and the significant attenuation of a sonic boom at the air/water interface, coupled with exponential attenuation with water depth, the sonic boom would not affect terrestrial or marine species, including marine mammals. No significant impacts from noise are therefore anticipated as a result of the Proposed Action.

4.3.2 No Action Alternative

Under the No Action Alternative, the FAA would not issue a reentry license to SpaceX for Dragon landings in in the Gulf of Mexico. Under the No Action alternative, current activities within the Gulf of Mexico would continue. There would be no new noise and compatible land use related effects as a result of the No Action Alternative.

4.4 Department of Transportation: Section 4(f)

4.4.1 Proposed Action

As stated in Exhibit 4-1 of FAA Order 1050.1F, a significant impact would occur if, "The action involves more than a minimal physical use of a Section 4(f) resource or constitutes a "constructive use" based on an FAA determination that the aviation project would substantially impair the Section 4(f) resource. Resources that are protected by Section 4(f) are publicly owned land from a public park, recreation area, or wildlife and waterfowl refuge of national, state, or local significance; and publicly or privately owned land from an historic site of national, state, or local significance. Substantial impairment occurs when the activities, features, or attributes of the resource that contribute to its significance or enjoyment are substantially diminished."

Depending on the location of the landing site, some NWRs have the potential to experience noise from sonic booms during reentry. As noted in the Section 4.3.1, these booms would be similar to a clap of thunder and last less than a seconds. There would be a maximum of six sonic booms per year and each boom would occur in a different location. Given the size of the splashdown and recovery zone, it is unlikely one location would be exposed to more than one boom per year. Therefore, the noise from sonic booms would not substantially affect the significance of the Section 4(f) resources in the NWR System as a result of the Proposed Action.

The proposed reentry, splashdown, and recovery zone encompasses the Flower Garden Banks National Marine Sanctuary, but as stated in Section 2.0, the Dragon spacecraft is able to land in a precise pre-determined area. Therefore, the spacecraft would not land in the area of the sanctuary and there would be no physical use, direct taking, or temporary occupancy of property belonging to the sanctuary as a result of the Proposed Action.

The Proposed Action would not result in the physical use, direct taking, or temporary occupancy of any Section 4(f) property. Constructive use of Section 4(f) properties would occur if proposed operations increased noise levels significantly and introduced visual elements that would significantly alter the use, character, or substantially impair the value of historic properties. Based on the analysis above, sonic booms would not result in a constructive use of any Section 4(f) property. Therefore, the Proposed Action would not result in significant impacts on Section 4(f) properties.

4.4.2 No Action Alternative

Under the No Action Alternative, the FAA would not issue a reentry license to SpaceX for Drago landings in in the Gulf of Mexico. Under the No Action alternative, current activities within the Gulf of Mexico would continue. There would be no use of Section 4(f) properties as a result of the No Action Alternative.

4.5 Biological Resources (Marine Wildlife)

As stated in Exhibit 4-1 of FAA Order 1050.1F, an impact would be significant if “[t]he U.S. Fish and Wildlife Service or the National Marine Fisheries Service determines that the action would be likely to jeopardize the continued existence of a federally listed threatened or endangered species, or would result in the destruction or adverse modification of federally designated critical habitat.” The FAA has not established a significance threshold for non-listed species.

Any action that may affect federally listed species or their critical habitats requires consultation with the USFWS and/or NMFS under Section 7 of the ESA of 1973 (as amended). Also, the MMPA of 1972 prohibits the taking of marine mammals, including harassing them, and may require consultation with NMFS. Under the Magnuson-Stevens Fishery Conservation Management Act, the FAA must consult with NMFS if the action may adversely affect EFH.

4.5.1 Proposed Action

After reentry, Dragon would splashdown in the Gulf of Mexico. The spacecraft would be recovered by a pre-positioned recovery vessel, and SpaceX would attempt to recover all parachutes. The recovered spacecraft would be returned to a commercially available wharf on the Gulf Coast, Port Canaveral, or a CCAFS-based wharf facility.

As discussed in Section 4.3, the sonic boom generated during Dragon reentry would most likely only impact the ocean’s surface. A portion of the gulf coast of Texas, Louisiana, Mississippi, Alabama, or Florida could experience the boom, depending on the location of the landing site. An overpressure of

0.41 pound per square foot (psf) could be expected approximately 19 miles from the splashdown site and 0.35 psf approximately 50 miles from the splashdown site. Due to the low magnitude of the boom, and the significant attenuation of a sonic boom at the air/water interface, coupled with exponential attenuation with water depth, the sonic boom would not affect marine species beneath the water's surface. Similarly, if the boom impacted land, no effects to terrestrial species, including federally listed species, are expected, as the noise level would be similar to the noise generated during a thunder clap.

Dragon would carry hypergolic propellants (i.e., MMH fuel and NTO oxidizer), which are toxic to marine organisms. Dragon propellant storage is designed to retain residual propellant, so any propellant remaining in Dragon is not expected to be released into the ocean. It is therefore extremely unlikely that a propellant leak would occur, but regardless, two potential scenarios are considered:

- The spacecraft survives to strike the water essentially intact, whereupon the residual propellant tanks rupture, releasing liquid propellants into surface waters.
- The spacecraft survives water impact without tank rupture and sinks to the bottom, but leaks residual propellant into the water over time.

NTO almost immediately forms nitric and nitrous acid on contact with water, and would be quickly diluted and buffered by seawater; hence, it would offer negligible potential for harm to marine life (TOXNET 2010). Hydrazine fuels are highly reactive and oxidize quickly forming amines and amino acids, which are beneficial nutrients to small marine organisms. Prior to oxidation, there is some potential for acute exposure of marine life to toxic levels which could potentially be lethal; however, the risk of such exposure is negligible due to the limited area and time. The half-life for hydrazine is approximately 14 days based on its unacclimated aqueous biodegradation half-life (Howard et al. 1991).

In addition, given the planned infrequency of Dragon's reentry, splashdown, and recovery operations in the Gulf of Mexico (i.e., six times per year), and the fact that marine species spend the majority of their time submerged as opposed to on the surface, it is extremely unlikely that any marine species, including marine mammals and sea turtles, would be affected (e.g., struck) by a Dragon splashdown and recovery operations. The spacecraft would remain on the surface throughout splashdown and recovery operations. Potential entanglement of marine species or ingestion of material would be avoided due to the recovery of all parachutes associated with the spacecraft (see Section 2.1.3). However, in the case of poor sea/weather conditions, it is possible not all parachutes are recovered. In this case, the unrecovered parachute(s) presents a potential hazard/stressor (entanglement or ingestion) for marine species, especially marine mammals and sea turtles. However, the primary material in the parachutes is nylon which is not easily degraded into small digestible components. For this reason and because the parachutes are expected to sink rapidly, parachutes are unlikely to be digested by marine species.

Pursuant to ESA Section 7, the FAA and NASA consulted with NMFS in April 2016 regarding potential impacts to federally listed marine species that could be affected by spacecraft and launch vehicle landing and splashdowns in the Atlantic Ocean and Gulf of Mexico. Federally listed species covered under this consultation included the green, Kemp's ridley, leatherback, hawksbill, and loggerhead sea turtles; smalltooth sawfish; Gulf sturgeon; shortnose sturgeon; Atlantic sturgeon; and North Atlantic right, blue, fin, humpback, sei, and sperm whales. The consultation also included critical habitat for the North Atlantic right whale and loggerhead sea turtle. The consultation covered all open-water landings occurring from launches originating at Kennedy Space Center, Cape Canaveral Air Force Station, and

SpaceX Texas Launch Site[2]. In their letter issued on August 8, 2016 (see Appendix B), NMFS concluded all potential effects of open-water landings/splashdowns to listed species and critical habitat to be discountable or insignificant, and concurred with the FAA's and NASA's determination that the action analyzed in the consultation is not likely to adversely affect ESA-listed species and critical habitat. The letter specified protective measures that are necessary to avoid or minimize potential effects to ESA-listed species and critical habitat as well as other marine mammals protected by the MMPA. SpaceX would implement those measures during Dragon recovery operations.

The 2016 ESA consultation with NMFS assumed all parachutes would be recovered and did not include an assessment of sonic booms impacting the water's surface. Because there is the chance of one or more parachutes would not be recovered, the FAA conducted additional ESA consultation with NMFS in 2017. This consultation included an assessment of sonic booms. In a letter dated October 2, 2017, NMFS concurred with the FAA's determination that the SpaceX Landing and Recovery Operations in the Atlantic Ocean, Pacific Ocean, and Gulf of Mexico are not likely to adversely affect threatened and endangered species or adversely modify designated critical habitat (see Appendix B).

Note that manatees are a common occurrence at the Port of Canaveral and CCAFS wharfs. In order to ensure proper protection, all work would be halted when manatees are within 50 feet of operations and vessels would be operated at idle speed.

In summary, NMFS determined the Proposed Action would not jeopardize the continued existence of a federally listed threatened or endangered species, and would not result in the destruction or adverse modification of federally designated critical habitat. There would be no effects to ESA-listed species under USFWS jurisdiction. The Proposed Action would not adversely affect marine mammals and would not affect populations of non-listed species. Therefore, the Proposed Action would not significantly impact biological resources.

4.5.2 No Action Alternative

Under the No Action Alternative, the FAA would not issue a reentry license to SpaceX for Dragon landings in in the Gulf of Mexico. Under the No Action alternative, current activities within the Gulf of Mexico would continue. There would be no new effects on biological resources as a result of the No Action Alternative.

4.6 Coastal Resources

As stated in Exhibit 4-1 of FAA Order 1050.1F, "The FAA has not established a significance threshold for Coastal Resources." However, the FAA has identified factors to consider when evaluating the context and intensity of potential environmental impacts on coastal resources. Please note that these factors are not intended to be thresholds. If these factors exist, there is not necessarily a significant impact; rather, the FAA must evaluate these factors in light of context and intensity to determine if there are significant impacts (FAA 2015).

[2] This EA does not include impacts from Dragon landings in the Gulf of Mexico from missions originating at SpaceX's Texas Launch Site.

Relevant factors to consider for this Proposed Action that may be applicable to coastal resources include, but are not limited to, situations in which the proposed action or alternative(s) would have the potential to:

- Pose an impact to coral reef ecosystems (and the degree to which the ecosystem would be affected);
- Cause an unacceptable risk to human safety or property; or
- Cause adverse impacts to the coastal environment that cannot be satisfactorily mitigated.

4.6.1 Proposed Action

The Proposed Action does not include any coastal construction or seafloor disturbing activities, and would be consistent with commonly occurring Gulf of Mexico maritime operations. Dragon landing operations and recovery activities would occur in deeper waters at least 15 nautical miles off the Gulf Coast, and the recovery vessel would remain in deep waters during the transport of the recovered Dragon to Port Canaveral, a CCAFS-based wharf facility, or a commercially available wharf on the Gulf Coast. Landing and recovery operations would not take place in intertidal areas, salt marshes, estuaries, and coral reefs. Potential noise impacts on wildlife are discussed in Section 4.5 Biological Resources. Dragon is designed to conduct precision landings and National Marine Sanctuaries and NWRs in the Gulf of Mexico would be avoided as discussed in Section 4.4.1. Any coral reefs occurring in the ROI will be avoided during planning of the landing location for each Dragon mission and operations. The Proposed Action is not expected to have a significant impact on coastal resources.

4.6.2 No Action Alternative

Under the No Action Alternative, the FAA would not issue a reentry license to SpaceX for Dragon landings in in the Gulf of Mexico. Under the No Action alternative, current activities within the Gulf of Mexico would continue. There would be no new effects on coastal resources as a result of the No Action Alternative.

4.7 Water Resources (Ocean Waters)

As stated in Exhibit 4-1 of FAA Order 1050.1F, a significant impact to surface waters would occur if, “The action would:

1. Exceed water quality standards established by Federal, state, local, and tribal regulatory agencies; or
2. Contaminate public drinking water supply such that public health may be adversely affected.”

Several aspects of the Proposed Action are potential sources of water quality pollutants. Dragon landing operations along with recovery vessel and RHIB activities are evaluated for the possible release of contaminants and hazardous constituents into ocean waters. A full discussion of hazardous materials, solid waste, and pollution prevention is presented in Sections 3.11 and 4.10.

The 5.4 nautical mile-radius splashdown zone for Dragon landings would be sited to avoid oil and gas drilling and production areas. Also, Dragon has been designed to perform precision landings within the splashdown zone. As a result, landing operations are not expected to cause oil spills in Gulf waters from reentry collisions with oil and gas exploration/extraction structures.

4.7.1 Proposed Action

Dragon's propellant storage is designed to retain residual propellant, so any propellant remaining in the spacecraft is not expected to be released into ocean waters. The spacecraft has multiple system redundancies in place in the event it is damaged upon reentry and/or splashdown that help to prevent unanticipated releases. If any propellant were to be released, it would rapidly disperse and does not represent a source of substantial environmental degradation to water quality.

Recovery vessel and RHIB operations have the potential to release small amounts of oil and gas into the water. However, vessel operations would be conducted in accordance with the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78), which prohibits certain discharges of oil, garbage, and other substances from vessels. The Proposed Action is therefore not expected to have a significant impact on ocean water resources.

4.7.2 No Action Alternative

Under the No Action Alternative, the FAA would not issue a reentry license to SpaceX for Dragon landings in the Gulf of Mexico. Under the No Action alternative, current activities within the Gulf of Mexico would continue. There would be no new effects on water resources as a result of the No Action Alternative.

4.8 Natural Resources and Energy Supply

As stated in Exhibit 4-1 of FAA Order 1050.1F, "The FAA has not established a significance threshold for Natural Resources and Energy Supply." However, the FAA has identified a factor to consider when evaluating the context and intensity of potential environmental impacts for natural resources and energy supply. Please note that this factor is not intended to be a threshold. If this factor exists, there is not necessarily a significant impact. This factor includes, but is not limited to, situations in which the proposed action or alternative(s) would have the potential to cause demand to exceed available or future supplies of these resources (FAA 2015).

4.8.1 Proposed Action

Recovery operations would require the use of fuel for the recovery vessel, RHIB and helicopter. Reentry operations would require the use of hypergolic fuels for deorbit. The demand for both types of fuel would be met without difficulty. The Proposed Action is not expected to significantly increase demand or use of natural resources and energy supply.

4.8.2 No Action Alternative

Under the No Action Alternative, the FAA would not issue a reentry license to SpaceX for Dragon landings in in the Gulf of Mexico. Under the No Action alternative, current activities within the Gulf of Mexico would continue. There would be no new effects on natural resources and energy supply as a result of the No Action Alternative.

4.9 Hazardous Materials, Solid Waste, and Pollution Prevention

As stated in Exhibit 4-1 of FAA Order 1050.1F, "The FAA has not established a significance threshold for Hazardous Materials, Solid Waste, and Pollution Prevention." However, the FAA has identified factors to consider in evaluating the context and intensity of potential environmental impacts for hazardous materials, solid waste, or pollution prevention. Please note that these factors are not intended to be thresholds. If these factors exist, there is not necessarily a significant impact; rather, the FAA must evaluate these factors in light of context and intensity to determine if there are significant impacts (FAA 2015). Factors to consider that may be applicable to hazardous materials, solid waste, and pollution prevention include, but are not limited to, situations in which the proposed action or alternative(s) would have the potential to:

- Violate applicable Federal, state, tribal, or local laws or regulations regarding hazardous materials and/or solid waste management;
- Involve a contaminated site (including, but not limited to, a site listed on the National Priorities List). Contaminated sites may encompass relatively large areas. However, not all of the grounds within the boundaries of a contaminated site are contaminated, which leaves space for siting a facility on non-contaminated land within the boundaries of a contaminated site. An Environmental Impact Statement (EIS) is not necessarily required. Paragraph 6-2.3.a of FAA Order 1050.1F allows for mitigating impacts below significant levels (e.g., modifying an action to site it on non-contaminated grounds within a contaminated site). Therefore, if appropriately mitigated, actions within the boundaries of a contaminated site would not have significant impacts;
- Produce an appreciably different quantity or type of hazardous waste;
- Generate an appreciably different quantity or type of solid waste or use a different method of collection or disposal and/or would exceed local capacity; or
- Adversely affect human health and the environment

4.9.1 Proposed Action

Hazardous Materials and Wastes

As described in the 2007 EA, SpaceX would be responsible for identifying, containing, labeling, and accumulating the hazardous wastes in accordance with all applicable federal, state, and local regulations. It is not anticipated that Proposed Action would increase hazardous waste production. Operations supporting the Dragon recovery operations could use a small amount of products containing hazardous materials, including petroleum, oil, and lubricant products, paints, solvents, oils, lubricants, acids, batteries, and chemicals. In particular, Dragon may contain approximately 20 percent of the maximum propellant load upon splashdown, including MMH. If human error (e.g., not following procedures, not wearing protective clothing, or not donning breathing equipment) occurs during Dragon recovery, exposure of personnel to toxic propellant vapors may result. This would give some level of short-term adverse health impact and an incremental increase in the chance of the exposed individual developing cancer. However, continued implementation of existing handling and management procedures for hazardous materials and hazardous wastes would limit the potential for impacts.

Management of hazardous materials is the responsibility of each individual or organization and is regulated under RCRA (40 CFR 260-280) and Rule 62-730. Hazardous materials and wastes would be handled in accordance with applicable federal, state, and local environmental and public and occupational health and safety regulations. Safeguards, including multiple system redundancies in case of damage upon reentry, are in place to minimize the release of toxic chemicals in the environment. SpaceX has developed emergency response plans to ensure accidental spills would be cleaned up quickly. No significant impacts from hazardous materials or hazardous waste management are anticipated.

Solid Waste

Solid wastes would be placed in covered receptacles until disposed of off-site to minimize accidental entry into marine waters or contact with stormwater and prevent offsite deposition from wind. Solid wastes would be salvaged or recycled to the maximum extent practicable and the remaining solid waste disposed of in appropriately permitted landfills. With the implementation of appropriate handling and management procedures, solid wastes generated as a result of recovery operations would have no significant impacts to the environment.

Pollution Prevention

Hazardous materials, substances and wastes used and generated as part of recovery operations would be collected, stored, and disposed of using practices that minimize the potential for accidental releases or contact with storm or marine water and in accordance with applicable spill prevention plans, RCRA and OSHA regulations. All accidental releases of polluting substance would be responded to quickly and appropriate clean up measures would be implemented in accordance with applicable laws to minimize impacts to the environment. Dragon has been designed to perform precise landings to avoid collisions with existing structures in the Gulf of Mexico and to avoid release of hazardous materials and pollutants. To avoid collision with marine vessels, to further ensure public and environmental safety, a NOTMAR would be issued 3-6 days prior to reentry, splashdown, and recovery efforts. As a result, recovery operations would have no significant impacts to the environment with regards to pollution.

4.9.2 No Action Alternative

Under the No Action Alternative, the FAA would not issue a reentry license to SpaceX for Dragon landings in in the Gulf of Mexico. Under the No Action alternative, current activities within the Gulf of Mexico would continue. There would be no new effects on hazardous materials, solid waste, and pollution prevention as a result of the No Action Alternative.

5.0 CUMULATIVE IMPACTS

Cumulative impacts are defined by the CEQ in 40 CFR § 1508.7 as: Impacts on the environment which result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions.

The CEQ regulations further require that NEPA environmental analyses address connected, cumulative, and similar actions in the same document (40 CFR § 1508.25). Additionally, the CEQ further explained in Considering Cumulative Effects Under the National Environmental Policy Act (CEQ 1997b) that “each resource, ecosystem and human community must be analyzed in terms of its ability to accommodate additional effects, based on its own time and space parameters.” Therefore, a cumulative effects analysis normally will encompass geographic boundaries beyond the immediate area of the Proposed Action, and include past, present, and reasonably foreseeable future actions, in order to capture these additional effects. Past, present, and reasonably foreseeable future actions within the Gulf of Mexico that have the potential to interact with the resources affected by the Proposed Action include:

- Continued oil and gas related platform activity (there are currently 3,858 active platforms along the Gulf coast) (NOAA 2013b).
- Maritime related activities including commercial fishing and transportation/shipping.
- Tourism activities – including beach recreation, sport/recreational fishing, and water sports.

In accordance with FAA Order 1050.1F, *Environmental Impacts: Policies and Procedures*, and the CEQ NEPA implementing regulations, the FAA analyzed the potential cumulative impacts. Based on the findings and potential impacts described, the cumulative impacts analysis focuses on air quality; climate; noise; water resources; natural resources and energy supply; and hazardous materials, solid waste, and pollution prevention. The FAA has determined that potential impacts to Section 4(f) resources; historic, architectural, archaeological, and cultural resources; biological resources; and coastal resources described in Chapter 4 would not occur or would not meaningfully interact with the potential effects of other past, present, and reasonably foreseeable future actions.

5.1 Air Quality

The operational emissions for the Proposed Action represent a negligible percentage of regional emissions and would not cause an exceedance of any NAAQS. Past, present, and reasonably foreseeable future actions include oil and gas extraction and marine vessels and associated port traffic that are assumed to contribute to regional air emissions. These activities occur within areas that are in attainment for NAAQS. When considered with other past, present, and foreseeable future actions, it is not anticipated that the Proposed Action would have significant cumulative impacts on air quality.

5.2 Climate

The total direct and indirect impacts from the Proposed Action would be constrained to small increases in GHG emissions as a result of vessel and helicopter activities. The small quantity of GHG emissions from the Proposed Action alone would not cause appreciable global warming that would lead to climate changes. However, these emissions would increase the atmosphere’s concentration of GHGs, and, in combination with past, present, and reasonably foreseeable future emissions from all other sources, contribute incrementally to climate change.

5.3 Noise and Noise-Compatible Land Use

The Proposed Action would generate a sonic boom six times per year during Dragon reentry. The noise would have only minor impacts on the land and would have only minor impacts on the ocean surface that would be similar to the sound of thunder. Past, present, and reasonably foreseeable future actions generate noise from vessels, aircrafts, equipment, and regular port activity. When considered with other past, present, and reasonably foreseeable future actions, it is not anticipated that the Proposed Action would contribute a noticeable incremental impact to noise and noise-compatible land use.

5.4 Water Resources

The Proposed Action may result in minimal and infrequent (i.e., six times per year) impacts to water quality in Gulf of Mexico as a result of potential releases of small amounts of oil and gas from vessels and unlikely, unanticipated releases of residual propellant. When considered with other past, present, and reasonably foreseeable future actions, it is not anticipated that the Proposed Action would contribute incremental impacts to water quality, and cumulative impacts would not be significant.

5.5 Natural Resources and Energy Supply

The Proposed Action would involve the consumption of fuel, oil, and lubricants for reentry, landing, and recovery operations. The commitment of energy resources to implement the Proposed Action in conjunction with past, present, and reasonably foreseeable future actions, is not anticipated to be excessive in terms of region-wide usage; cumulative impacts to natural resources and energy supply would not be significant.

5.6 Hazardous Materials, Solid Waste, and Pollution Prevention

Operations supporting the Dragon reentries, splashdowns and recoveries would use a small amount of products containing hazardous materials, including paints, solvents, oils, lubricants, acids, batteries, propellants, and chemicals. Continued implementation of existing handling and management procedures for hazardous materials, hazardous wastes, and solid wastes generated would limit the potential for impacts. Management of hazardous materials is the responsibility of each individual or organization and is regulated under RCRA (40 CFR parts 260-280) and Rule 62-730. After completion of its mission, Dragon would complete a deorbit burn and reenter the atmosphere. Debris related to parachute deployment would include the parachute doors and frangible nuts. These items would not be recoverable and would sink to the ocean floor. Impacts involving hazardous materials, solid waste and pollution prevention associated with Dragon reentries, splashdowns and recoveries have been analyzed in detail in three previous NEPA documents (*Environmental Assessment for the Operation and Launch of the Falcon 1 and Falcon 9 Space Vehicles at Cape Canaveral Air Force Station Florida 2007* and *Supplemental Environmental Assessment to the November 2007 Environmental Assessment for the Operation and Launch of the Falcon 1 and Falcon 9 Space Vehicles at Cape Canaveral Air Force Station Florida*). These analyses found that the amount of solid waste generated would be minimal, and largely consist of administrative and personal material such as paper, cans and bottles that would be recycled. It further found that processing of routine payload spacecraft would increase hazardous waste production, but by small percentages. The analyses concluded that as all applicable federal, state, and county rules and regulations would be followed for the proper storage, handling, and usage of hazardous materials, less than significant impacts on hazardous materials management would occur. As impacts from the Proposed Action and findings would be substantially similar to these previously analyzed actions and findings it is not expected that there would be substantial cumulative contamination issue as a result of the Proposed Action.

Past, present, and reasonably foreseeable future actions would be subject to same regulatory controls, and oversight as the Proposed Action (e.g. RCRA, CERCLA, OSHA, and DOT regulations). Several thousand oil drilling platforms and commercial and recreation vessels are present in the Gulf of Mexico that have in the past, or have the potential in the future, to release hazardous materials and solid waste. Maritime related activities and tourism also contribute to the release of pollutants and solid waste that flow into the gulf from land sources.

Safeguards in the form of multiple system redundancies in the spacecraft are in place to minimize the release of toxic chemicals in the environment. Dragon has been designed to perform pinpoint landings to avoid collisions with existing structures in the Gulf of Mexico and to avoid release of hazardous materials and pollutants. To avoid collision with marine vessels, to further ensure public and environmental safety, a Notice to Mariners (NOTMAR) would be issued 3-6 days prior to reentry, splashdown, and recovery efforts. When considered with other past, present, and foreseeable future actions, it is not anticipated that the Proposed Action would contribute an incremental impact to hazardous materials, solid waste, and pollution prevention, and cumulative impacts would not be significant.

6.0 LIST OF PREPARERS AND CONTRIBUTORS

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Appendix A: Air Quality

Air Quality Emissions Calculation Table

Table A-1 RECOVERY OPERATIONS EMISSIONS

Helicopter	Hours of Operation	Emission Factors in lb/operation							Total Emissions in Tons per Year						
		VOC(2)	CO	NOx	SO_2(3)	PM_{10}	$PM_{2.5}$(4)	CO_2	VOC	CO	NOx	SO_2	PM_{10}	$PM_{2.5}$	CO_2
Chinook H-47(1) Single Landing/Take Off (2)	NA	14.04	26.86	7.34	3.36	3.3	3.30	4,833	0.04	0.08	0.02	0.01	0.01	0.01	14.50
		Emission Factors in lb/hr							Total Emissions in Tons per Year						
Cruising		VOC	CO	NOx	SO_2(4)	PM_{10}	$PM_{2.5}$	CO_2	VOC	CO	NOx	SO_2	PM_{10}	$PM_{2.5}$	CO_2
Cruise (2 hours total per Dragon operation)	12	3.17	10.21	14.62	4.96	4.94	4.94	7,198.64	0.11	0.37	0.53	0.18	0.18	0.18	259.15
								Tons per Year:	**0.16**	**0.45**	**0.55**	**0.19**	**0.19**	**0.19**	**274**
								CO2e in Metric Tons per Year:							**248**

Marine Equipment	Hours of Operation	Engine Power in kW	Load Factor	(5) Emission Factors in g-kW/hr per vessel								
				VOC	CO	NOx	SO_2	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_2O
160-ft Salvage Vessel(6)	858	7600	0.75	0.27	1.5	9.8	0.007	0.26	0.25	690.00	0.09	0.02
RHIBs	432	75	0.85	0.27	5.00	6.80	0.006	0.30	0.29	690.00	0.09	0.02
				Total Emissions in Tons per Year								
				VOC	CO	NOx	SO_2	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_2O
	160-ft Salvage Vessel(6)			1.46	8.09	52.83	0.04	1.40	1.35	3,719.78	0.49	0.11
	8 RHIBs			0.07	1.21	1.65	0.00	0.07	0.07	167.58	0.02	0.005
	Tons per Year:			**1.52**	**9.30**	**54.48**	**0.04**	**1.47**	**1.42**	**3,887.36**	**0.51**	**0.11**
	CO2e in Metric Tons per Year (7):									**3,567**		

	VOC	CO	NOx	SO_2	PM_{10}	$PM_{2.5}$	CO_2e
Total Annual Emissions	**1.68**	**9.75**	**55.03**	**0.23**	**1.66**	**1.61**	**3,815**

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Appendix B: Agency Coordination

UNITED STATES DEPARTMENT OF COMMERCE
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AUG 08 2016

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Dear Mr. Dankert and Mr. Czelusniak:

This letter responds to your request for consultation with us, the National Marine Fisheries Service (NMFS), pursuant to Section 7 of the Endangered Species Act (ESA) for the following action.

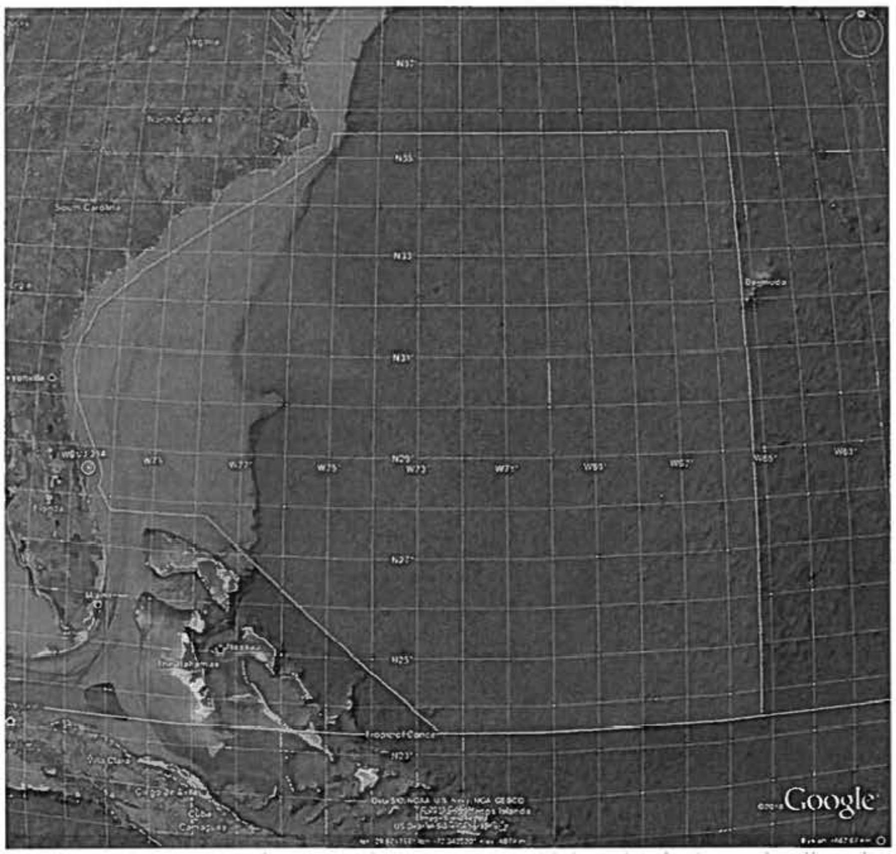
Applicant(s)	SER Number	Project Type(s)
National Aeronautics and Space Administration (NASA) and Federal Aviation Administration	SER-2016-17894	Waterborne landings of spacecraft

Consultation History

We received your letter requesting consultation on April 11, 2016. We discussed the project with the applicant on May 3, 2016, and requested additional information. During this call, we determined that the project would be expanded from the request to analyze 2 launches with NASA as the lead federal agency to now analyzing all launches occurring from the Kennedy Space Center (KSC), Cape Canaveral Air Force Station (CCAFS), and SpaceX Texas Launch Complex, with the lead federal agency being assigned as NASA, Federal Aviation Administration, or the U.S. Air Force. After exchanging 3 drafts of the project description, we received a final response on July 14, 2016, and initiated consultation that day.

Project Location

Address	Latitude/Longitude	Water body
Kennedy Space Center and Canaveral Air Force Station, Brevard County, Florida	28.608402°N, 80.604201°W (North American Datum 1983) Coordinates provided are for launch pad 39A. Other launch pads at the KSC and CCAFS may be used.	Atlantic Ocean off of Cape Canaveral and Gulf of Mexico
Texas SpaceX Launch Site, 2 miles east of Boca Chica Village, Cameron County, Texas	25.99684°N, 97.15523°W (World Geodetic System 1984)	Gulf of Mexico



Representative image of spacecraft and launch vehicle Atlantic Ocean landing site (Image provided by NASA)


Representative image of spacecraft and launch vehicle Gulf of Mexico landing site (Image provided by NASA)

Existing Site Conditions
The KSC and CCAFS are located on Merritt Island on the northeast coast of Florida. The Texas SpaceX launch site is located on a private site along the east coast of Texas away from the nearby beach. All launch areas are located in upland areas and landing areas are located in open-water within the Atlantic Ocean or Gulf of Mexico, as shown in the images above. The open-water areas for planned landings start a minimum of 5 nautical miles offshore and exclude North Atlantic right whale critical habitat in the Atlantic Ocean.

Project Description
For the purposes of this consultation, the term "spacecraft" will be used to describe modules sent into orbit on the launch vehicle carrying payloads, supplies, or crew. The term "launch vehicle" will be used to describe the rocket and all of its components.

The launch complexes on KSC and CCAFS provide the capability for a variety of vertical and horizontal launch vehicles including, but not limited to, Atlas V, Delta IV, Delta IV Heavy, Liberty, Falcon 9 and 9 v1.1, Falcon Heavy, Antares, RSLV-S, Athena IIc, Xaero, and the Space Launch System to be processed and launched. These launch vehicles and their commercial or government operators are responsible for transporting various spacecraft and payloads into orbit, including reusable manned and unmanned spacecraft such as Orion, Dream Chaser, Boeing CST-100, Liberty Composite Crew Module, and the SpaceX Crew and Cargo Dragon.

The SpaceX Texas launch site provides the capability for operating the Falcon 9 and Falcon Heavy launch vehicles. All Falcon 9 and Falcon Heavy launches would be expected to have payloads including satellites or experimental payloads. Additionally, the Falcon 9 and Falcon Heavy may also carry the SpaceX Dragon spacecraft. Most payloads would be commercial; however, some could be government sponsored launches.

Commercial and government spacecraft launched from KSC, CCAFS and the SpaceX Texas launch complex may result in portions of the spacecraft and/or launch vehicle returning to earth and landing in the Atlantic Ocean or Gulf of Mexico. The launch trajectories are specific to each particular launch vehicle's mission. However, all launches are conducted to the east over the

Atlantic Ocean, similar to past and current launches from KSC and CCAFS. All launch trajectories from the SpaceX Texas launch facility would be to the east over the Gulf of Mexico.

The following is a representative example of a nominal launch, waterborne landing and recovery based on the SpaceX Falcon 9 launch vehicle and the Crew Dragon spacecraft launched from KSC. This scenario is also generally applicable to other launch vehicles and spacecraft launch and recovery operations. It should be noted that currently not all of the above mentioned launch vehicles have a recoverable first or second stage. For example, launch vehicles in the Atlas and Delta family are classified as evolved expendable launch vehicles. These types of launch vehicles destruct upon reentry into the atmosphere and are not recovered. In the unlikely event of a launch failure, pad abort, or assent abort, efforts would be made to attempt to recover any remaining portions of the launch vehicle or spacecraft. Any debris that could not be recovered from the surface would sink to the ocean bottom.

There are several scenarios that could occur due to a launch failure:

- The entire launch vehicle and spacecraft, with onboard propellants, fails on the launch pad and an explosion occurs. The spacecraft may be jettisoned into the nearshore waters.
- The entire launch vehicle and spacecraft, with onboard propellants, is consumed in a destruction action during assent. The launch vehicle is largely consumed in the destruction action and the spacecraft is jettisoned, but residual propellant escapes and vaporizes into an airborne cloud.
- The launch vehicle and spacecraft survive to strike the water intact or partially intact potentially releasing propellants into the surface waters.

The probability of any of these launch failure scenarios is unknown and highly unlikely but could potentially have a short term localized adverse effect on marine life and habitat. To date, NASA has had a 98-99% success rate with launches.

Following the nominal launch of the launch vehicle and following first stage separation the launch vehicle would make a powered decent returning to either a designated landing pad located onshore or a drone ship located approximately 500 miles down range on the Atlantic Ocean east of Cape Canaveral or in the Gulf of Mexico. The manned or unmanned spacecraft, after completion of its mission, would descend into the Atlantic Ocean or Gulf of Mexico either under parachute canopy or propulsive landing. These capsules are relatively small in size, averaging less than 200 square feet (ft^2) in size. The main parachutes may be up to 150 feet (ft) in diameter.

A propulsive landing scenario and parachute landing scenario generally follow the same landing sequence with the main difference being that under a propulsive landing scenario the spacecraft would fire its engines to slow its decent. The spacecraft performs a deorbit burn in orbit and re-enters the atmosphere on a lifting guided trajectory. At high altitudes, the vehicle may perform an "engine burp" in order to test engine health before the propulsive landing. For a propulsive landing, the drogue chutes may be used but the main parachutes will not be deployed. Instead, at an altitude of between approximately 500 and 1,000 meters, the vehicle will light its engines and start to decelerate until ultimately it makes a waterborne landing. In a non-propulsive waterborne landing scenario the main parachutes are deployed at a predesignated altitude and slow the spacecraft to a safe speed prior to entering the water.

Following a successful landing, a contracted vessel will retrieve the parachutes and spacecraft from the water surface. Since the contracted vessel will be in the water to observe the test, recovery of the capsule and parachutes is expected to begin within an hour of the landing. The vessel will either use an overhead crane to load the capsule onto the vessel or tow the capsule back to shore at Port Canaveral or other nearby commercial wharf where it will be offloaded and transported to an inland facility.

A spacecraft reentering the atmosphere for either a propulsive or non-propulsive waterborne landing may contain residual amounts of propellant used to support on-orbit operations, the deorbit burn, entry and attitude control and propulsive landings. Spacecraft are designed to contain residual propellant and it is not expected that there would be a release of any propellants into the water. Once the spacecraft is safely transported back to land the remaining propellants would be offloaded.

In the unlikely event that any propellants are released into the water during a failed launch or a water landing, they would be quickly dispersed and diluted and would not be expected to create any long term effects on habitat or species within proximity to the landing area. According to NASA, spacecraft may carry hypergolic propellants, which are toxic to marine organisms. Specifically, the spacecraft may carry nominal values of monomethylhydrazine fuel and nitrogen tetroxide oxidizer. Propellant storage is designed to retain residual propellant, so any propellant remaining in is not expected to be released into the ocean. Nitrogen tetroxide almost immediately forms nitric and nitrous acid on contact with water, and would be very quickly diluted and buffered by seawater; hence, it would offer negligible potential for harm to marine life. With regard to hydrazine fuels, these highly reactive species quickly oxidize forming amines and amino acids. Prior to oxidation, there is some potential for exposure of marine life to toxic levels, but for a very limited area and time. A half-life of 14 days for hydrazine in water is suggested based on the unacclimated aqueous biodegradation half-life.

Within the overall missions that could potentially have waterborne landings there may be a limited number of pad abort and assent abort testing operations that would involve launching spacecraft on a low altitude non-orbit trajectory resulting in a waterborne landing within 1-20 miles east of the launch site in the coastal waters of the Atlantic Ocean. This type of testing operation would typically involve a non-propulsive landing using both drogue and main parachutes. Recovery operations would be consistent with the description above.

As the space program advances, there is currently a general progression in the development of technology and mission operations to enable both launch vehicles and spacecraft to land on barges at sea and ultimately on land. To that end, the need for open-water landings of routine missions may be phased out in the future. However, it is likely that waterborne landings in the Atlantic Ocean or Gulf of Mexico will be utilized as back-up landing locations to land based landing sites. NASA estimates that approximately 60 open-water landings could occur in the next 10 years including test launches associated with pad abort and ascent abort operations. Open-water landings may occur day or night at any time of year. This consultation address all open-water landings occurring from KSC, CCAFS and the SpaceX Texas Launch Complex result in portions that follow the protective measures defined below.

Construction Conditions

NASA will follow the protective measures listed below:

1) **Education and Observation:** All personnel associated with the project shall be instructed about the presence of species protected under the Endangered Species Act (ESA) and the Marine Mammal Protection Act (MMPA).
   a) A dedicated observer shall be responsible for monitoring for ESA-species during all in-water activities including transiting marine waters to retrieve space launch equipment. Observers shall survey the area where space equipment landed in the water to determine if any ESA-listed species were injured or killed.
   b) All personnel shall be advised that there are civil and criminal penalties for harming, harassing, or killing ESA listed species or marine mammals.
   c) More information about ESA-listed species is available on our website at: http://sero.nmfs.noaa.gov/protected_resources/section_7/threatened_endangered/index.html

2) **Reporting** of interactions with protected species:
   a) Any collision(s) with and/or injury to any sea turtle, sawfish, or whale, shall be reported immediately to NMFS's Protected Resources Division (PRD) at (1-727-824-5312) or by email to takereport.nmfsser@noaa.gov.
   b) Smalltooth sawfish: Report sightings to 1-941-255-7403 or email Sawfish@MyFWC.com
   c) Sea turtles and marine mammals: Report stranded, injured, or dead animals to 1-877-WHALE HELP (1-877-942-5343).
   d) North Atlantic right whale: Report injured, dead, or entangled right whales to the U.S. Coast Guard via VHF Channel 16.

3) **Vessel Traffic and Construction Equipment**: All vessel operators must watch for and avoid collision with ESA-protected species. Vessel Operators must maintain a safe distance by following these protective measures:
   a) Sea turtles: Maintain a minimum distance of 150 ft.
   b) North Atlantic right whale: Maintain a minimum 1,500 ft (500 yard) distance.
   c) Vessels 65-ft long or more must comply with the Right Whale Ship Strike Reduction Rule (50 CFR 224.105) including reducing speeds to 10 knots or less in Seasonal Management Areas (http://www.fisheries.noaa.gov/pr/shipstrike/).
   d) Mariners shall check various communication media for general information regarding avoiding ship strikes and specific information regarding right whale sightings in the area. These include NOAA weather radio, U.S. Coast Guard NAVTEX broadcasts, and Notices to Mariners.
   e) Marine mammals (i.e., dolphins, whales, and porpoises): Maintain a minimum distance of 300 ft.
   f) When these animals are sighted while the vessel is underway (e.g., bow-riding), attempt to remain parallel to the animal's course. Avoid excessive speed or abrupt changes in direction until they have left the area.

g) Reduce speed to 10 knots or less when mother/calf pairs or groups of marine mammals are observed, when safety permits.

4) **Hazardous Materials Emergency Response**: In the unlikely event of a failed launch or landing, SpaceX would follow the emergency response and cleanup procedures outlined in their Hazardous Material Emergency Response Plan. These procedures may include containing the spill using disposable containment materials and cleaning the area with absorbents or other materials to reduce the magnitude and duration of any impacts. In most launch failure scenarios at least a portion of the fuels will be consumed by the launch, and any remaining fuels will be diluted by seawater and biodegrade over time (timeframes are variable based on environmental conditions).

Effects Determination(s) for Species the Action Agency or NMFS Believes May Be Affected by the Proposed Action

Species	ESA Listing Status	Action Agency Effect Determination	NMFS Effect Determination
Sea Turtles			
Green (North Atlantic and South Atlantic distinct population segment [DPS])	T	NLAA	NLAA
Kemp's ridley	E	NLAA	NLAA
Leatherback	E	NLAA	NLAA
Loggerhead (Northwest Atlantic Ocean DPS)	T	NLAA	NLAA
Hawksbill	E	NLAA	NLAA
Fish			
Smalltooth sawfish (U.S. DPS)	E	NLAA	NLAA
Gulf sturgeon (Atlantic sturgeon, Gulf subspecies)	T	NLAA	NLAA
Shortnose sturgeon	E	NLAA	NLAA
Atlantic sturgeon (Carolina DPS)	E	NLAA	NLAA
Atlantic sturgeon (South Atlantic DPS)	E	NLAA	NLAA
Marine Mammals			
North Atlantic right whale	E	NLAA	NLAA
Blue whale	E	ND	NLAA
Fin whale	E	ND	NLAA
Humpback whale	E	ND	NLAA
Sei whale	E	ND	NLAA
Sperm whale	E	ND	NLAA
E = endangered; T = threatened; NLAA = may affect, not likely to adversely affect; ND = no determination			

Critical Habitat

North Atlantic right whale critical habitat

NASA planned landings are proposed to occur outside of North Atlantic right whale critical habitat. In the unlikely event that a launch failure occurred in nearshore waters near Cape Canaveral, it could occur in North Atlantic right whale critical habitat. The following essential features are present in Unit 2:

- Sea surface conditions associated with Force 4 or less on the Beaufort Scale
- Sea surface temperatures of 7°C to 17°C
- Water depths of 6 to 28 m, where these features simultaneously co-occur over contiguous areas of at least 231 square nautical miles of ocean waters during the months of November through April. When these features are available, they are selected by right whale cows and calves in dynamic combinations that are suitable for calving, nursing, and rearing, and which vary, within the ranges specified, depending on factors such as weather and age of the calves.

We do not believe any of the essential features may be affected by the proposed action.

Loggerhead sea turtle critical habitat

The in-water landing sites are located within the boundary of loggerhead sea turtle critical habitat. The following primary constituent elements (PCEs) are present in the Atlantic Ocean and Gulf of Mexico landing areas that include Units Logg-N-1 to Logg-N-19 plus Logg-S-1 and Logg-S-2. Since the open-water landing areas begin 5 nautical miles offshore, nearshore reproductive habitat is not considered within the planned landing areas. In the unlikely event that a launch failure occurred in nearshore waters near Cape Canaveral, it could occur in loggerhead nearshore reproductive critical habitat.

- Nearshore reproductive habitat: The physical or biological features of nearshore reproductive habitat as a portion of the nearshore waters adjacent to nesting beaches that are used by hatchlings to egress to the open-water environment as well as by nesting females to transit between beach and open water during the nesting season. The following primary constituent elements support this habitat: (i) Nearshore waters directly off the highest density nesting beaches and their adjacent beaches, as identified in 50 CFR 17.95(c), to 1.6 kilometers offshore; (ii) Waters sufficiently free of obstructions or artificial lighting to allow transit through the surf zone and outward toward open water; and (iii) Waters with minimal manmade structures that could promote predators (i.e., nearshore predator concentration caused by submerged and emergent offshore structures), disrupt wave patterns necessary for orientation, and/or create excessive longshore currents.
- Breeding areas: the physical or biological features of concentrated breeding habitat as those sites with high densities of both male and female adult individuals during the breeding season. Primary constituent elements that support this habitat are the following: (i) High densities of reproductive male and female loggerheads; (ii) Proximity to primary Florida migratory corridor; and (iii) Proximity to Florida nesting grounds.
- Constricted migratory habitat: the physical or biological features of constricted migratory habitat as high use migratory corridors that are constricted (limited in width) by land on one side and the edge of the continental shelf and Gulf Stream on the other side. Primary

constituent elements that support this habitat are the following: (i) Constricted continental shelf area relative to nearby continental shelf waters that concentrate migratory pathways; and (ii) Passage conditions to allow for migration to and from nesting, breeding, and/or foraging areas.

- Sargassum habitat: the physical or biological features of loggerhead *Sargassum* habitat as developmental and foraging habitat for young loggerheads where surface waters form accumulations of floating material, especially *Sargassum*. Primary constituent elements that support this habitat are the following: (i) Convergence zones, surface-water downwelling areas, the margins of major boundary currents (Gulf Stream), and other locations where there are concentrated components of the *Sargassum* community in water temperatures suitable for the optimal growth of *Sargassum* and inhabitance of loggerheads; (ii) *Sargassum* in concentrations that support adequate prey abundance and cover; (iii) Available prey and other material associated with *Sargassum* habitat including, but not limited to, plants and cyanobacteria and animals native to the *Sargassum* community such as hydroids and copepods; and (iv) Sufficient water depth and proximity to available currents to ensure offshore transport (out of the surf zone), and foraging and cover requirements by *Sargassum* for post-hatchling loggerheads, i.e., >10 m depth.
- Winter habitat: the physical or biological features of loggerhead winter habitat are warm water habitat south of Cape Hatteras near the western edge of the Gulf Stream used by a high concentration of juveniles and adults during the winter months. Primary constituent elements that support this habitat are the following: (i) Water temperatures above 10° C from November through April; (ii) Continental shelf waters in proximity to the western boundary of the Gulf Stream; and (iii) Water depths between 20 and 100 m.

We do not believe any of the PCEs may be affected by the proposed action.

Analysis of Potential Routes of Effects to Species

Sea turtles, smalltooth sawfish, sturgeon, whales may be affected by open-water landings if they were to be struck by falling materials, spacecraft, or controlled burn water landings. Due to the relative small size of capsules (less than 200 ft^2), NMFS believes that is highly unlikely that protected species will be struck and that the effects are discountable. Smalltooth sawfish and sturgeon are bottom dwelling and unlikely to interact with these items at the surface. Sea turtles and whales spend time at the surface to breath and are thus are at a higher risk of interacting with spacecraft. However, turtles and whales spend the majority of their time submerged as opposed to on the surface, thus lowering the risk of interactions. These launches have been occurring for decades with no known interactions with sea turtles or whales. Also, launches occur intermittently (occurring approximately every few months) and the goal is to ultimately reduce and eliminate the need for open-water landings.

Sea turtles and whales could also become entangled in the parachutes that will transport the capsule to the water surface. However, we believe that these species will avoid the area immediately following a landing and that all materials will be retrieved quickly (approximately 1 hour). Therefore, we believe the risk of entanglement is discountable.

Sea turtles, smalltooth sawfish, sturgeon, and whales could be affected by any hazardous materials spilled into the Atlantic Ocean or Gulf of Mexico during the proposed action.

However, such an effect is highly unlikely (98-99% success rate), failed missions do not necessarily occur over marine waters, and most if not all fuel would be consumed or contained. For planned marine landings, all fuel valves will shut automatically prior to landing to retain any residual fuels. Therefore, although a small fuel spill is possible, it is highly unlikely and any risk to protected species is discountable.

Conclusion
Because all potential project effects to listed species and critical habitat were found to be discountable, insignificant, or beneficial, we conclude that the proposed action is not likely to adversely affect listed species and critical habitat under NMFS's purview. This concludes your consultation responsibilities under the ESA for species under NMFS's purview. Consultation must be reinitiated if a take occurs or new information reveals effects of the action not previously considered, or if the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat in a manner or to an extent not previously considered, or if a new species is listed or critical habitat designated that may be affected by the identified action. NMFS's findings on the project's potential effects are based on the project description in this response. Any changes to the proposed action may negate the findings of this consultation and may require reinitiation of consultation with NMFS.

We have enclosed additional relevant information for your review. We look forward to further cooperation with you on other projects to ensure the conservation of our threatened and endangered marine species and designated critical habitat. If you have any questions on this consultation, please contact Nicole Bonine, Consultation Biologist, at (727) 824-5336, or by email at Nicole.Bonine@noaa.gov.

Sincerely,

for

Roy E. Crabtree, Ph.D.
Regional Administrator

Enc.: 1. *Sea Turtle and Smalltooth Sawfish Construction Conditions* (Revised March 23, 2006)
2. *PCTS Access and Additional Considerations for ESA Section 7 Consultations* (Revised March 10, 2015)

File: 1514-22.V

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Silver Spring, MD 20910

OCT - 2 2017

Refer to NMFS No: FPR-2017-9231

Mr. Daniel Murray
Space Transportation Development Division
U.S. Department of Transportation
Federal Aviation Administration
Office of Commercial Space Transportation
800 Independence Avenue Southwest
Washington, DC 20591

Re: Request for Initiation of Informal Consultation under Section 7(a)(2) of the Endangered Species Act for the SpaceX Landing and Recovery Operations in the Atlantic Ocean, Gulf of Mexico, and Pacific Ocean.

Dear Mr. Murray:

On August 25, 2017, NOAA's National Marine Fisheries Service (NMFS) received your request for written concurrence that the Federal Aviation Administration's (FAA), proposed issuance of licenses to the Space Exploration Technologies Corporation (SpaceX) to launch and recover spacecraft in the Atlantic Ocean, Gulf of Mexico, and Pacific Ocean, is not likely to adversely affect species listed (or proposed for listing) as threatened or endangered or critical habitats designated under the Endangered Species Act (ESA). 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.

Background

The mission of the FAA Office of Commercial Space Transportation is to ensure protection of the public, property, and the national security and foreign policy interests of the United States (U.S.) during commercial launch or reentry activities, and to encourage, facilitate, and promote U.S. commercial space transportation. In carrying out its mission, the FAA issues licenses to commercial space launch providers for the launch of launch vehicles (rockets) and reentry of spacecraft (i.e., spacecraft reentering Earth's atmosphere from space). One such commercial space launch provider is SpaceX.

SpaceX operates a family of rockets collectively known as "Falcon." The Falcon family of vehicles, includes the Falcon 9 and soon-to-be launched Falcon Heavy. They operate these from launch complexes at three sites: the National Aeronautics and Space

Canaveral Air Force Station (CCAFS), and the USAF Vandenberg Air Force Base (VAFB). All Falcon 9 and Falcon Heavy launches have payloads, including satellites, experimental payloads, or SpaceX's Dragon spacecraft (Dragon). Dragon is a free-flying spacecraft designed to deliver cargo and people to orbiting destinations. SpaceX has two versions of Dragon: Dragon-1 and Dragon-2. Dragon-1 is used for cargo missions to the International Space Station (ISS), and Dragon-2 will eventually be used to transport astronauts to the ISS. In time, SpaceX anticipates for all Dragon missions (cargo and humans) to use the Dragon-2. After completing its mission to the ISS, the Dragon returns to Earth and lands in the ocean. Under the program considered here, SpaceX is currently evaluating Dragon landings and fairing recovery in the Atlantic Ocean, Gulf of Mexico, and Pacific Ocean.

One of SpaceX's goals under this program is to recover and reuse as much of the Falcon rocket and associated parts in order to reduce the cost of launches. SpaceX's first successful landing of the Falcon 9 first stage booster occurred on December 21, 2015, and was a major milestone toward SpaceX's goal of fully recovering and reusing every aspect of the rocket booster. SpaceX booster landings are becoming routine, meaning that these large, complex boosters are rarely left to splash down in the ocean, break up, and sink. SpaceX is also attempting to recover the payload fairings (nosecones) after launches.

Consultation History

- On April 11, 2016, NASA, the FAA, and USAF submitted a request for section 7 informal consultation to NOAA Fisheries' Southeast Regional Office (SERO) for the SpaceX and NASA launch and recovery activities occurring from the Kennedy Space Center, the Cape Canaveral Air Force Station, and SpaceX Texas Launch Complex near open ocean waters in the Atlantic Ocean and Gulf of Mexico.

- On August 8, 2016, NMFS issued a concurrence letter for those proposed activities (SER-2016-17894).

- Subsequent to concluding the 2016 consultation, SpaceX informed NASA and the FAA that parafoils and parachutes associated with the payload fairings that reenter the Earth's atmosphere and land in the Atlantic Ocean after a launch might not be fully recovered by SpaceX. The FAA also learned the parachutes associated with other spacecraft (e.g., Dragon) reentry were not always recovered. These aspects of the project were not considered in the 2016 consultation since it was assumed all parachutes and parafoils would be fully recovered.

- In addition, since the 2016 consultation was completed, SpaceX determined operations were also going to be conducted in the Pacific Ocean. The NMFS 2016 consultation did not consider operations in the Pacific Ocean.

- On June 7, 2017, via conference call, staff from the FAA, NASA, USAF and NMFS Office of Protected Resources (Headquarters and SERO staff) discussed ongoing operations and ESA coverage needs for future operations. The parties mutually agreed that NMFS Endangered Species Act (ESA) Interagency Cooperation Division at NOAA Headquarters would complete the ESA section 7 consultation for the 2017-2024 SpaceX Landing and Recovery Operations since they were anticipated to occur in multiple ocean basins within different NMFS regional office jurisdictions.

For the reasons provided above, the FAA submitted a request for informal consultation to NMFS Office of Protected Resources, ESA Interagency Cooperation Division on August 25, 2017, with additional information provided on September 13, 2017, to include the operations occurring in the Atlantic Ocean, Pacific Ocean and Gulf of Mexico during 2017-2024. The fairing recovery operations will occur over any of the ocean basins listed above, and be conducted in a similar manner to what was described in the NMFS August 8, 2016 letter of concurrence.

Proposed Action

The FAA is proposing to issue permits to SpaceX in order to deploy weather balloons for Falcon booster landings and fairing recovery, and undertake Dragon reentry and recovery operations in open waters occurring in the Atlantic Ocean, Gulf of Mexico, and Pacific Ocean. The Space Transportation section of the National Space Transportation Policy of 1994 addressed the commercial launch sector, stating: "assuring reliable and affordable access to space through U.S. space transportation capabilities is fundamental to achieving National Space Policy goals." SpaceX's activities ensure these requirements continue to be met in an efficient and effective manner, and therefore continue to support the U.S. goal of encouraging activities by the private sector to strengthen and expand U.S. space transportation infrastructure (FAA 2017). Therefore, the purpose of these activities is to continue to allow SpaceX to fulfill the U.S. goal to reduce the costs of space transportation in order to make continued exploration, development, and use of space more affordable.

This consultation does not address site-specific impacts associated with launch or landing noise, construction activities, or Falcon booster return operations, or incorporate other site-specific consultations led by the FAA, NASA, or USAF. Each agency has ensured compliance with the ESA for launches occurring at VAFB, KSC, and CCAFS. The CCAFS and the USAF determined launches and landings would have no effect on ESA-listed species under NMFS' jurisdiction (USAF 2013a, 2013b, 2017) for projects launching from their locations on the Atlantic Ocean and Gulf of Mexico. Similarly, VAFB determined launches from VAFB would have no effect on ESA-listed species under NMFS' jurisdiction for projects occurring on the Pacific Ocean. The FAA has also determined no effect will occur for ESA-listed species from launch activities associated with the SpaceX program considered in this consultation. Therefore, this consultation considers only the effects of rocket landings and recovery in open waters on ESA-listed species and designated critical habitats. Descriptions of the rockets and specific components of the program activities are described below.

The Falcon Vehicles

SpaceX currently launches its Falcon 9 rocket from KSC, CCAFS, and VAFB for government and commercial customers. The Falcon 9 payload transport system includes a fairing system. The Falcon 9's payload fairing is made up of two halves, which separate at the desired moment in order to facilitate the deployment of the payload at the desired orbit. Previously, both halves of the fairing were left to splashdown in the ocean, break apart, and sink. More recently, SpaceX has been working on developing mechanisms to recover the payload fairing in order to further their reusability goals; and have begun staging a team to recover the fairing (with parafoil) after splashdown in the ocean.

As part of SpaceX's fairing recovery effort, SpaceX added a parachute system to one of the fairing halves. The parachute system consists of one drogue parachute and one main parafoil (see Figures 1 and 2 below) Also, a nitrogen cold gas attitude control system was added to the fairing halves in order to null the initial rotation rates of the fairing halves and re-orient them into a favorable orientation prior to re-entry. SpaceX's long-term goal is to control the parafoil to return both fairing halves to either a pre-positioned droneship or land. This operation is currently occurring in the Atlantic Ocean following launches from KSC. This program will be extended to include missions from CCAFS and VAFB.

Figure 1. Payload Fairing Parafoil

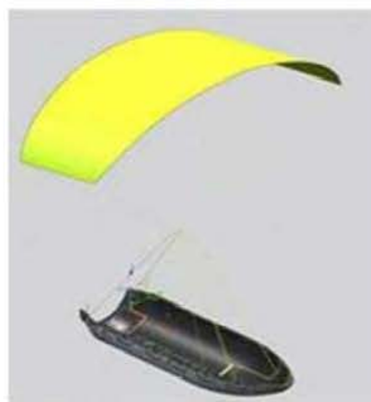


Figure 2. Payload fairing half with parafoil deployed

The parachute system slows the descent of the fairing to enable a soft splashdown such that the fairing remains intact. Following re-entry of the fairing into Earth's atmosphere, a drogue parachute is deployed at a high altitude (approximately 50,000 feet [ft]) to begin the initial slow down and to extract the parafoil. The drogue parachute (and the attached deployment bag) is then cut away following the successful deployment of the parafoil. The predicted impact points of both the fairing, parafoil, and drogue parachute assembly have been propagated using modeling tools (FAA 2017).

SpaceX is also evaluating two parachute systems for the fairing (Type 1 and Type 2). The specifications of each system are noted below (Tables 1 and 2). The Type 2 system has a similar drogue parachute as the Type 1 system but a larger and lighter parafoil than Type 1.

Table 1. Specifications of Type 1 and Type 2 Fairing Drogue Parachutes (FAA 2017)

Drogue Type	Canopy Material	Area (ft^2)	Suspension Line Material	Deployment Bag (ft^2)[a]
Type 1	Nylon	63.59	Kevlar	28[b]
Type 2	Nylon	113	Kevlar	28[c]

[a] The deployment bag is part of the drogue parachute assembly; the two components are connected.
[b] Spectra cloth with Kevlar webbing.
[c] Nylon cloth.
ft^2 = square feet

Table 2. Specifications of Type 1 and Type 2 Fairing Parafoils (FAA 2017)

Parafoil Type	Canopy Material	Area (ft^2)	Suspension Line Length (ft)
Type 1	Nylon	1,782	42.6
Type 2	Nylon	3,000	50

ft = feet; ft^2 = square feet

The fairing and parafoil are recovered by a salvage ship that is stationed in a Range Safety-designated safety zone near the anticipated splashdown area. The salvage ship is able to locate the fairing using GPS data from mission control and strobe lights on the fairing data recorders. Upon locating the fairing, a rigid-hulled inflatable boat is launched. Crew hook rig lines to the fairing and connect a buoy to the parafoil, then release the parafoil riser lines and secure it by placing it into a storage drum. However, if sea or weather conditions are poor, recovery of the fairing and parafoil may be unsuccessful.

Recovery of the drogue parachute assembly is attempted if the recovery team can get a visual fix on the splashdown location. However, because the drogue parachute assembly is deployed at a high altitude, it is difficult to locate. In addition, based on the size of the assembly and the density of the material, the drogue parachute assembly becomes saturated within approximately one minute of splashing down and begins to sink. This makes recovering the drogue parachute assembly difficult and unlikely. However, SpaceX is working on an engineering solution for recovery of the drogue parachute assembly in future operations. They hope to have a solution developed in early 2018, but the timing is uncertain.

The salvage ship returns to a private dock and the fairing is transported to a SpaceX facility via truck. Once at a SpaceX facility, further post-flight processing ensures the fairing is a source of information for continuous program improvement. If this system proves to be effective, the parachute/parafoil system will be added to the second fairing half in the future in order to enable recovery of the full payload fairing system.

The Dragon Rockets

The Dragon (1 and 2) is composed of two main elements: the capsule for pressurized crew and cargo and the unpressurized cargo module or "trunk" (see Figure 3). The capsule contains a pressurized section, an unpressurized service section, and a nosecone. Other primary structures include a welded aluminum pressure vessel, primary heat shield support structure, and back shell thermal protection system support structure. This structure supports secondary structures including the SuperDraco engines (for Dragon-2), propellant tanks, pressurant tanks, parachute system, and necessary avionics. The pressurized section consists of the welded pressure vessel, forward hatch, side hatch, docking tunnel, docking adapter, and windows. The Dragon-1 capsule's dry weight could range from 8,000 to 15,000 pounds depending on its cargo and configuration. The Dragon 2 capsule weighs approximately 16,976 pounds without cargo, with a height of approximately 2317 ft (including the trunk) and a base width of 13 ft. Dragon's propulsion system uses nitrogen tetroxide (NTO) and monomethylhydrazine (MMH) propellant combination (FAA 2017).

Figure 3. Dragon-2 (FAA 2017)

Dragon contains two sets of parachutes: drogue and main parachutes. The drogue parachutes are thin parachutes deployed during reentry to gain control of the spacecraft at speeds that would destroy larger parachutes and therefore are deployed before the larger and thicker main parachutes (see Figure 4). For both versions of Dragon, the vehicle is rigged with two drogue parachutes. Each drogue parachute has a diameter of 19 ft with 72 ft of risers/suspension and are made of variable porosity conical ribbon. The drogues typically land within one to two kilometers from Dragon.

Shortly after the drogue parachutes are deployed, they are released and the main parachutes are deployed (Figure 4). The main parachutes would slow Dragon to a speed of approximately 13 miles per hour allowing for a "soft" splashdown in the water. For both versions of Dragon, the main parachutes are made of Kevlar and nylon and have a diameter of 116 ft with 147 ft of risers/suspension. Dragon-1 is rigged with three main parachutes, while Dragon-2 is rigged with four main parachutes.

Figure 4. Dragon-1 Main Parachutes with (smaller) Drogue Parachutes (FAA 2017)

Dragon Reentry and Recovery Operations

Each Dragon landing operation consists of three elements: Dragon reentry, splashdown, and recovery. After completing its mission in space, Dragon travels back to Earth where it completes a deorbit burn and reenters the Earth's atmosphere. During reentry, Dragon creates a sonic boom. The sonic boom creates an overpressure of 0.41 pound per square foot (psf), and could be expected to occur approximately 19 miles from the splashdown site. Further out, a 0.35 psf approximately 50 miles from the splashdown site could occur. A Dragon reentry would never be conducted in any type of stormy weather unless deemed necessary in an emergency situation (e.g., a medical emergency with an astronaut). The trunk (Figure 1) supports the capsule during the mission and contains a truss structure to hold unpressurized cargo. At the conclusion of each mission, the trunk would be left in orbit.

SpaceX has launches and reentry operations scheduled involving Dragon from 2017 – 2024:

- November 2017: Dragon-1 reentry in the Pacific Ocean – 2 drogue parachutes and 3 main parachutes
- 2018–2020: 6 Dragon reentries per year
- 3 Dragon-1 reentries in the Pacific Ocean – total of 6 drogue parachutes and 9 main parachutes each year
- 3 Dragon-2 reentries in the Atlantic Ocean – total of 6 drogue parachutes and 12 main parachutes each year
- 2021–2024: 6 Dragon reentries per year
- All Dragon-2 reentries in the Atlantic Ocean – total of 12 drogue parachutes and 24 main parachutes each year.

Only one reentry event is scheduled for 2017, and will occur in November (launches in October), and splashdown will occur in the Pacific Ocean. Beginning in 2018, SpaceX anticipates up to six Dragon reentry and splashdown events per year through 2024, including up to three annual Dragon-1 splashdowns in the Pacific Ocean and up to three annual Dragon-2 splashdowns in the Atlantic Ocean (in the bulb or Superbox described in the Action Area section below). Of the three Dragon-2 splashdowns in the Atlantic Ocean, one of these could occur in the Gulf of Mexico (i.e., contingency splashdown site for Dragon-2). Within the next few years, all Dragon missions would phase to Dragon-2 missions; SpaceX anticipates six per year and expects all to land in the bulb or superbox of the Atlantic Ocean or Gulf of Mexico. The Atlantic Ocean superbox and the recovery areas in the Gulf of Mexico and Pacific Ocean would be contingency landing areas.

Payload Fairing Recovery Operations
Between 2017-2018, SpaceX anticipates 15 launches involving fairing recovery attempts. Four of the 15 launches might also involve attempting to recover both halves of the fairing, thus would involve two drogue parachutes and two main parafoils. Therefore, there is the potential to have up to 19 drogue parachutes and 19 parafoils land in the ocean (Atlantic and Pacific Oceans). Of the 15 launches involving fairing recovery attempts within the next 12–15 months (e.g., 2017-2018), SpaceX anticipates approximately five would occur at VAFB, where the fairing would splash down in the Pacific Ocean. The other ten launches involving fairing recovery would occur in the Atlantic Ocean.

From 2019-2024, SpaceX anticipates the frequency of launches involving fairing recovery to increase. In 2018, SpaceX anticipates approximately two recovery attempts, and from 2019-2024, SpaceX anticipates approximately three recovery attempts per month. Thus, for all seven years, SpaceX anticipates up to 480 drogue parachutes and 480 parafoils would land in the ocean. All years will involve recovery attempts of both halves of the fairing. SpaceX also intends to recover all drogue parachutes and parafoils, but it is possible some of the drogue parachutes and parafoils will not be recovered due to sea or weather conditions at the time of recovery.

Weather Balloon Deployment for Falcon Booster Landings and Fairing Recovery
Once the Falcon 9 is launched, it uses onboard predictive simulation to estimate where it will land. Part of the simulation is an estimate of wind speeds in the vicinity of the booster landing zone. The accuracy of the wind profile affects the likelihood the booster will land successfully. In order to estimate wind speeds, SpaceX measures it in the landing zone using weather balloons made of latex, with radiosondes attached to each balloon. Measurements are taken at various intervals before landing events and used to create the required profiles of expected wind conditions for each landing event. Data from the balloons is gathered and transmitted to SpaceX via the radiosonde. Each radiosonde is relatively small (about the size of a milk carton) and is powered by a 9-volt battery. The latex balloon attached to each weather balloon typically has a diameter at launch of approximately four feet. When a balloon is deployed, it rises to approximately 20–30 kilometers into the air and then and bursts. This bursting causes the balloon to shred into many pieces that fall back to Earth, along with the radiosonde, all which land in the open ocean. The radiosonde does not have a parachute. Therefore, pieces of the balloon and the radiosonde are not recovered. However, the radiosonde is expected to rapidly sink to the ocean floor.

From now (2017) through March 2018, SpaceX plans to release about 36 weather balloons. This corresponds to four weather balloons released for each mission (identified in Table 3) that involves a fairing recovery. After March 2018, SpaceX estimates the frequency of weather balloon deployments to potentially double in 2018 (i.e., approximately two missions per month involving the release of four weather balloons each mission; which is approximately 96 weather balloons in 2018) and then triple in 2019-2024 (approximately three missions per month involving the release of four weather balloons each mission; which is approximately 144 weather balloons each year from 2019–2024). Thus, for all missions from 2017-2024, SpaceX estimates releasing approximately 1,000 weather balloons.

Table 3. SpaceX Schedule of Operations, August 2017 through March 2018 (FAA 2017)

	Late Aug	Late Aug	Late Sept	Early Oct	Early Nov	Early Nov	Early Dec	Jan 2018	Feb 2018	March 2018
Operation	FR	FR	FR	FR	FR	DR(P)	FR	FR	FR	FR
Launch Site	SLC-4E	LC-39A	SLC-4E	LC-40	LC-40	LC-39A	SLC-4E	LC-39A	LC-40	LC-40

Notes:

DR(P) = Dragon reentry in the Pacific Ocean; FR = fairing recovery

LC-39A = Kennedy Space Center; LC-40 = Cape Canaveral Air Force Station; SLC-4E = Vandenberg Air Force Base

Dragon abort tests are being coordinated and are not currently on the schedule.

Dragon Abort Test – Florida

SpaceX is also planning on completing an ascent abort testing operation that involves Dragon-2 "ejecting" from a Falcon 9 following lift off and traveling on a low altitude non-orbital trajectory. This would result in the Dragon splashing down within 1–20 miles east of the launch site (CCAFS or KSC) in the coastal waters of the Atlantic Ocean. This operation was considered in the NMFS 2016 consultation; however, that consultation did not assess potential effects from potentially unrecovered parachutes. The abort testing operation would involve a non-propulsive landing using both drogue and main parachutes. Recovery operations would be consistent with the description above for Dragon recovery.

Measures to Avoid and Minimize Adverse Effects to Listed Species and Critical Habitat

The FAA, NASA, USAF, and SpaceX will follow the environmental protection measures described in the NMFS 2016 consultation for activities occurring in the Atlantic Ocean, Gulf of Mexico and Pacific Ocean missions. Additionally, as it relates to the reporting requirements, the FAA will submit a report to NMFS by December 31 of each year documenting the outcome of each launch mission involving a payload fairing recovery attempt, Dragon reentry, and/or Dragon abort tests. NASA will support the FAA in developing this report as it relates to NASA-sponsored launches. Annual reports will include the following: 1) the dates of all payload fairing recovery missions, Dragon reentries, and Dragon abort tests; 2) approximate locations (GPS coordinates) of all fairing recoveries (and drogue parachute recoveries, if applicable) and Dragon recoveries (including abort tests); 3) any available information on the fate of unrecovered parachutes and parafoils; and 4) any evidence that ESA-listed species were adversely affected by the action. This information will then be used to improve or modify future operations in order to further reduce the risks on ESA-listed species from the SpaceX mission activities.

Action Area

The action area is defined in 50 CFR § 402.02 as "all areas to be affected directly or indirectly by the federal action and not merely the immediate area involved in the action." For the SpaceX missions, the action area includes all recovery zones located in regions of the Atlantic Ocean, Gulf of Mexico, and Pacific Ocean. These zones are described below.

Atlantic Ocean Recovery Zone

The recovery zone in the Atlantic Ocean is referred to as the "superbox." The western boundary of the superbox is a minimum of five nautical miles offshore (Figure 5). The superbox is the current Atlantic Ocean recovery zone for Dragon-1. For Dragon-2, the superbox would be used mainly for contingency landings because Dragon-2 would contain astronauts, and therefore SpaceX and NASA would like to land Dragon-2 as close to the shore as possible. SpaceX is planning Dragon-2 splashdowns in an area referred to as the "bulb" (Figure 6). The bulb would be the nominal landing zone for Dragon-2, with the superbox acting as a contingency splashdown location. SpaceX designed the shape of the bulb such that at all locations within the bulb are greater than five nautical miles from the coast in order to avoid critical habitat for the North Atlantic right whale.

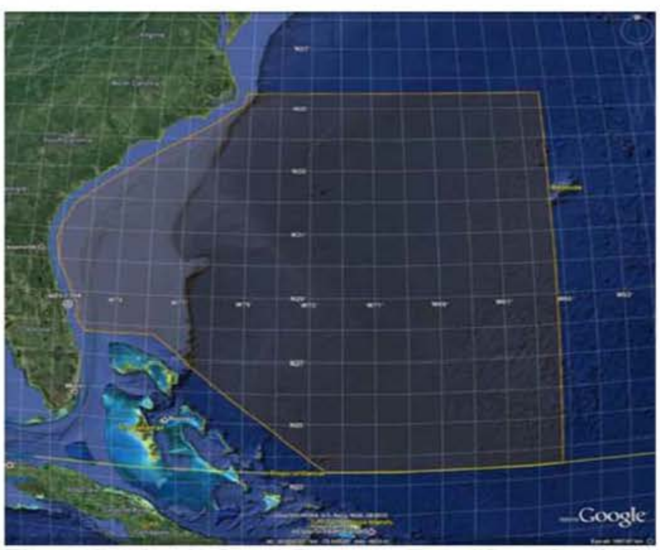


Figure 6. Atlantic Ocean Recovery Zone "Superbox" (FAA 2017)

Figure 7. Atlantic Ocean Recovery Zone "Bulb" (FAA 2017)

Gulf of Mexico Recovery Zone

The recovery zone in the Gulf of Mexico is positioned in deep waters 15–140 nautical miles off the Gulf of Mexico coastline from southern Texas to southern Florida and is completely within the U.S. exclusive economic zone (Figure 8). The Gulf of Mexico would serve as a possible splashdown location for Dragon missions originating from the SpaceX South Texas Launch Site (currently under construction) and a contingency landing location for Dragon missions originating from Florida.

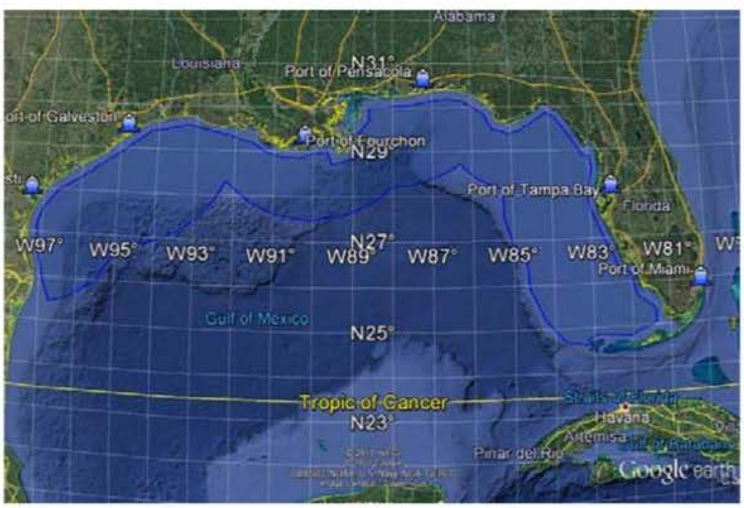


Figure 8. Gulf of Mexico Recovery Zone (FAA 2017)

Pacific Ocean Recovery Zone

The eastern boundary of the Pacific Ocean recovery zone starts a minimum of five nautical miles offshore (Figure 9). It includes the Monterey Bay National Marine Sanctuary off the coast of California. However, no splashdowns are planned to occur in the Sanctuary. Splashdowns would only occur in Sanctuary waters due to unforeseen events or safety concerns. The Pacific Ocean recovery zone would be a contingency splashdown location for Dragon-2 missions.

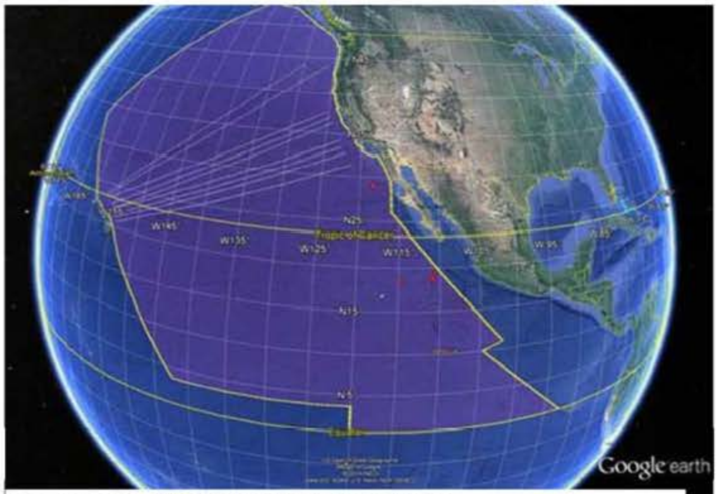


Figure 9. Pacific Ocean Recovery Zone

Action Agency's Effects Determination

The FAA has concluded that the proposed action may affect, but is not likely to adversely affect the following ESA-listed species or designated critical habitats:

Table 4. Species Present in the Action Area – Oceans of the Atlantic, Pacific and Gulf of Mexico.

Common Name	Scientific Name	ESA Listing (FR Number)	Critical Habitat Designation (FR Number)	ESA Status	Agency Effects Determination
Marine Mammals					
North Atlantic right whale	*Eubalaena glacialis*	March 6, 2008 (73 FR 12024)	July 5, 1994/February 26, 2016 (59 FR 28805/81 FR 4837)	Endangered	NLAA
North Pacific right whale	*Eubalaena japonica*	December 2, 1970/March 6, 2008 (73 FR 12024)	April 8, 2008 (73 FR 19000)	Endangered	NLAA
Blue whale	*Balaenoptera musculus*	December 2, 1970 (35 FR 18319)	Not designated	Endangered	NLAA
Gray Whales	*Eschrichtius robustus*	December 2, 1970 (35 FR 18319)	Not designated	Endangered	NLAA
Humpback whale – Mexico DPS	*Megaptera novaeangliae*	December 2, 1970/ October 2, 2016 (35 FR 18319/81 FR 62259)	Not designated	Threatened	NLAA
Fin whale	*Balaenoptera physalus*	December 2, 1970 (35 FR 18319)	Not designated	Endangered	NLAA

Table 4. Species Present in the Action Area – Oceans of the Atlantic, Pacific and Gulf of Mexico.					
Common Name	**Scientific Name**	**ESA Listing (FR Number)**	**Critical Habitat Designation (FR Number)**	**ESA Status**	**Agency Effects Determination**
Sei whale	*Balaenoptera borealis*	December 2, 1970 (35 FR 18319)	Not designated	Endangered	NLAA
Sperm whale	*Physeter macrocephalus*	December 2, 1970 (35 FR 18319)	Not designated	Endangered	NLAA
Southern Resident killer whales	*Orcinus orca*	February 16, 2006 (70 FR 69903)	December 29, 2006 (71 FR 69054)	Endangered	NLAA
Guadalupe fur seal	*Arctocephalus townsendi*	December 16, 1985 (50 FR 51252)	Not designated	Endangered	NLAA
Sea Turtles					
Green sea turtle – North and South Atlantic DPS	*Chelonia mydas*	May 6, 2016 (81 FR 20057)	September 2, 1998 (63 FR 46693)	Threatened	NLAA
Green sea turtle - East Pacific DPS	*Chelonia mydas*	May 6, 2016 (81 FR 20057)	Not designated	Threatened	NLAA
Green sea turtle - Florida and Mexico breeding colonies	*Chelonia mydas*	May 6, 2016 (81 FR 20057)	September 2, 1998 (63 FR 46693)	Endangered	NLAA
Hawksbill sea turtle	*Eretmochelys imbricata*	June 2, 1970 (35 FR 8491)	September 2, 1998 (63 FR 46693)	Endangered	NLAA
Loggerhead sea turtle – North pacific DPS	*Caretta caretta*	September 22, 2011 (76 FR 58868)	Not designated	Endangered	NLAA
Loggerhead sea turtle - Northwest Atlantic Ocean DPS	*Caretta caretta*	September 22, 2011 (76 FR 58868)	August 11, 2014 (79 FR 39856)	Endangered	NLAA
Olive Ridley sea turtle	*Lepidochelys olivacea*	July 28, 1978 (43 FR 32800)	Not designated	Threatened	NLAA
Kemp's ridley sea turtle	*Lepidochelys kempii*	December 2, 1970 (35 FR 18319)	Not designated	Endangered	NLAA
Leatherback sea turtle – Atlantic and Pacific DPSs	*Dermochelys coriaacea*	June 2, 1970 (35 FR 8491)	Designated (44 FR 17710, 77 FR 4170)	Endangered	NLAA
Fishes					
Atlantic sturgeon – Carolina and South Atlantic DPSs	*Acipenser oxyrinchus*	April 6, 2012 (77 FR 5879)	June 3, 2016 (81 FR 35701) Proposed	Endangered	NLAA
North American Green sturgeon, Southern DPS	*Acipenser medirostris*	June 6, 2006 (71 FR 17757)	November 9, 2009 (74 FR 52300)	Threatened	NLAA
Gulf sturgeon (Atlantic sturgeon,	*Acipenser oxyrinchus*	September, 30, 1991 (56 FR	March 19, 2003 (68 FR 13370)	Threatened	NLAA

Table 4. Species Present in the Action Area – Oceans of the Atlantic, Pacific and Gulf of Mexico.					
Common Name	**Scientific Name**	**ESA Listing (FR Number)**	**Critical Habitat Designation (FR Number)**	**ESA Status**	**Agency Effects Determination**
Gulf subspecies)	*desotoi*	49653)			
Shortnose sturgeon	*Acipenser brevirostrum*	March 11, 1967 (32 FR 4001)	Not designated	Endangered	NLAA
Nassau grouper	*Epinephelus striatus*	July 29, 2016 (81 FR 42268)	Not designated	Threatened	NLAA
Scalloped hammerhead shark –Central and Southwest Atlantic DPSs	*Sphyrna lewini*	September 2, 2014 (79 FR 38213)	Not designated	Threatened	NLAA
Scalloped hammerhead shark Eastern Atlantic, Eastern Pacific DPS	*Sphyrna lewini*	September 2, 2014, (79 FR 38213)	Not designated	Endangered	NLAA
Oceanic Whitetip shark	*Carcharhinus longimanus*	December 29, 2016 (81 FR 96304)	Not designated	Proposed for listing as threatened	NLAA
Smalltooth sawfish - U.S. DPS	*Pristis pectinata*	April 1, 2003 (68 FR 15674)	September 2, 2009 (74 FR 45353)	Endangered	NLAA
Chinook Salmon– California Coastal ESU	*Oncorhynchus tshawytscha*	August 29, 2005 (70 FR 37160)	January 2, 2006 (70 FR 52488)	Threatened	NLAA
Chinook Salmon Central Valley Spring-Run ESU	*Oncorhynchus tshawytscha*	August 29, 2005 (70 FR 37160)	January 2, 2006 (70 FR 52488)	Threatened	NLAA
Chinook Salmon – Lower Columbia River ESU	*Oncorhynchus tshawytscha*	August 29, 2005 (70 FR 37160)	January 2, 2006 (70 FR 52488)	Threatened	NLAA
Chinook Salmon – Puget Sound ESU	*Oncorhynchus tshawytscha*	August 29, 2005 (70 FR 37160)	January 2, 2006 (70 FR 52629)	Threatened	NLAA
Chinook Salmon– Sacramento River Winter-Run ESU	*Oncorhynchus tshawytscha*	August 29, 2005 (70 FR 37160)	June 16, 1993 (58 FR 33212)	Endangered	NLAA
Chinook Salmon– Snake River Fall-Run and Spring/Summer Run ESUs	*Oncorhynchus tshawytscha*	August 29, 2005 (70 FR 37160)	December 28, 1993 (58 FR 68543)	Threatened	NLAA
Chinook Salmon– Upper Columbia River Spring-Run ESU	*Oncorhynchus tshawytscha*	August 29, 2005 (70 FR 37160)	January 2, 2006 (70 FR 52629)	Endangered	NLAA
Chinook Salmon– Upper Willamette	*Oncorhynchus tshawytscha*	August 29, 2005 (70 FR	January 2, 2006 (70 FR 52629)	Threatened	NLAA

Table 4. Species Present in the Action Area – Oceans of the Atlantic, Pacific and Gulf of Mexico.					
Common Name	**Scientific Name**	**ESA Listing (FR Number)**	**Critical Habitat Designation (FR Number)**	**ESA Status**	**Agency Effects Determination**
River ESU		37160)			
Chum Salmon – Columbia River ESU	*Oncorhynchus keta*	August 29, 2005 (70 FR 37160)	January 2, 2006 (70 FR 52629)	Threatened	NLAA
Chum Salmon – Hood Canal Summer-Run ESU	*Oncorhynchus keta*	August 29, 2005 (70 FR 37160)	January 2, 2006 (70 FR 52629)	Threatened	NLAA
Coho Salmon – Central California Coast ESU	*Oncorhynchus kisutch*	August 29, 2005 (70 FR 37160)	January 2, 2006 (70 FR 52629)	Endangered	NLAA
Coho Salmon– Lower Columbia River ESU	*Oncorhynchus kisutch*	August 29, 2005 (70 FR 37160)	January 2, 2006 (70 FR 52629)	Threatened	NLAA
Coho Salmon– Oregon Coast ESU	*Oncorhynchus kisutch*	73 FR 7816	January 2, 2006 (70 FR 52629)	Threatened	NLAA
Coho Salmon - Southern Oregon and Northern California Coasts ESU	*Oncorhynchus kisutch*	August 29, 2005 (70 FR 37160)	June 4, 1999 (64 FR 24049)	Threatened	NLAA
Steelhead – California Central Valley DPS	*Oncorhynchus mykiss*	February 6, 2006 (71 FR 834)	January 2, 2006 (70 FR 52487)	Threatened	NLAA
Steelhead – Central California Coast DPS	*Oncorhynchus mykiss*	February 6, 2006 (71 FR 834)	January 2, 2006 (70 FR 52487)	Threatened	NLAA
Steelhead – Lower and Columbia River DPSs	*Oncorhynchus mykiss*	February 6, 2006 (71 FR 834)	January 2, 2006 (70 FR 52629)	Threatened	NLAA
Steelhead – Northern California DPS	*Oncorhynchus mykiss*	February 6, 2006 (71 FR 834)	January 2, 2006 (70 FR 52487)	Threatened	NLAA
Steelhead - Puget Sound DPS	*Oncorhynchus mykiss*	June 11, 2007 (72 FR 26722)	March 25, 2016 (81 FR 9251)	Threatened	NLAA
Steelhead – Snake River Basin DPS	*(Oncorhynchus mykiss)*	February 6, 2006 (71 FR 834)	January 2, 2006 (70 FR 52629)	Threatened	NLAA
Steelhead – South-Central and Central California Coast DPSs	*Oncorhynchus mykiss*	February 6, 2006 (71 FR 834)	January 2, 2006 (70 FR 52487)	Threatened	NLAA
Steelhead – Upper Columbia and Upper Willamette River DPSs	*Oncorhynchus mykiss*	February 6, 2006 (71 FR 834)	January 2, 2006 (70 FR 52629)	Threatened	NLAA
Steelhead - Southern California DPS	*Oncorhynchus mykiss*	February 6, 2006 (71 FR 834)	January 2, 2006 (70 FR 52487)	Endangered	NLAA

Key: 1) DPS = Distinct population segment; 2) NLAA = Not likely to adversely affect

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.

Effects on ESA-listed Species in the Action Area

As ESA-listed species and species proposed for listing may be present within the action area, potential impacts could occur for the species provided in Table 4 above. Although the Gulf of Mexico contains ESA-listed coral species, corals are not included in this consultation because the FAA has determined the project activities will have no effect on coral species.

Aspects of the SpaceX Program that may affect ESA-listed species or critical habitats include the open ocean landings (splashdowns) of the Falcon or Dragon aircraft and associated fairings and parachutes components, as well as deployment of the expendable weather balloons and attached radiosondes, and the abort test off of Florida. The fairing or rocket capsule and radiosondes may directly strike an animal, the parachute and parafoils lines and material may cause entanglement, and ESA-listed species could ingest the pieces of latex weather balloons. Additionally, animals present in the area of Dragon reentry could be exposed to sound produced during a sonic boom. These impacts could lead to mortality, injury or the disruption of essential behaviors, potentially leading to reduced fitness of individual ESA-listed species. The likelihood that ESA-listed species would be impacted by these stressors was determined by considering factors that include: the scale and scope of the action; NMFS' expectations of how components of the SpaceX missions are likely to behave following an oceanic landing; the life histories and distribution of ESA-listed species within the action area; and the physical characteristics of the action area. The potential effects of each of these potential stressors are discussed in the next sub-sections.

Effects of a Direct Strike

ESA-listed species may be affected by Dragon reentry and recovery operations, payload fairing recovery operations, abort test, or radiosonde deployment if they were struck by falling materials or spacecraft. However, due to the relatively small size of the Dragon capsule, fairing, radiosondes and other parts associated with the action (e.g., nuts and bolts) compared to the vast open ocean, it is highly unlikely protected species will be struck directly by any of these materials.

The ESA-listed fish species that may be present in any of the action areas do not spend a large majority of time at the shallower surface depths where direct strikes are likely to occur. They are expected to be distributed throughout deeper depths in the water column (e.g., salmonids, sharks), or located along the shelf or substrate waters less than 110 meters (m) deep (e.g., smalltooth sawfish, groupers and sturgeon species). Additionally, a physical strike affecting a fish depends on the relative size of the object potentially striking the fish and the location of the fish in the water column. Since fish are likely able to detect an object descending in the water column (e.g., sensing the pressure wave or displacement of water), they would have the ability to swim away from an oncoming object.

Marine mammals and sea turtles do spend time at the surface to bask and breathe and thus may be at a higher risk of interacting with the Dragon, fairing, and other parts. Since turtles and whales spend the majority of their time submerged as opposed to on the surface, the risk of being directly hit by any falling parts is extremely low. The same is true for Guadalupe fur seals when not on land.

The only ESA-listed animal under NMFS' jurisdiction that could be present on land is the Guadalupe fur seal. However, splashdown areas are expected to occur at least five nautical miles offshore and not near any haul-outs of Guadalupe fur seals.

Expended materials from rocket launches have been occurring for decades with no known interactions with any of these species. Because it would be extremely unlikely for an ESA-listed species to be directly struck by components of the rocket capsule or fairings, we find the potential effects of a direct strike for any ESA-listed species to be discountable.

Effects of Payload Fairing Recovery Operations

Under current operations, both halves of the payload nose fairing are expected to splashdown into the open ocean waters. The action area within each ocean recovery zones are quite large, but fairing recovery always takes place 300–500 nautical miles offshore. Thus, fairing recovery occurs in deep water, far offshore. Depths are around 13,000 ft (3,962 m) at the typical recovery point for the west coast and around 15,000 ft (4,572 m) or more at the typical east coast recovery point. Half of each of the nose fairings has an attached recovery system so that SpaceX can recover the fairing for research and potential re-use. The other half of each nose fairing, if unrecovered will sink to the bottom of the ocean, as happens with all other fairings and stages in other non-SpaceX launches. The probability of the fairing striking an ESA-listed species was determined to be discountable as discussed above. Entanglement or ingestion are the other potential risks from this activity. The following discusses the effects of these stressors from fairing recovery operations.

In most cases, SpaceX expects to recover both the halves of the fairing and main portions of the recovery system of parafoils. Recovery of the drogue parachute assembly is attempted if the recovery team can get a visual fix on the splashdown location. However, because the drogue parachute assembly is deployed at a high altitude, it is difficult to locate. In addition, based on the size of the assembly and the density of the material, the drogue parachute assembly becomes saturated within approximately one minute of splashing down and begins to sink. The drogue parachute's primary material (nylon) is in the family of high molecular weight polymers, which are not easily degraded by abiotic (physical or chemical) or biotic processes (Haines and Alexander 1974). Photo-oxidative degradation, the process of decomposition of the material by light (most effectively by near-ultraviolet [UV] and UV wavelengths), would be the most effective source of damage exerted on the nylon parachute. However, upon entering the water column, the drogue parachute would rapidly sink below the depths to which UV radiation in the oceans penetrates, eventually resting on the ocean floor where exposure to UV light would not occur, making photo-oxidation improbable. Once on the ocean floor, the relatively constant temperatures and lower oxygen concentration (as compared to the atmosphere) would slow any resultant degradation (Andrady 1990; Andrady 2011). Small fragments may also temporarily re-suspend in the water column, but the potential for this would be based entirely on local ocean floor conditions and the fragments would not be expected to resuspend higher in the water column where they would likely be encountered by ESA-listed species.

The two primary pathways of potential adverse effects to ESA-listed marine species from fairing recovery operations would be via ingestion of parachute material or entanglement in parachute lines. Given the rapid descent of the parachute in the water column, ESA-listed species are not expected to be exposed to either the opportunity for ingestion or entanglement for more than one hour, generally. Based on conservative estimates, the drogue parachute would have sunk to a depth of 1,000 ft (300 m) within 46 minutes and the parafoil (if it is not recovered) would reach the same depth in one to two hours. The ocean depths where components would ultimately sink and settle is approximately 13,000 -15,000 ft (3962-4572m).

In addition, once half fairing and radiosondes (more details on radiosonde deployment are included in the weather balloon discussion below) settle on the sea floor, it would be very unlikely for listed species to interact with them.

Ingestion

For marine mammals, humpback whales are expected to occupy waters approximately 20 m deep, where they do the most of their foraging (Wiley et. al 2011). The other mysticete whale species would be expected to occur in deeper waters, around 200 m off the continental shelf (Calambokidis et al., 2008) as mysticetes tend to forage in that portion of the water column (Watkins & Schevill 1976; Goldbogen et al., 2007; Horwood, 2009; Goldbogen et al., 2011). Sperm whales tend to forage in waters deeper than mysticetes (e.g., 400 to 600 m) and sometimes at or near the benthos (Mathias et al., 2012; Miller et al., 2013), but not at the depths where the majority of components are expected to settle (> 3,000m). Guadalupe fur seals are expected to be found in the tropical waters of the Southern California/ Mexico region. During breeding season (June – August), they are found in coastal rocky habitats and caves, but their distribution at other times is not well known. Although most of their breeding grounds on Guadalupe Island, Mexico, small populations are found off of Baja California on San Benito Island and off of Southern California at San Miguel Island thus could be present in the action area during the SpaceX Mission's activities. Their diet consists primarily of squid and a variety of fish species, thus they are expected to occupy shallower depths in the water column, well above the settling depths of the radiosondes and fairing components. Therefore the likelihood of any marine mammal encountering an expended radiosonde or sunken fairing half once it has settled over the long-term is expected to be so low as to be discountable.

Foraging individuals at or near the sea surface could ingest portions of the parachutes or parafoils. Ingestion of debris may cause a physical blockage in the digestive system to the point of starvation or that results in ulceration or rupture, cause the animal to feel satiated and reduce its foraging effort and overall fitness, or to introduce toxic chemicals into the tissues of animals, causing adverse health or reproductive consequences (Laist 1997). Ingestion of debris, particularly plastics, has been reported more frequently for cetacean species (Baulch and Perry 2014). There are numerous reports in the literature (e.g., Arbelo et al. 2013; Sadove and Morreale 1990) documenting a range of consequences to large whales resulting from ingestion of plastic materials. Such consequences may be subtle, as when debris builds up over time in an animal's stomach, giving it the feeling of satiation with no nutritional value, consequently reducing appetite and feeding, the result being an animal in poor body condition and compromised fitness (Secchi and Zarzur 1999). However, for the reasons explained above, the average time it would take to recover components, the rapid sink times for unrecovered parts would limit the opportunity for individuals foraging at the surface or higher in the water column to a very short duration, in most cases no longer than one to two hours. In addition, because of the ultimate settlement depths and time it would take for the parachute material to degrade into smaller plastic components, re-suspension and availability for ingestion by marine mammals in the water column is unlikely. For these reasons, NMFS has determined the likelihood of any marine mammal ingesting portions of the parachutes or parafoils to be so low as to be discountable.

Since it is possible that the ultimate location of the radiosondes and unrecovered fairing halves on the sea floor settle in shallower waters than anticipated, they could be within the range of depths observed for diving sea turtles, particularly leatherbacks (maximum recorded dive depths to 1,280 m (Doyle et al. 2008), this occurrence is expected to be rare, since very deep dives (greater than 300 m) are rare for this species (Houghton et al. 2008). Moreover, the depth of settlement for the majority of components is estimated to be greater than 3,000 meters, the likelihood of any sea turtle encountering an expended radiosonde or sunken fairing half once it has settled over the long-term is extremely unlikely. Since pieces of the parachutes might appear similar to prey items for sea turtles, they could attempt to bite floating parachutes. However, should a turtle become curious and attempt to bite the parachute, the nylon material is resistant to tears and would most likely remain intact. Plus, since it would take a long period of time for parachute components to degrade into smaller pieces, smaller ingestible pieces of parachutes are not be expected to be located at depths available for turtles to access. For these reasons, coupled with the rapid sink rates, there is little risk of ingestion of parachute or parachute materials by sea turtles. NMFS has determined the likelihood of a sea turtle being exposed to the potential stressor of ingestion to be so low as to be discountable.

Any listed fish species present in the action area during mission activities are likely to occupy shallower waters of the action area. Juvenile and adult sturgeon live in coastal waters and estuaries when not spawning or rearing, generally in shallow (10-50 m) nearshore areas, and typically forage on "benthic" invertebrates (e.g., crustaceans, worms, mollusks) (Johnson et al. 1997). Sub-adults and adults of green sturgeon could be located along the sea floor in shelf waters out to the 110 m contour (Erickson and Hightower 2007) during the project's activities. Within the action area, scalloped hammerhead sharks could be found in coastal warm temperate and tropical seas in the Atlantic and Pacific Oceans along the continental and insular shelves, in water depths between 450-512 m up to 1000 m, and have been recorded entering bays and estuaries. Similar to other shark species, scalloped hammerheads feed on a variety of prey species including teleost, cephalopods, crustaceans and rays (Compagno 1984; Miller et al. 2014). The oceanic whitetip shark is an epipelagic species and inhabits waters offshore on the outer continental shelf and around islands in deep water usually in the upper 80 m, and is capable of foraging at depths greater than 200 m into the mesopelagic zone (Howey-Jordan et al. 2013; Howey et al. 2016) in tropical and warm temperate regions, mostly between 10° N and 10° S but also within 30 ° N and 35 ° S (Backus et al. 1956; Strasburg 1958; Compagno 1984; Bonfil et al. 2008). The diet of oceanic whitetip sharks includes a variety of fish, cephalopods, and may include seabirds, rays, turtles, and refuse (Compagno 1984). Finally, the majority if salmonid species (e.g., steelhead) prefer to occupy the uppermost stratum (10-30 m) while at sea, rendering the potential for interaction with the fairing halves, radiosondes, or parachutes very unlikely. Since the species of fishes that could be present in the action area are expected to be located and foraging in water depths beyond the ranges of effect for most of the mission activities, interactions with any of the components are extremely unlikely. For these reasons, NMFS considers the potential of ingestion of materials associated with the proposed action on any listed fish species to be insignificant and discountable.

Entanglement

Entanglement of an ESA-listed marine species could occur should an individual investigate or be struck by or encounter the parachute or parafoil after it lands in the water. Entanglement in lines or the material can wrap an animal's flippers, flukes, fins, or head and make movement or breathing and other natural behaviors difficult or impossible.

Unlike other materials in which fish may become entangled (such as gill nets and nylon fishing line which are hard to see), parachutes and parafoils are relatively large and visible, reducing the chance that visually oriented fish would accidentally become entangled in it. Additionally, due to their size, mobility, and likely inhabited areas of the water column and ocean substrates (described above), ESA-listed fish species are not expected to become entangled in parachutes, parafoils (and associated lines and fragments) floating or sinking in the water column.

Entanglement by parachutes and lines poses a greater risk for marine mammals. However, given the relative size difference between the (comparatively small) parachutes and parafoils (and the associated lines), and a (much larger) individual whale, the probability of entanglement is unlikely. Furthermore, since the unrecovered fairing drogue parachute or parafoil would sink fairly rapidly following water impact, the material would not be available for entanglement except for a short period of time during its descent to the ocean floor. Upon reaching the sea floor, marine mammals are not likely to interact with the material as these species would not likely be engaged in foraging behaviors at that depth (as described above), and, consequently, would be located higher in the water column.

Any unrecovered Dragon parachutes that do not immediately sink, could be available for a longer period of time for entanglement to occur. Although this time is not expected to be longer than a few hours in most cases. However, because Dragon parachutes float, there is a high chance of SpaceX recovering the parachutes soon after Dragon splashes down in the ocean, and therefore a low chance of a marine mammal becoming entangled in the parachute as Dragon recovery usually occurs within one hour of splashdown. In addition, the most recent Dragon missions occurring have resulted in full recovery of all parachute components. Also, the infrequent nature of the action renders the probability of a marine mammal encountering a parachute or parafoil, whether within the water column or on the seafloor, a highly unlikely event.

Sea turtles could encounter an unrecovered parachute or parafoil and subsequently become entangled. Balazs (1985) reported sea turtle entanglements involving monofilament line, ropes, netting, cloth debris, tar, and plastic bands around the neck. However, similar to marine mammals, multiple factors render this potential stressor highly unlikely. First, Dragon reentry missions, Dragon abort tests, and payload fairing recovery attempts would be infrequent. Second, the expected sink rate of the fairing drogue parachutes and parafoils would remove the material from the water column stratum most commonly frequented by migrating and foraging sea turtles in a short time frame. Though it is possible the ultimate location of the material on the seafloor could be within the range of depths observed for diving sea turtles, particularly leatherbacks (maximum recorded dive depths to 1,280 meters [4,200 feet; Doyle et al. 2008]), it has recently been determined from satellite telemetry that very deep dives (greater than 300 meters [980 feet]) are rare (Houghton et al. 2008). Third, although Dragon parachutes float, there is a high chance of SpaceX recovering the parachutes soon after Dragon splashes down in the ocean, and therefore a low chance of a sea turtle encountering a parachute. Finally, the low density of sea turtles in the splash down area makes the likelihood of an individual becoming entangled in the descending or seafloor-resting material highly unlikely.

Guadalupe fur seals are non-migratory and their breeding grounds are almost entirely on Guadalupe Island, Mexico. There are small populations off Baja California on San Benito Island and off southern California at San Miguel Island. During breeding season, they are found in coastal rocky habitats and caves. Little is known about their whereabouts during the non-breeding season. If a parachute were to land near a Guadalupe fur seal, the seal could become entangled. Since the unrecovered fairing drogue parachute or parafoil would sink fairly rapidly following water impact, the material would not be available for entanglement except for a short period of time during its descent to the ocean floor. Upon reaching the sea floor, Guadalupe fur seal would not interact with the material as the seals would not be engaged in foraging behaviors at that depth, and, consequently, would be located higher in the water column. Although Dragon parachutes float, there is a high chance of SpaceX recovering the parachutes soon after Dragon splashes down in the ocean, and therefore a low chance of a Guadalupe fur seal encountering a parachute. Also, the infrequent nature of the action renders the probability of a Guadalupe fur seal encountering a parachute or parafoil a highly unlikely event.

Given that we have found it extremely unlikely for ESA-listed species to be struck by the fairings and drogue parachute assembly, we also expect animals investigating and becoming entangled in the accompanying parafoils or the drogue parachute assembly during the hour or so they are at or near the surface of the water to be similarly unlikely, and therefore discountable.

Effects of Weather Balloon and Radiosonde Deployment

Similar to the anticipated effects from Dragon and fairing recovery operations, the deployment of weather balloons and attached radiosondes could affect species through directly landing on or striking an individual, entanglement or ingestion (Hoss and Settle 1990; Baulch and Perry 2014; Schuyler et al. 2012). However, a direct strike of an animal would be extremely unlikely for all of the reasons previously discussed. Because many species considered in this analysis swim below the ocean surface, the small size and weight of the radiosonde (e.g., milk carton) and the descent velocities of the sinking components are such that an animal could swim either vertically or laterally out of the way, thereby reducing the effect on the animal to a brief behavioral disruption such as a startle and/or avoidance response. Interactions with a sunken radiosonde were previously discussed in the section regarding fairing recovery operations. Entanglement or attempted ingestion of the balloon fragments would also be unlikely for similar reasons, but also because the latex balloons are expected to break into small fragments, thereby reducing the chance that they would be of a size that poses a risk to species.

Commonly cited research (Burchette 1989) asserts that nearly all latex balloons at burst altitude rupture into small, ribbon-like fragments. According to Burchett (1989), results show the balloon rises to a height of about 28,000 ft (5 miles) where the volume increases to the point where the elastic limit of the rubber is reached. The temperature at this altitude is approximately 40 degrees Fahrenheit (°F) below zero. Under these conditions of extreme elongation and low temperature, the balloon undergoes "brittle fracture" where the rubber actually shatters along grain boundaries of crystallized segments. The resultant pieces of rubber are small strands comparable to the size of a quarter (Burchette 1989) from an 11-inch diameter balloon. Similar findings were recently obtained by researchers at the University of Colorado and NOAA (University of Colorado and NOAA 2017). As such, it is assumed the weather balloons would land in the ocean in small shreds, although no information is available on the size of the shreds from weather balloons which are four times the size of the latex balloons studied by Burchette (1989).

These balloon pieces would be positively buoyant, float on the surface, and begin to photo-oxidize due to ultraviolet light exposure. Degradation would occur at a slower rate than on land due to less heat buildup and the biofouling. Numerous studies show latex in water will degrade, losing tensile strength and integrity, though this process can require multiple months of exposure time (Pegram and Andrady 1989; Andrady 1990; Irwin 2012). In addition, field tests conducted by Burchette (1989) showed latex rubber balloons are very degradable on exposure in the environment under a broad range of exposure conditions, including exposure to sunlight and weathering, exposure to water, and exposure to soil. The balloon samples showed significant degradation after six weeks of exposure (Burchette 1989).

As the latex balloon fragments float on the surface, they would become a substrate for microflora, such as algae, and eventually become weighted down with heavy-bodied epifauna, such as tunicates (Foley 1990). In addition to further degradation of the latex material, the embedded organisms would cause the material to become negatively buoyant, making it slowly sink to the ocean floor. The degree to which such colonization would occur would correspond to the amount of time the balloon would remain at or near the ocean's surface. Additionally, an area's geographic latitude (and corresponding climatic conditions) has been shown to have a marked effect on the degree of biofouling on marine debris. Studies in temperate waters have shown that fouling can result in positively buoyant materials (e.g., plastics) becoming neutrally buoyant, sinking below the surface into the water column after only several weeks of exposure (Ye and Andrady 1991; Lobelle and Cunliffe 2011), or descending farther to rest on the seafloor (Thompson et al. 2004).

The ingestion of plastic materials, especially in significant quantities is of concern for the health and survival of a wide range of marine species. Over the course of the SpaceX Program from 2017-2024, we expect approximately 1,000 weather balloons (four per mission; see Table 3 for annual numbers), will be released from either the droneship or fairing recovery operations. While we do not know the exact landing location of the disintegrated fragments of these balloons and their accompanying radiosonde, we do expect that they will be dispersed over areas of the ocean in the general vicinity of their release location. Given the expected fate and size of the weather balloon material shreds we do not anticipate that accidental ingestion of a latex shred will harm marine mammals, sea turtles, or fishes through impaction of their digestive systems (Irwin 2012). Because these shreds should also only be available in the upper portions of the water column on the order of weeks, we also expect the potential exposure of these shreds to ESA-listed marine species to also be of similar duration.

For these reasons, and since the radiosonde itself is expected to quickly sink to the bottom after splashdown, there is an extremely low chance that an ESA-listed marine species would encounter and ingest latex shreds from the SpaceX weather balloons. Moreover, in the unlikely event an animal should ingest a small piece of latex, the minimal to no impact we expect from such ingestion, we find the weather balloon and radiosonde release impacts to be both discountable and insignificant.

Effects from a Sonic Boom

The sonic boom produced during a Dragon reentry may affect animals located on land (in-air) or underwater. The sound produced from a sonic boom is not expected to transmit from air through water (discussed further below); therefore, the only marine mammal with the potential to be affected by an in-air sonic boom would be the Guadalupe fur seal, from the Dragon reentry operations that would occur over the Pacific Ocean. However, any sonic boom generated during Dragon reentry, would be generated at an altitude of approximately 55,000–65,000 ft in the air. SpaceX conducted a sonic boom analysis for Dragon-1 landings at CCAFS using the single-event prediction model, PCBOOM (BRRC 2015). Based on the analysis and the fact that the reentry trajectories (Mach, altitude, and angle-of-attack profiles) are the same between sites, a maximum predicted sonic boom overpressure of 0.41 pound per square foot (psf) could be expected. This peak overpressure could extend approximately 19 miles from the splashdown site. An overpressure of 0.35 psf could extend approximately 50 miles from the splashdown site. For comparison, an overpressure of 1.0 psf is similar to a thunder clap. For these reasons, a sonic boom is unlikely to injure a fur seal; at most a sonic boom may potentially result in a short-duration startle response. NMFS' current in-air acoustic threshold for pinnipeds (except for harbor seals) is 100 dBA RMS re: 1 μPa.

All of the sonic boom pressure signals measured in an experiment conducted by Sohn et al. (2000) decayed to ambient levels in all frequency bands by 40-50 m (131-164 ft). Therefore, the amount of pressure that would damage hearing for Guadalupe fur seals would decay to non-harmful levels before reaching areas on land where seals may be hauled-out. Moreover, 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*). These species are considered more skittish than Guadalupe fur seals, thus Guadlaupe fur seals are less likely to be disturbed by sonic booms compared to harbor seals or California sea lions as they are rarely observed showing any kind of behavioral reaction even when harbor seals or California sea lions have reacted to a sonic boom (NMFS 2016).

For animals located underwater, the overpressures from the sonic boom are not expected travel through the water column and affect and marine species underwater. Acoustic energy from in-air noise does not effectively cross the air/water interface; therefore, most of the noise is reflected off the water surface (Richardson 1995). In addition, underwater sound pressure levels from in-air noise are not expected to reach or exceed threshold levels for injury to any marine species. Previous research conducted by the USAF supports this conclusion with respect to sonic booms, indicating there is no risk of harassment for protected marine species in water (U.S. Air Force Research Laboratory 2000). Therefore, sonic booms would have no effect on ESA-listed marine species located underwater. Therefore, we consider the effect on ESA-listed species from sonic boom exposure to be insignificant and discountable.

In summary, based on the discussion above, the stressors associated with the SpaceX Program such as direct striking of an individual by rocket, fairings or radiosondes, and/or ingestion, entanglement from parachutes, parafoils, weather balloon materials and lines, and acoustic effects from the sonic boom exposure present a very low risk to species present in the action area. Because of this we determined all of the potential stressors affecting ESA-listed and proposed for listing species to be insignificant or discountable.

Effects on Designated Critical Habitats in the Action Area.

Within the Atlantic Ocean and Gulf of Mexico Recovery Zones, designated critical habitat exists for the North Atlantic right whale, the Northwest Atlantic Ocean DPS of the loggerhead sea turtle and gulf sturgeon.

For the North Atlantic Right Whale, two units of critical habitat have been designated (Unit 1 and Unit 2). Unit 1 does not occur in the action area. Unit 2 is for calving and consists of all marine waters from Cape Fear, North Carolina, southward to approximately 27 nautical miles below Cape Canaveral, Florida. Unit 2 occurs off the coast of CCAFS and extends seaward approximately five nautical miles off the coast north of CCAFS. Unit 2 contains essential features such as sea surface conditions and suitable water depths for calving, nursing, and rearing. However, none of the proposed actions will have any effect on these conditions (such as temperature and water depth) and because the action area is designed to avoid these areas (the "bulb", Figure 6) to the greatest extent possible, we do not expect any of the essential features of critical habitat for the North Atlantic Right Whale will be adversely affected by the proposed action.

Within the Gulf of Mexico Recovery Zone, designated critical habitat for the Northwest Atlantic Ocean Distinct Population Segment of the loggerhead sea turtle is also present These areas of habitat include overlapping areas of nearshore reproductive habitat, constricted migratory habitat, breeding habitat, and Sargassum habitat. Since the landing/splashdown area begins five nautical miles offshore, nearshore reproductive habitat is not considered within the planned landing/splashdown areas. Portions of this critical habitat are primarily Sargassum (a type of algae) habitat utilized by juvenile loggerheads for foraging and development. None of the activities proposed for the SpaceX missions occurring within critical habitat are expected to adversely affect these essential features. Therefore, no adverse effects on loggerhead turtle habitat is expected from the proposed action in the Gulf of Mexico Recovery Zone.

For the gulf sturgeon, critical habitat is present in units 8-14 within the Gulf of Mexico. This includes 2,333 square miles of estuarine and marine habitat. Most subadult and adult gulf sturgeon spend cool months (October or November through March or April) in estuarine areas, bays, or in the Gulf of Mexico. They are known to utilize these areas for staging, resting and foraging. The PCEs within the action area include areas with abundant prey items and substrates necessary to support subadult and adult life stages. Additional PCEs include water quality and sediment quality parameters necessary for normal behavior, growth, and viability of all life stages; and safe and unobstructed migratory pathways necessary for passage within and between riverine, estuarine, and marine habitats. However, none of the proposed activities are anticipated to affect prey availability, substrates, water quality parameters or migratory pathways since the only stressors anticipated to occur are direct strike, entanglement and ingestion of materials associated with the missions (described in the Effects on ESA-listed Species in the Action Area), which were all determined to be insignificant or discountable. Therefore, NMFS does not expect any critical habitat for gulf sturgeon to be adversely affected by the proposed actions.

Within the Pacific Ocean Recovery Zone, designated critical habitat exists for the endangered North Pacific right whale, leatherback sea turtles, Southern Resident killer whales, and the southern DPS of North American green sturgeon. Critical habitat has not been designated or proposed for the other ESA-listed marine mammals, ESA-listed fishes, green sea turtles, loggerhead sea turtles, olive ridley sea turtles, and hawksbill sea turtles in the Pacific Ocean action area; therefore, none was analyzed in this consultation.

The portions of the action area that possesses critical habitat for North Pacific Right whales is a very small section of the immense recovery zone (a small area spanning from 40° to 55° N and 120° W to 159° E). The area of critical habitat in this area is essential for foraging of right whales. However, these areas of the action area are primarily planned for Dragon landings, which are anticipated to be infrequent and will have a low probability of affecting that portion of the action area since this habitat is located closer to the shoreline and most Dragon landings are expected to occur beyond five nautical miles in deep waters, and therefore discountable.

Critical habitat within the action area for the Southern Resident killer whales contains PCEs associated with water quality to support growth and development, prey availability for growth, reproduction and development, and overall population growth; and passage conditions to allow for migration, resting, and foraging. None of the stressors associated with the proposed action are expected to affect these PCEs. And, because the stressors described in the *Effects of the Action on ESA-listed Species in the Action Area* were all found to be insignificant or discountable, none of the activities are expected to adversely affect critical habitat for the Southern Resident killer whale.

Leatherback sea turtle critical habitat also is present in the Pacific Ocean Recovery Zone action area. 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 within the action area. For these reasons, NMFS concludes that the proposed action is not likely to adversely affect critical habitat for leatherback sea turtles.

For the southern DPS of North American green sturgeon, the designated critical habitat would be in coastal waters extending along the west coast between coastal U.S. marine waters within 60 fathoms depth (110 m) from Monterey Bay, California (including Monterey Bay), north to Cape Flattery, Washington, including the Strait of Juan de Fuca, Washington, to its United States boundary. For the reasons described in the *Effects of the*

Action on ESA-listed Species in the Action Area section, none of the stressors associated with the project activities are expected to adversely affect critical habitat for green sturgeon.

In addition, the effects of the proposed action on critical habitats in any of the ocean areas are reasonably likely to include small areas of disturbance in the water column as the rocket components land and begin to sink, and finally small areas of substrate disturbance resulting in brief increases in turbidity if a fairing half or radiosonde lands in the shallower waters. However, should these impacts occur, the effects and duration are expected to be very minor and temporary. Therefore, the effects on critical habitat from sinking and settling of rocket and fairing components are expected to be insignificant and discountable.

In summary, based on the discussion above, the stressors associated with the SpaceX Program that may affect designated critical habitats in the action areas present a very low risk and are not expected to result in any long term effects on habitats or adversely affect the PCEs for each species' habitats. For these reasons, NMFS determined all of the potential stressors affecting designated critical habitats to be insignificant or discountable.

Conclusion

After reviewing the information described in the August 25, 2017 Biological Evaluation for the SpaceX Program, additional information submitted by the FAA via emails and conference calls occurring between June and September 2017, previous NMFS letters of concurrence issued for the program missions in 2016, current status of the ESA-listed and proposed species and designated critical habitat, as well as the probable effects of the action, NMFS concurs with the FAA's determination that the SpaceX Landing and Recovery Operations in the Atlantic Ocean, Pacific Ocean and Gulf of Mexico, are not likely to adversely affect threatened and endangered species or adversely modify designated critical habitat.

Reinitiation of Consultation

Reinitiation of consultation is required and shall be requested by the FAA 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 ESA consultation.

Please direct questions regarding this letter to the NMFS Office of Protected Resources, Ms. Jacqueline Meyer (301) 427-8492 or jacqueline.pearson-meyer@noaa.gov.

Sincerely,

For Cathryn E. Tortorici
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Appendix C: Sonic Boom Modeling

Blue Ridge Research and Consulting, LLC

Technical Memo

Sonic Boom Noise Analysis for the SpaceX Dragon Reentry

May 29, 2015

Prepared for:
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1 Sonic Boom Modeling

SpaceX is proposing to land the Dragon capsule at two potential locations, Cape Canaveral Air Force Station (CCAFS), Florida and White Sands Missile Range (WSMR), New Mexico. This memo documents the sonic boom noise analysis for the two Dragon capsule reentry trajectories.

A vehicle creates sonic booms during supersonic flight. The potential for the boom to intercept the ground depends on the trajectory and speed of the vehicle as well as the atmospheric profile. The sonic boom is shaped by the physical characteristics of the vehicle and the atmospheric conditions through which it propagates. These factors affect the perception of a sonic boom. The noise is perceived as a deep double boom, with most of its energy concentrated in the low frequency range. Although sonic booms generally last less than one second, their potential for impact may be considerable.

The single-event prediction model, PCBoom4 (Plotkin, 1996; Plotkin, 1989; Plotkin, et al., 2002), is used to predict a sonic boom footprint. PCBoom4 calculates the magnitude and location of sonic boom overpressures on the ground from a vehicle in supersonic flight. Several inputs are required to calculate the sonic boom footprint, including the aircraft model, the trajectory path, the atmospheric conditions and the ground surface height. Predicted sonic boom footprints are generally presented as contours of constant peak overpressure (in terms of pounds per square foot, psf).

2 Noise Modeling Parameters

The PCBoom4 vehicle inputs include the vehicle length and vehicle weight. These parameters are summarized in Table 1 for the SpaceX Dragon capsule, specific to its reentry configuration. SpaceX personnel provided two reentry trajectories: one landing at CCAFS and the second at WSMR. The trajectory excel file provided, 'trajectories_for_blueridge_04282015.xlsx' contained the parameters time, latitude, longitude, altitude, Mach, heading, and flight path angle. Additional derivations required for PCBoom4 were calculated using the data provided. Site-specific atmospheric profiles were extended to the necessary altitudes and utilized for the following analysis.

Table 1. Vehicle parameters used in acoustic modeling

Vehicle	SpaceX Dragon
Length	14.2 ft
Total Weight	21,000 lbs

3 Results

The peak overpressure contours resulting from the nominal reentry trajectories of the Dragon capsule are shown in Figure 1 and Figure 2 for CCAFS and WSMR, respectively. The maximum predicted sonic boom overpressure is 0.41 psf for CCAFS and 0.37 psf for WSMR. The proposed operational tempo includes two nighttime landings and four daytime landings. The maximum noise exposure associated with the proposed operational tempo and max psf is predicted to be a C-weighted DNL of 33 dBC for CCAFS and 32 dBC for WSMR, which translates to an equivalent A-weighted DNL of 38.5 dBA for CCAFS and 37.5 dBA for WSMR, according to ANSI 12.9 Part 4 Annex B.

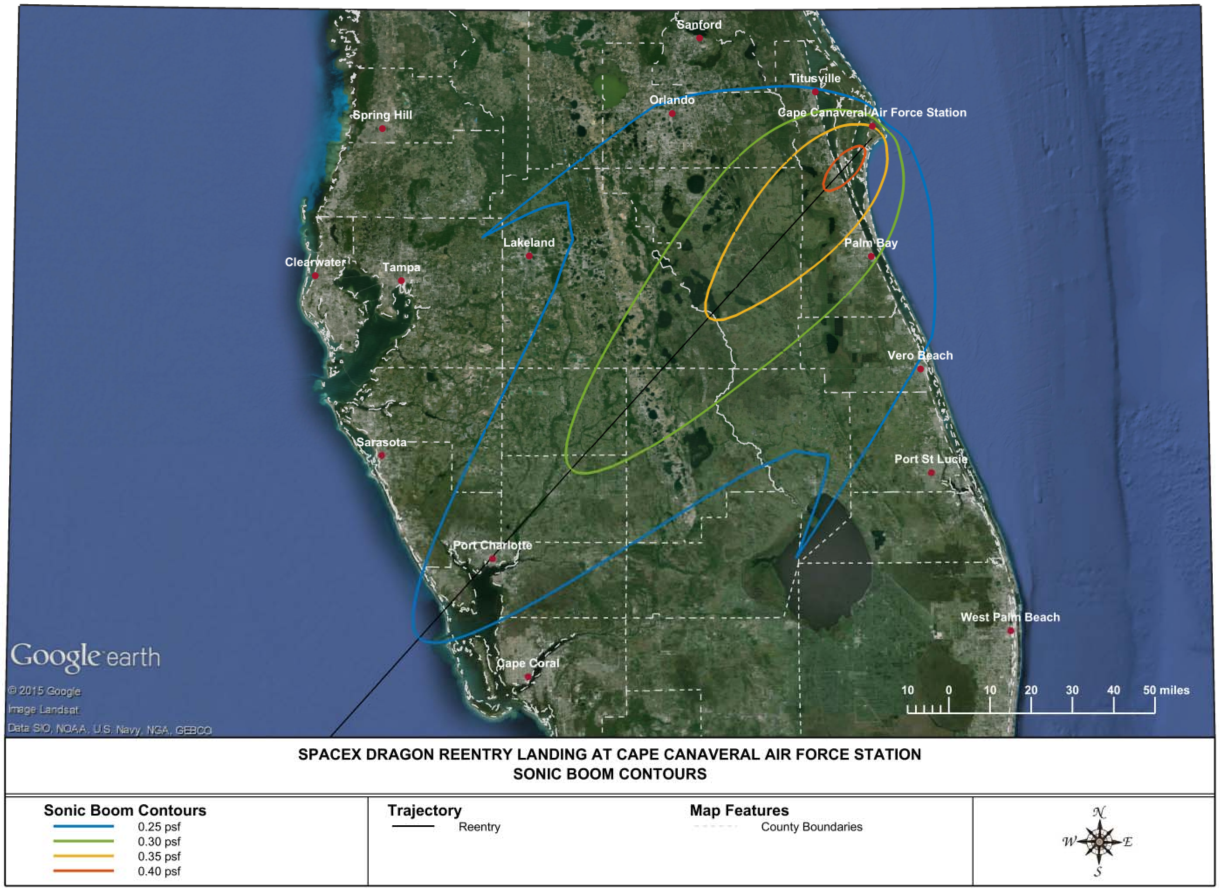

Figure 1. Sonic boom peak overpressure contours resulting from Dragon reentry to CCAFS

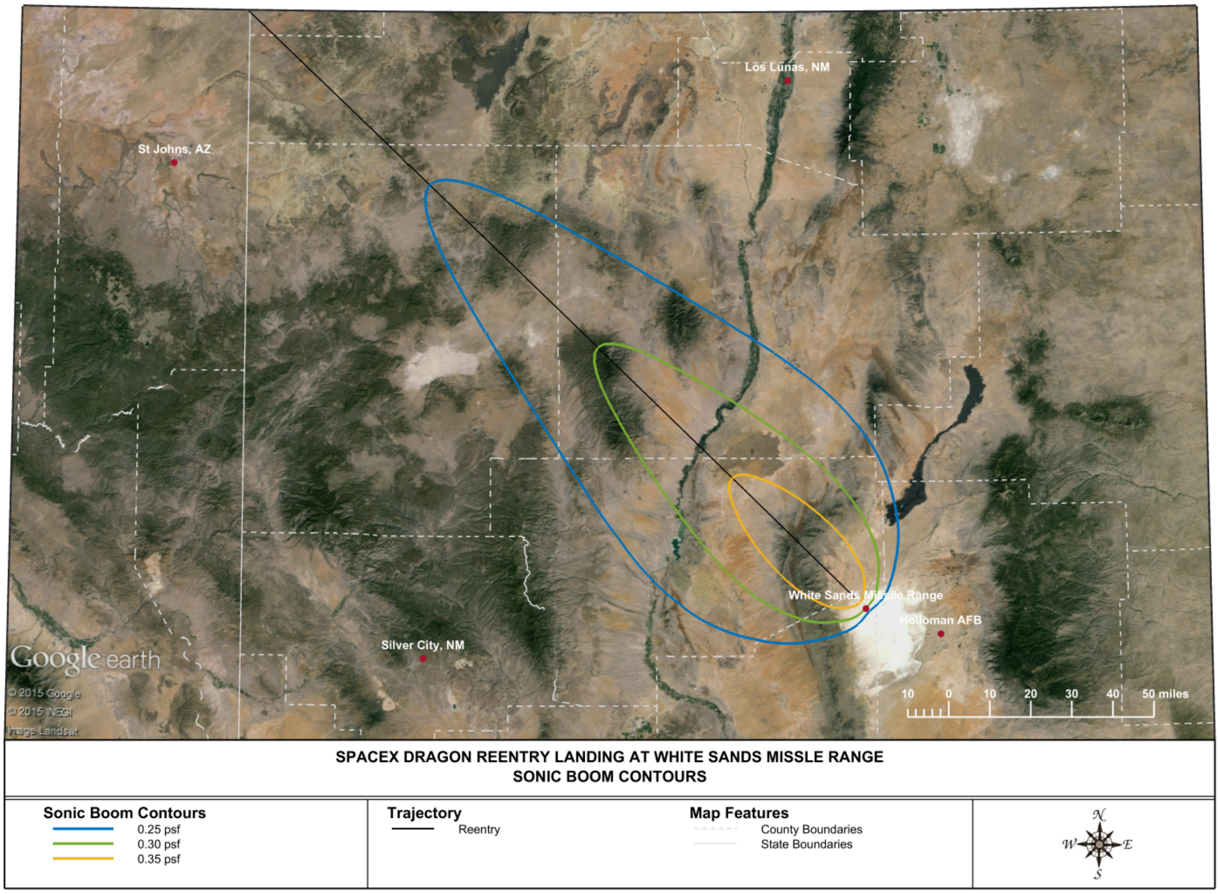

Figure 2. Sonic boom peak overpressure contours resulting from Dragon reentry to White Sands Missile Range

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Appendix D: Public Comments and FAA Responses

Klewicki, Laura

From: Thomas Stagliano <tstag@ix.netcom.com>
Sent: Friday, April 06, 2018 8:49 AM
To: Dragon_Gulf_Landing_EA
Subject: Dragon SpaceX capsule should Not be allowed to land in the Gulf of Mexico

Regardless of the "Environmental" discussions, for many years (since the creation of the FAA/AST) **commercial** reentry vehicles are Not certified. They are licensed to reenter and land in such a fashion that they provide an Extremely low probability of injuring or killing any people on the surface of the Earth or hitting and damaging any human constructed facilities,ships or airplanes.

To land in the Gulf of Mexico would require the Dragon capsule to over-fly Mexico and/or parts of Texas.

The FAA/AST has Always assumed that a licensed reentry vehicle will have a 100% probability of Failure and will break-up and crash at any point along its ground track.

Because the ground track of the Dragon would take the capsule over heavily populated areas of Mexico and/or Texas, plus over platforms in the Gulf of Mexico, there is No way that the FAA/AST can Guarantee that its Required minimal probability of injuring or killing people will be met.

Therefore, the FAA must dis-allow this license to land the Dragon capsule in the Gulf of Mexico.

Thank you.

- Tom

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FAA Response to the Public Comment

As part of reviewing a reentry license application, the FAA conducts a safety review to determine whether an applicant is capable of reentering a reentry vehicle and payload, if any, to a designated reentry site without jeopardizing public health and safety and the safety of property. A safety approval is part of the licensing record on which the licensing determination is based. To obtain safety approval for reentry, an applicant must demonstrate the following for public risk:

- The risk to the collective members of the public from the proposed launch meets the public risk criteria of 14 CFR §417.107(b)(1);
- The risk level to the collective members of the public, excluding persons in water-borne vessels and aircraft, from each proposed reentry does not exceed an expected number of 1×10^{-4} casualties from impacting inert and explosive debris and toxic release associated with the reentry; and
- The risk level to an individual does not exceed 1×10^{-6} probability of casualty per mission.