



Federal Aviation
Administration

Draft Environmental Assessment for Issuing SpaceX a Launch License for an In-flight Dragon Abort Test, Kennedy Space Center, Brevard County, Florida

November 2018



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AGENCIES: Federal Aviation Administration (FAA), lead Federal agency; National Aeronautics and Space Administration (NASA) and U.S. Air Force, cooperating agencies.

This Draft Environmental Assessment (EA) is submitted for review pursuant to section 102(2)(C) of the National Environmental Policy Act (NEPA) of 1969, as amended (42 United States Code 4321, et seq.), Council on Environmental Quality NEPA implementing regulations (40 Code of Federal Regulations Parts 1500 to 1508), and FAA Order 1050.1F, *Environmental Impacts: Policies and Procedures*.

DEPARTMENT OF TRANSPORTATION, FEDERAL AVIATION ADMINISTRATION: SpaceX has applied to the FAA for a launch license to conduct a one-time in-flight Dragon abort test at Kennedy Space Center's Launch Complex 39A. The FAA's proposal to issue a launch license to SpaceX is considered a major federal action subject to environmental review under NEPA. SpaceX is proposing to conduct the abort test using a Falcon 9 (Block 5) launch vehicle and a Dragon-2 (i.e., SpaceX's crew version of Dragon). Dragon-2 was developed with the intent to carry astronauts. The proposed abort test is part of SpaceX's commercial crew certification process with NASA. The abort test is scheduled to occur in 2019.

The Draft EA evaluates the potential environmental impacts from the Proposed Action and No Action Alternative on the following impact categories: visual effects (including light emissions); coastal resources; air quality; climate; noise and noise-compatible land use; biological resources; water resources (surface waters); hazardous materials, solid waste, and pollution prevention; and historical, architectural, archeological, and cultural resources. Potential cumulative impacts are also addressed in the Draft EA.

PUBLIC REVIEW PROCESS: In accordance with the applicable requirements, the FAA is initiating a public review and comment period for the Draft EA. The 30-day public comment period for the NEPA process begins with the publication of the Draft EA. Comments are due on December 31, 2018.

CONTACT INFORMATION: To submit comments on the Draft EA or ask questions, please contact Mr. Daniel Czelusniak, Environmental Protection Specialist, Federal Aviation Administration, 800 Independence Avenue, SW, Suite 325, Washington, DC 20591; email SpaceXDragonAbortEA@icf.com.

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

Responsible FAA Official:



Kelvin Coleman

Date: Nov. 15, 2018

Acting Associate Administrator for Commercial Space Transportation

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1 INTRODUCTION

Founded in 2002, SpaceX Exploration Technologies Corporation (SpaceX) is a space transportation and technology company headquartered in Hawthorne, California. SpaceX currently operates their Falcon family of launch vehicles, which includes the Falcon 9 and the Falcon Heavy, from launch complexes at Kennedy Space Center (KSC), Florida, Cape Canaveral Air Force Station (CCAFS), Florida, and Vandenberg Air Force Base (VAFB), California. All Falcon 9 and Falcon Heavy launch vehicles have payloads, including satellites, experimental payloads, and SpaceX's Dragon spacecraft (Dragon). 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 was developed with the intent to carry astronauts. Most launches are conducted for commercial clients; however, some are government-sponsored launches. SpaceX first launched the Falcon 9 at CCAFS on June 4, 2010 at Launch Complex 40 (LC-40). SpaceX has launched over 40 times from CCAFS, KSC, and VAFB. Some of SpaceX's Falcon 9 launch missions have included boost-back and landing of the first stage booster. SpaceX has conducted over 15 boost-backs and landings, with the landing occurring either on SpaceX's dronship (a special-purpose barge) in the Atlantic Ocean or Pacific Ocean, or on land at Landing Zones 1 and 2 (LZ-1 and LZ-2), CCAFS.

SpaceX is applying to the FAA's Office of Commercial Space Transportation for a new launch license for an in-flight Dragon abort test conducted at KSC's LC-39A. The proposed abort test is being conducted as part of SpaceX's commercial crew certification process with NASA and using NASA's facilities. The FAA's proposed issuance of a license (the Proposed Action) is subject to environmental review under the National Environmental Policy Act (NEPA) as amended (42 United States Code [U.S.C.] § 4321, et seq.). This EA evaluates the potential environmental impacts associated with a one-time in-flight Dragon abort test. As the lead federal agency, the FAA prepared this EA in accordance with NEPA, Council on Environmental Quality (CEQ) NEPA-implementing regulations (40 Code of Federal Regulations [CFR] Parts 1500–1508), and FAA Order 1050.1F, *Environmental Impacts: Policies and Procedures*. The National Aeronautics and Space Administration (NASA) and U.S. Air Force (USAF) are cooperating agencies in the development of this EA (see Section 1.2 for a description of agency roles).

1.1 LOCATION AND BACKGROUND

KSC is located midway between Miami and Jacksonville on Florida's Space Coast on Merritt Island, Florida, and is north-northwest of Cape Canaveral on the Atlantic Ocean. KSC is approximately 34 miles long and roughly six miles wide, covering 219 square miles (see Figure 1-1). NASA manages a myriad of space-related operations at KSC. Currently, SpaceX launches the Falcon 9 from LC-39A, which has previously supported Space Shuttle launches. In addition to launching the Falcon 9 at LC-39A, SpaceX launched the Falcon Heavy for the first time from LC-39A on February 6, 2018.

LC-39A construction was started in 1965 and completed in 1966 to support the Apollo Program. It was later modified for the Shuttle Program. The launch complex has been used for rocket and Shuttle launch purposes, including operations and maintenance support. NASA prepared an EA in 2013 to increase KSC spaceport capabilities and allow both commercial and governmental entities to use LC-39A and LC-39B

for launch purposes using a variety of vertical launch vehicles, including Falcon launch vehicles (NASA 2013). The FAA was a cooperating agency for the NASA 2013 EA. In 2015, NASA granted a lease to SpaceX to operate at LC-39A and construct a horizontal integration facility. Additional components of SpaceX activities at LC-39A were reviewed by NASA via NASA's Environmental Checklist and Record of Environmental Consideration process.¹ SpaceX successfully launched the first of several Falcon 9 vehicles at LC-39A on February 19, 2017, and launched the Falcon Heavy for the first time on February 6, 2018.

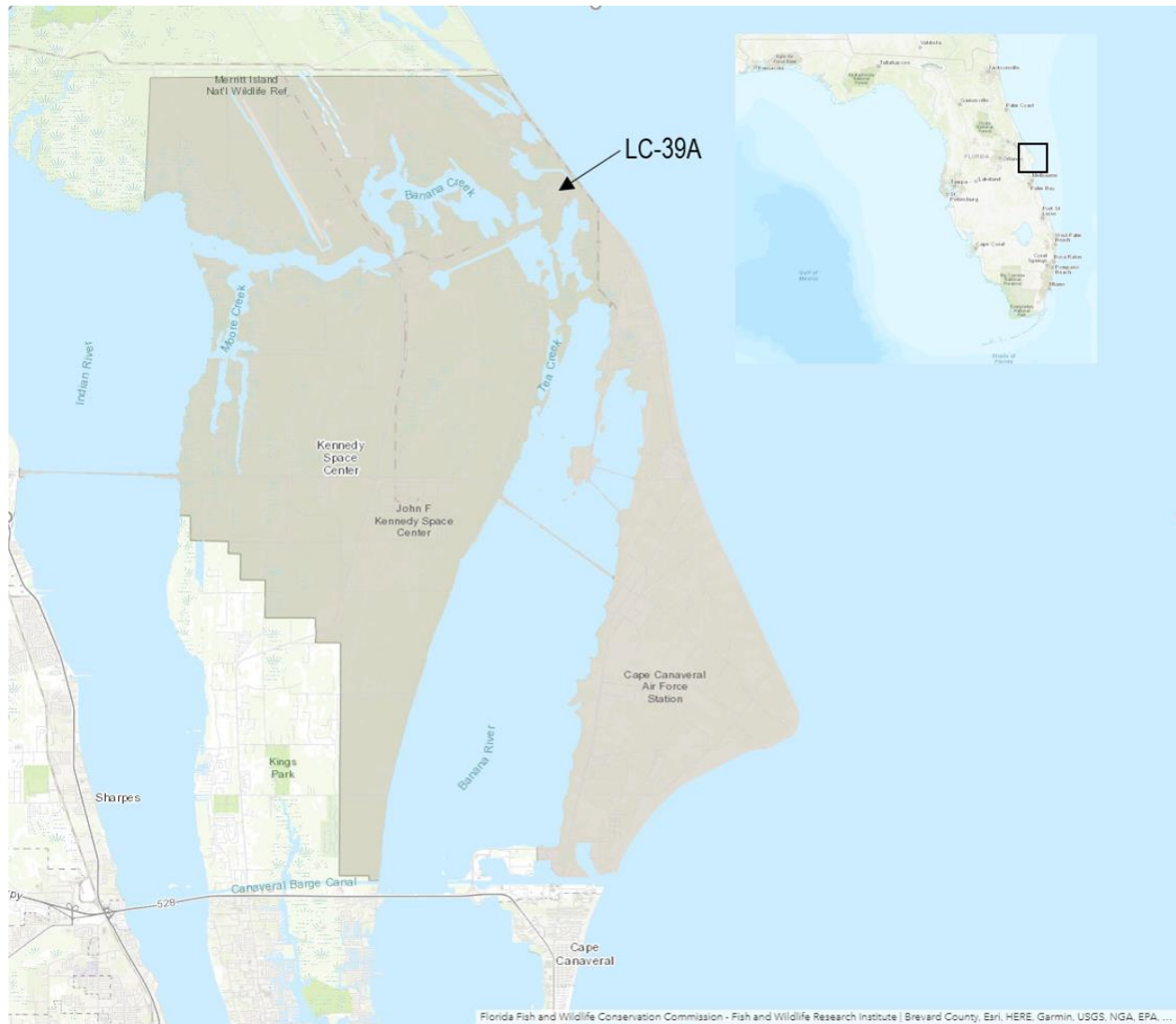


Figure 1-1. Kennedy Space Center Map

1.2 FEDERAL AGENCY ROLES

1.2.1 FAA OFFICE OF COMMERCIAL SPACE TRANSPORTATION

As the lead Federal agency, the FAA is responsible for analyzing the potential environmental impacts of the Proposed Action. As authorized by chapter 509 of Title 51 of the U.S. Code, the FAA licenses and

¹ NASA documents use of categorical exclusions in a form called a Record of Environmental Consideration (see NASA Procedural Requirement 8580.1).

regulates U.S. commercial space launch and reentry activity, as well as the operation of non-federal launch and reentry sites. The mission of the 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 during commercial launch or reentry activities, and to encourage, facilitate, and promote U.S. commercial space transportation.

1.2.2 COOPERATING AGENCIES

As defined in 40 CFR §1508.5, a cooperating agency may be any federal agency other than the lead agency that has jurisdiction by law or special expertise with respect to the environmental impacts expected to result from a proposal. An agency has “jurisdiction by law” if it has the authority to approve, veto, or finance all or part of the proposal (40 CFR §1508.15). An agency has “special expertise” if it has statutory responsibility, agency mission, or related program experience with regards to a proposal (40 CFR §1508.26). A lead agency must request the participation of cooperating agencies as early as possible in the NEPA process, use the environmental analyses and proposals prepared by cooperating agencies as much as possible, and meet with cooperating agencies at their request (40 CFR §1501.6[a]).

The FAA requested the participation of NASA and USAF (45th Space Wing) as cooperating agencies in the preparation of this EA due to their jurisdiction by law and special expertise. LC-39A is located on NASA’s KSC property and the KSC Center Director has ultimate responsibility for all operations that occur on KSC property. Additionally, NASA provides special expertise with respect to environmental issues concerning space launch vehicles, especially crewed capsules like the Dragon-2. The 45th Space Wing has a special interest and specific expertise with regards to all activities located at or near CCAFS. The 45th Space Wing also has interest in managing their local environmental related activities performed by their growing number of other tenants at CCAFS who may be affected by any proposed actions.

1.3 PURPOSE AND NEED

The purpose and need provide the foundation for identifying intended results or benefits and future conditions. The purpose and need can help define the range of reasonable alternatives to a proposed action. According to FAA Order 1050.1F, Paragraph 6-2.1(c), the purpose and need presents the problem being addressed and describes what the FAA is trying to achieve with the Proposed Action.

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 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).

1.3.2 SPACEX’S PURPOSE AND NEED

The purpose of SpaceX’s proposal to conduct the in-flight Dragon abort test is to continue to support missions for NASA, as well as to conduct business with commercial customers. SpaceX’s proposal is needed to demonstrate the Dragon launch abort system and to facilitate meeting NASA’s human certification plan requirements. SpaceX’s proposal provides greater capability in its mission to support the ISS and other commercial enterprises. SpaceX’s activities continue to fulfill the United States’ expectation that space transportation costs are reduced to make continued exploration, development, and use of space more affordable. The Space Transportation section of the National Space Transportation Policy of 1994 addressed the commercial launch sector, stating that “assuring reliable and affordable access to space through U.S. space transportation capabilities is fundamental to achieving National Space Policy goals.”

1.4 PUBLIC INVOLVEMENT

In accordance with CEQ’s NEPA-implementing regulations and FAA Order 1050.1F, the FAA has made this Draft EA available for public review for a 30-day period. Interested parties are invited to submit comments on the Draft EA on or before December 31, 2018. Before including your address, phone number, e-mail address, or other personal identifying information in your comment, be advised that your entire comment—including your personal identifying information—may be made publicly available at any time. While you can ask us in your comment to withhold from public review your personal identifying information, we cannot guarantee that we will be able to do so.

The FAA provided public notice of the availability of the Draft EA for public review and comment through the *Federal Register*. Chapter 7 contains a list of agencies that received notification of the Draft EA. An electronic version of the Draft EA is available on the FAA’s website.²

Following the close of the public comment period, the FAA will revise the EA, as necessary, in response to comments received on the draft document, and a Final EA will be prepared. The Final EA will reflect the FAA’s consideration of comments and will provide responses to substantive comments, as necessary. Following review of the Final EA, the FAA will either issue a Finding of No Significant Impact (FONSI) or decide to prepare an Environmental Impact Statement (EIS).

² https://www.faa.gov/about/office_org/headquarters_offices/ast/environmental/nepa_docs/review/launch/.

2 DESCRIPTION OF THE PROPOSED ACTION AND ALTERNATIVES

This chapter describes the Proposed Action (Section 2.1), the No Action Alternative (Section 2.2), and alternatives considered but not carried forward for further analysis (Section 2.3).

2.1 PROPOSED ACTION

The FAA is proposing to issue a new launch license to SpaceX to perform a one-time in-flight Dragon abort test (hereafter referred to as the abort test) from LC-39A. An overview of the abort test and the descriptions of the various launch components and features are provided in the following sections.

2.1.1 ABORT TEST OVERVIEW

As part of SpaceX's commercial crew certification process with NASA, SpaceX proposes to conduct an abort test. The abort test is currently scheduled for 2019. The abort test would involve observation, photography, and debris management associated with the breakup of the Falcon 9 first and second stages.

The purpose of the abort test is to demonstrate the Dragon launch abort system and to facilitate meeting NASA's human certification plan requirements. The launch scenario where an abort is initiated during the ascent trajectory at the maximum dynamic pressure (known as max Q) is a design driver for the launch abort system. It dictates the highest thrust and minimum relative acceleration required between Falcon 9 and the aborting Dragon. As the in-flight abort would occur during the first stage portion of the launch trajectory, the second stage of Falcon 9 would be simplified (see Section 2.1.3).

The abort test would be conducted from LC-39A. The integration and processing flow of Dragon and Falcon 9 would be similar to that of a standard Dragon launch. Dragon would be integrated vertically with the trunk and then rotated to horizontal position and mated to the second stage of Falcon 9 while in the transporter-erector. The vehicle would then be rolled out to the pad and moved to a vertical position.

The abort test would start with a nominal launch countdown and release at T-0. The Falcon 9 with the Dragon attached would follow a standard ISS trajectory with the exception of launch azimuth to approximately Mach 1. The Falcon 9 would be configured to shut down and terminate thrust, targeting the abort test shutdown condition (simulating a loss of thrust scenario). Dragon would then autonomously detect and issue an abort command, which would initiate the nominal startup sequence of Dragon's SuperDraco engine system. Concurrently, Falcon 9 would receive a command from Dragon to terminate thrust on the nine first stage Merlin 1D (M1D) engines. Dragon would then separate from Falcon 9 at the interface between the trunk and the second stage, with a frangible nut system. Under these conditions, the Falcon 9 vehicle would become uncontrollable and would break apart. SpaceX would not attempt first stage booster flyback to KSC, CCAFS, or a dronship, nor would they attempt to fly the booster to orbit.

Dragon would fly until SuperDraco burnout and then coast until reaching apogee, at which point the trunk would be jettisoned. Draco thrusters would be used to reorient Dragon to entry attitude. Dragon

would descend back toward Earth and initiate the drogue parachute deployment sequence at approximately 6 miles altitude and main parachute deployment at approximately 1 mile altitude. Dragon recovery operations would be very similar to actions for normal Dragon reentry and recovery (USAF 2013), although Dragon recovery during the abort test would occur approximately 9–42 miles from shore, and normal Dragon recovery is approximately 200 miles offshore (see Section 2.8.1). The recovery vessel would recover all parachutes deployed by Dragon, as possible, including the two drogue and four main parachutes. Recovery of the drogue parachute assembly would be 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, because of 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.

2.1.2 DRAGON TEST VEHICLE

SpaceX has developed Dragon to deliver cargo and experiments to the ISS and Low Earth Orbit (Dragon-1) and to transport astronauts to the ISS (Dragon-2) (Figure 2-1). Dragon weighs approximately 17,000 pounds without cargo and is approximately 17 feet tall with a base width of 13 feet. Dragon-2 is composed of the capsule for pressurized crew and cargo, the unpressurized cargo module or “trunk,” 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. The thermal protection structure supports secondary structures including the SuperDraco engines, propellant tanks, pressurant tanks, parachute system, and necessary avionics.

The Dragon test vehicle is intended to represent the final flight configuration of Dragon-2. Systems, subsystems, and components critical to the success of in-flight abort would be in the final configuration. Non-critical systems would either be eliminated or simplified to reduce the complexity of the ground refurbishment process to conduct the abort test. Dragon would contain approximately 5,650 pounds of hypergolic propellant, including approximately 3,500 pounds of dinitrogen tetroxide (NTO) and 2,150 pounds of monomethylhydrazine (MMH). Dragon would contain approximately 2,400 pounds of residual propellant after the abort test.

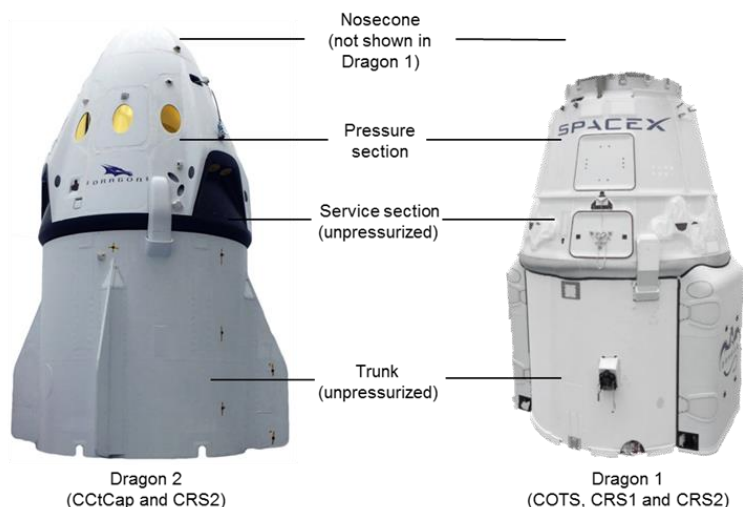


Figure 2-1. Dragon-1 and Dragon-2

2.1.3 FALCON 9

A Falcon 9 (Block 5) first stage booster would be used for the abort test (Figure 2-2). The booster would be a standard Falcon 9 first stage and configured in an expendable configuration for the abort test. Landing legs and grid fins would be removed. No booster recovery burns would be attempted. As such, a full triethylaluminum-triethylborane (TEA-TEB) mixture used as a first and second stage ignitor would not be used. The booster would be capable of flying a mission profile that allows for the target abort velocity to be achieved. The booster would include nine M1D engines and be configured to perform an ascent abort shutdown. Each engine is propelled by liquid oxygen (LOX) and rocket fuel (RP-1; highly refined form of kerosene) and produces 190,000 pounds of thrust at sea level (for a total of 1.71 million pounds of thrust from all nine engines). The booster would carry the standard set of flight instrumentation.

The second stage would be a standard Falcon 9 second stage, with the exception of the M1D vacuum engine. The components essential to propellant loading operations would be carried, but the thrust chamber, turbopump, thrust vector control actuators, and other components required for performing second stage burns, would be omitted, as the mission concludes part-way through the first stage ascent burn. Propellant loading would follow standard loading operations for the second stage.

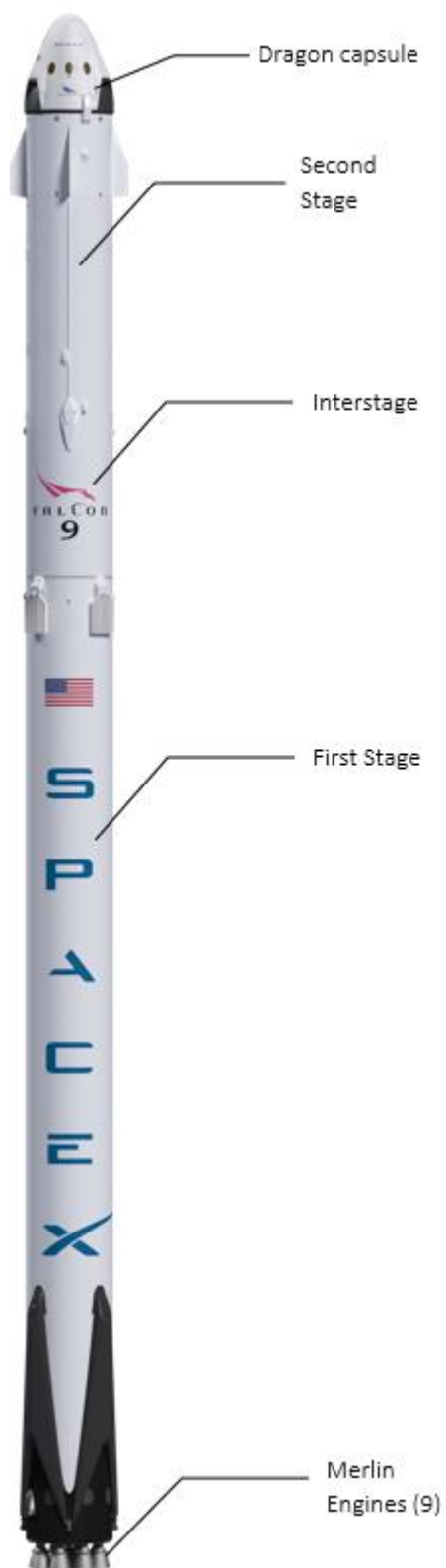


Figure 2-2. Falcon 9 Overview

2.1.4 FLIGHT TERMINATION

The baseline Autonomous Flight Safety System would be used, with destructors on both stages. Deviations from the crew configuration include no pyrovalve for thrust termination on the second stage. The qualified version of the safety system at the time of the abort test would be used.

2.1.5 PRE-TEST FALCON STATIC FIRE

With Falcon 9 on the launch pad, a short (few seconds) static fire test would be performed to verify the functional integrity of integrated ground systems and to verify integrated propellant loading operations. The static fire would be performed with Dragon onboard to ensure integrity of the Falcon 9-Dragon interface and interactions between the vehicles. The standard launch procedure would be followed, and launch automation would be used to load propellant on Falcon 9. The nine M1D engines would be started and brought to full power, and then shut down. Engine and vehicle health would be evaluated for nominal performance, after which safing operations would be conducted.

2.1.6 ABORT TEST SEQUENCE

During the initial flight of the Falcon 9 with the Dragon attached, the flight track would be normal. The separation of Dragon from Falcon 9 would occur approximately between 83 and 100 seconds after launch. Dragon and the trunk would separate from the second stage and continue to coast to its apogee, eventually dropping the trunk and deploying the drogue parachutes. At the point where Dragon and the trunk separate, the first and second stage would become unstable and break up approximately 2–4 miles down range from the shore. After the main chutes deploy, Dragon would drift approximately 3 miles and land approximately 9–42 miles from shore. Table 2-1 presents time and distance for each of the abort test events.

Table 2-1. Time and Distance of Dragon Abort Test Events

Event	Time [sec]	Altitude [miles]	Range Offshore [miles]	Mach [---]
Launch	0	0.01	0	0
Separation	83–100	9.1–17.3	1.37–3.9	1.5–2.5
1 st Stage Breakup	89.8–115	11–19.3	1.8–4.2	1.9–1.6
Jettison Trunk (Apogee)	125– 187.5	17.3–45	3.8–24.2	0.43–1.5
Drogue Chute Deployment	221–340	5.5–5.6	6.3–41	0.61
Main Chute Deployment	324–444	1.1	6.5–42.3	0.15–0.16

Notes: sec = seconds

2.1.7 FIRST AND SECOND STAGE DISPOSITION

The initiation of the Dragon abort sequence also shuts down the Falcon 9 engines. The first and second stages would briefly continue on a ballistic path and then break-up immediately after Dragon separation, approximately 2–4 miles downrange. The abort test trajectory would follow a standard ISS trajectory with the exception of launch azimuth to reduce the likelihood of booster debris landing on-shore. Figure 2-3 illustrates the undispersed abort test trajectory. At the point of breaking up, the stages would be carrying the following approximate fuel loads of LOX and RP-1:

Stage 1 LOX: 631,300 pounds

Stage 1 RP-1: 257,500 pounds

Stage 2 LOX: 168,100 pounds

Stage 2 RP-1: 65,000 pounds

The extra LOX carried as ballast for the abort test would provide an environment that is oxidizer rich and would promote combustion of the remaining RP-1.

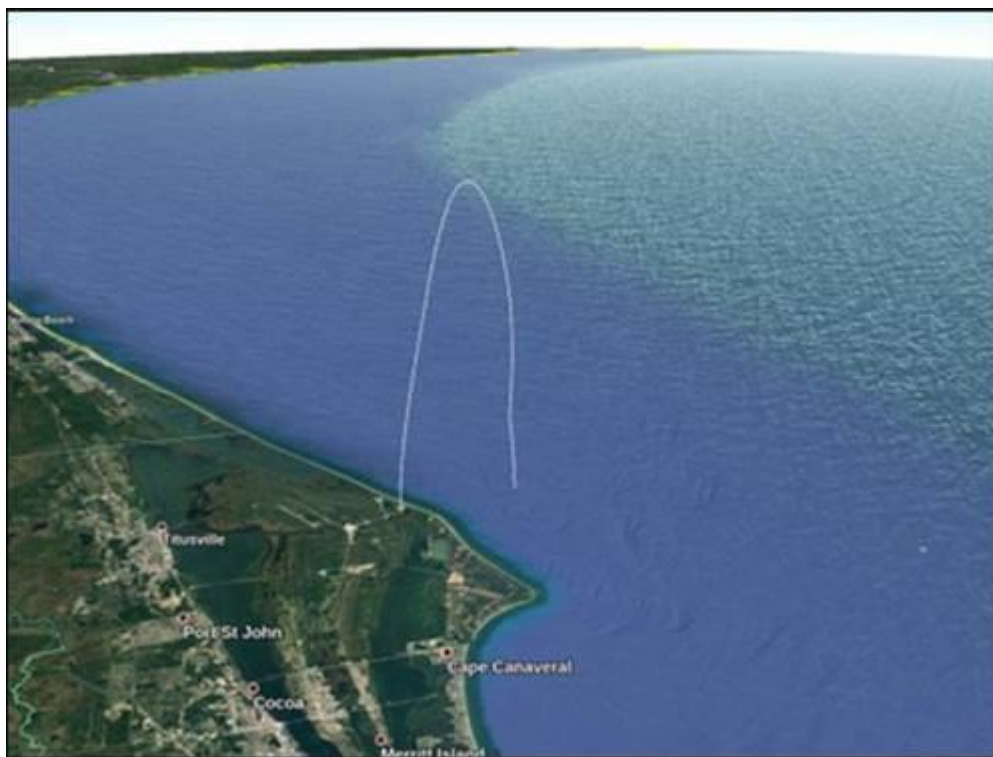


Figure 2-3. Representation of Flight Path for Dragon Separation

2.1.8 DRAGON RECOVERY

SpaceX has substantial experience working with commercial operators on both the East and West coasts for Dragon and Falcon 9 booster recovery operations. Using a recovery vessel (Figure 2-4), SpaceX would

execute a fast, safe recovery operation and collect high-rate telemetry from the test vehicle. This operational planning builds off of SpaceX's experience collecting telemetry at sea and recovering Dragon-1 capsules, which have much more hypergolic propellants on board than what would occur during the abort test. Additional vessels would be used to initially approach Dragon and prepare it for recovery. The capsule and propellant tanks are expected to be fully sealed; however, the recovery team would approach the capsule while wearing self-contained breathing apparatus and perform a "sniff check" to confirm there are no hypergol leaks and perform a visual inspection for unfired ordnance. Once the capsule is recovered, the helium and propellant systems would be depressurized before returning directly to Port Canaveral, Florida or a CCAFS wharf.



Figure 2-4. Dragon Recovery Vessel

There would be two recovery methods, a primary and a backup. The primary method is similar to Dragon-1 recoveries, using an A-frame crane to pick Dragon out of the water and place it on the back of the recovery vessel (Figure 2-5). The backup method involves towing Dragon back to port using a raft or towing Dragon directly in the water (Figure 2-6). The jettisoned trunk would sink upon landing in the ocean and would not be recovered.



Figure 2-5. Recovery A-frame Crane Operation



Figure 2-6. Dragon Tow Raft

2.1.9 BOOSTER DEBRIS DISPERSION

SpaceX anticipates a Falcon 9 breakup after Dragon abort. After thrust termination and abort separation, the Falcon 9 trajectory would be uncontrolled and would be expected to start departing from the nominal trajectory. In this nominal scenario, the propellant is expected to be consumed in the deflagration or

aerosolized. This is consistent with behavior SpaceX observed in previous failures, including a Falcon 9 failure at their test site in McGregor, Texas, which failed at low altitude. In the event of an unanticipated and off-nominal condition, the following Falcon 9 breakup scenarios may be encountered:

Off-nominal Scenario 1: Premature Falcon 9 failure results in an early abort, followed by aerodynamic breakup. Propellant is expected to be consumed similar to the nominal abort scenario.

Off-nominal Scenario 2: Violation of autonomous flight termination criteria results in commanded destruct of Falcon 9, resulting in breakup of Falcon 9. Propellant is expected to be consumed similar to the nominal abort scenario. Dragon is anticipated to abort in this scenario. In general, failure cases are likely to result in an abort prior to an autonomous flight termination rule violation, as the abort triggers are more stringent by virtue of being designed to anticipate vehicle structural breakup from aerodynamic loads.

Off-nominal Scenario 3: For early aborts where Falcon 9 velocity, and hence dynamic pressure, are still relatively low, if no autonomous flight termination rules are violated, Falcon 9 might impact the ocean's surface intact. For aborts closer to the abort time frame, an intact impact is unlikely. In the event of Falcon 9 intact impact, propellant is expected to be consumed in the higher yield explosion resulting from propellant mixing upon impact.

SpaceX has determined that the probability of an off-nominal scenario occurring would be less than 1 percent. Therefore, the modeling of debris impact points was conducted only for the anticipated nominal scenario. Falcon 9 would be expected to experience an aerodynamic breakup within a few seconds of Dragon aborting. SpaceX would only launch during wind conditions that would result in no debris landing on land during the nominal scenario. The wind restrictions would vary at each altitude. At 1–12 miles of altitude, the wind speed conditions would be more restrictive because the fragments spend the majority of their fall time in this altitude. Minimal wind restrictions would be in place above an altitude of 12 miles, due to the lower density.

The debris impact points from SpaceX's Monte Carlo dispersion model and anticipated area of impact are shown in Figure 2-2. Aerodynamic and command destruct catalogs are provided as part of the Flight Data Package. This includes the number of fragments, mass, area, drag coefficients and resulting calculated ballistic coefficients, and the imparted velocity from the breakup. Debris propagation analysis was performed by the 45th Space Wing as part of the risk analysis process. These results are used to generate Notices to Airmen (NOTAMs) and Local Notices to Mariners (NOTMARs), as well as to generate Flight Hazard Areas taking into account the effects of debris dispersal, hypergol dispersion, and Dragon abort dispersions, which SpaceX considers an off-normal scenario.

Based on the debris catalog (provided as an appendix to the Final Flight Data Package submitted to the FAA, NASA, and USAF), SpaceX expects most of the debris is expected to sink relatively quickly after impact with the ocean's surface. The debris would be composed of inert materials that would not change the characteristics of the ocean's bottom substrate. The debris that would have the potential to float include fragments from carbon fiber overwrapped pressure vessels (COPVs) and transfer tubes. SpaceX

has performed successful recovery of all of these floating items during previous Falcon 9 first stage booster landing attempts.

SpaceX plans to recover all floating debris. Details of the debris recovery strategy are discussed below.

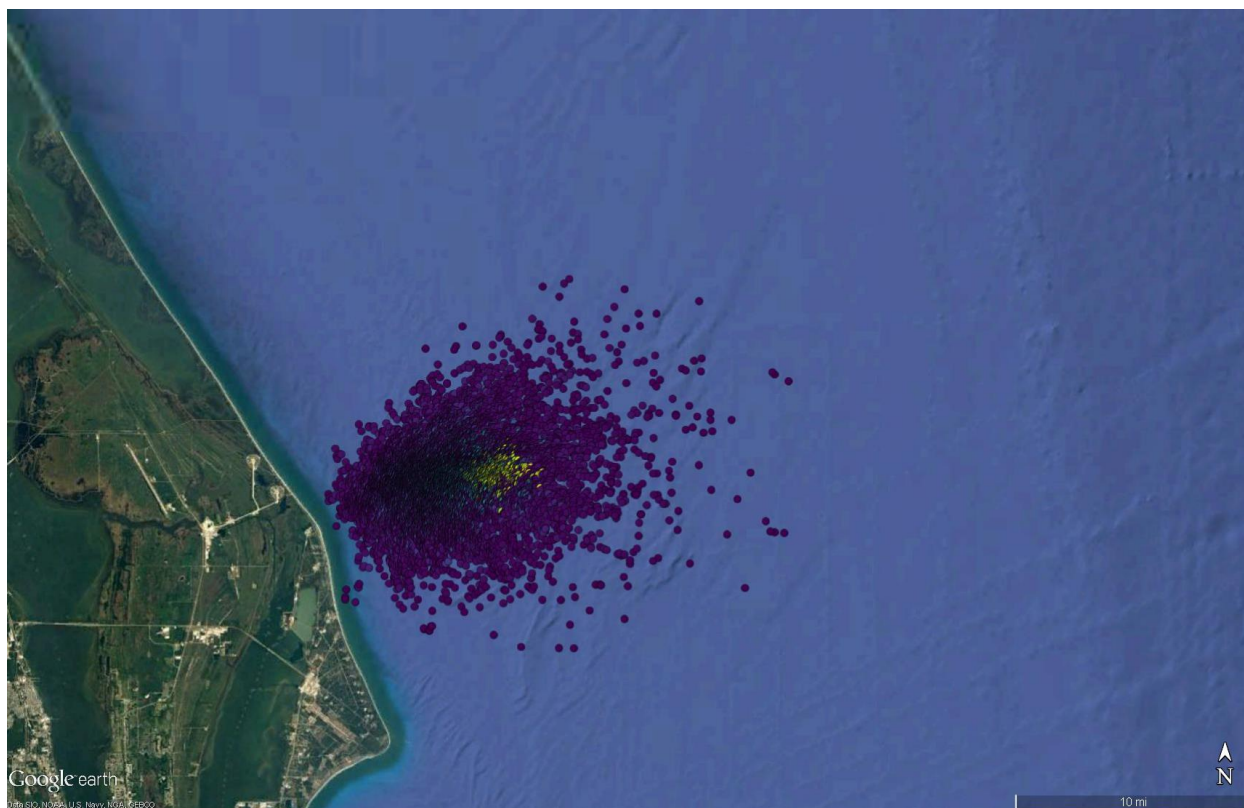


Figure 2-3. Monte Carlo Model of Debris Relative to Dragon Landing Dispersed Ellipse

2.1.10 DEBRIS RECOVERY PLAN

SpaceX would mobilize a multi-layered debris recovery operation to ensure necessary environmental protections are ready and available as soon as possible post-launch. Once the abort test commences, SpaceX would monitor the flight for nominal performance indicators including thrust, trajectory path, and propulsion systems. SpaceX would receive reports from existing assets to confirm debris status in flight and on the ocean surface. Assets would include mobile platforms used for launch surveillance and/or tracking cameras. All of the debris is expected to sink and fall within the hazard area already published for launch via the NOTAM and NOTMAR. Mobile assets would survey the applicable debris once the Eastern Range (Risk Assessment Center) confirms debris fall time and no longer poses a safety hazard.

Upon receiving survey debris observations, the debris recovery team would first recover any items deemed a public safety or maritime traffic hazard and then recover miscellaneous floating items, including items that are projected to float towards the shoreline based on observations and expected weather conditions. If it's necessary to access the beach to recover debris, SpaceX would coordinate with the applicable property owner.

SpaceX debris recovery would be a collaborative effort with the U.S. Coast Guard to ensure maritime safety based on the projected debris field of 2–20 miles offshore. Per customary practice, SpaceX would request the Emergency Operations Centers (EOCs) from Brevard County, KSC, and CCAFS to support SpaceX during the launch operation. The EOCs would also help facilitate any immediate land-based debris recovery efforts if needed.

2.1.11 BIOLOGICAL MONITORING

During recovery efforts, supporting assets would be instructed to report all observations to include any marine species affected by the abort test. Reporting would occur according to the FAA's and NASA's Endangered Species Act (ESA) section 7 consultations with the National Marine Fisheries Service (NMFS) (see Appendix A for the correspondence). Any collision(s) with and/or injury to any protected species (i.e., species protected by the ESA and Marine Mammal Protection Act [MMPA]) would be reported immediately to NMFS's Protected Resources Division. All vessel operators would watch for and avoid collision with protected species. Vessel operators would maintain a safe distance by following the protective measures outlined in the ESA consultations (Appendix A).

As stated above, if the observations of the initial debris field survey and forecasted weather conditions project debris to come ashore, SpaceX would coordinate resources for debris recovery with the appropriate property owner(s). KSC and CCAFS would conduct their routine beach patrols and would contact SpaceX if any debris is discovered and if any protected species (e.g., nesting sea turtles) may be affected. SpaceX would promptly respond and recover the debris and notify the U.S. Fish and Wildlife Service (USFWS) if protected species were located on the beach.

2.1.12 AIRSPACE COORDINATION

Airspace use would be coordinated by the FAA. All airspace launch operations would comply with the necessary notification requirements, including issuance of NOTAMs and NOTMARs. A NOTAM provides notice of unanticipated or temporary changes to components of, or hazards in, the National Airspace System (FAA Order JO 7930.2M, Air Traffic Policy). Per customary practice, SpaceX would coordinate with the FAA and USAF to provide notification of launch and other pre-launch operations (e.g., static engine test) and establish secure areas in the vicinity of the launch pad. The 45th Operations Group operates the Eastern Range and facilitates special use airspace requests.

The Proposed Action would not require the FAA to alter the dimensions (shape and altitude) of the airspace. However, temporary closures of existing airspace may be necessary to ensure public safety during the abort test. Advance notice via NOTAMs and NOTMARs would assist general aviation pilots and mariners in scheduling around any temporary disruption of flight or shipping activities in the area of operation. The abort test would be of short duration and scheduled in advance to minimize interruption to airspace. For these reasons, environmental impacts of the temporary closures of airspace and the issuance of NOTAMs under the Proposed Action are not anticipated and thus are not addressed further in the EA. Moreover, in accordance with FAA Order 1050.1F, Paragraph 5-6.1 (Categorical Exclusions for Administrative/General Actions), issuance of NOTAMs is categorically excluded from NEPA review absent extraordinary circumstances.

2.2 NO ACTION ALTERNATIVE

CEQ regulations (44 CFR §1502.14) require agencies to consider a “no action” alternative in their NEPA analyses 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. Under the No Action Alternative, the FAA would not issue a license to SpaceX to conduct the abort test, and therefore SpaceX would not conduct the abort test. The No Action Alternative does not satisfy the FAA’s purpose of and need for action. Also, SpaceX’s ability to fully meet the NASA requirements, as well as National Space Transportation Policy goals of providing low-cost reliable access to and from space, would be negatively affected under the No Action Alternative.

2.3 ALTERNATIVES CONSIDERED BUT NOT CARRIED FORWARD

This section describes other alternatives considered and eliminated from further environmental analysis. FAA Order 1050.1F, paragraph 6-2(d), states:

“The alternatives discussed in an EA must include those that the approving official will consider. There is no requirement for a specific number of alternatives or a specific range of alternatives to be included in an EA. An EA may limit the range of alternatives to the proposed action and no action when there are no unresolved conflicts concerning alternative uses of available resources. Alternatives are to be considered to the degree commensurate with the nature of the proposed action and agency experience with the environmental issues involved. Generally, the greater the degree of impacts, the wider the range of alternatives that should be considered. The preferred alternative, if one has been identified, should be indicated. For alternatives considered but eliminated from further study, the EA should briefly explain why these were eliminated.”

SpaceX considered conducting the abort test from VAFB (Space Launch Complex 4W). However, because of potentially greater technical difficulties at VAFB, and a greater amount of federally protected aspects of the environment (e.g., Channel Islands) which could create additional environmental concerns, this site was not selected.

SpaceX originally considered recovering the Falcon 9 first stage booster during the abort test by conducting a boost-back and landing at LZ-1. However, due to the abort test mission parameters requiring Dragon separation at max Q, SpaceX was unable to create a trajectory that would allow boost-back and landing. Similarly, SpaceX evaluated having the first stage re-light after Dragon separation and fly further out in the Atlantic Ocean, either for a dronship landing or impact with the ocean 124–186 miles offshore. Issues with achieving approval for flight termination qualification after the Dragon separation event proved impossible for these options.

3 AFFECTED ENVIRONMENT

This chapter provides a description of the environmental impact categories that have the potential to be affected by the Proposed Action, as required by FAA Order 1050.1F. The environmental impact categories assessed in detail in this EA include visual effects (including light emissions); coastal resources; air quality; climate; noise and noise-compatible land use; biological resources; water resources (surface waters); hazardous materials, solid waste, and pollution prevention; and historical, architectural, archeological, and cultural resources. In accordance with 40 CFR §1502.15 and FAA Order 1050.1F, Paragraph 6-2.1.e, the level of detail provided in this chapter is commensurate with the importance of the potential impact on the environmental impact categories.

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 described in each section below. Previous NEPA documents have addressed and described the affected environment for SpaceX's Falcon launch vehicle program at LC-39A and areas of the Atlantic Ocean for Dragon reentry, as follows:

LC-39A: NASA's 2013 EA for the multi-use of LC-39A and LC-39B (NASA 2013). The FAA was a cooperating agency in the preparation of this EA and issued a FONSI (FAA 2016) to support issuing launch licenses to SpaceX for Falcon 9 and Falcon Heavy launch operations at LC-39A.

Dragon Reentry in Atlantic: The USAF's 2007 EA and 2013 Supplemental EA for Falcon 9 and Falcon Heavy launch operations at LC-40, including Dragon reentry in the Atlantic Ocean (USAF 2007, 2013). The FAA was a cooperating agency in the preparation of the 2007 EA and 2013 Supplemental EA and issued FONSIs (FAA 2009, 2013) to support issuing licenses to SpaceX for Falcon 9 and Falcon Heavy launch operations at LC-40 and Dragon reentry.

In accordance with 40 CFR §1502.21, this chapter incorporates material by reference from the EAs mentioned above to cut down on bulk without impeding agency and public review of the Proposed Action. The incorporated material is cited and summarized. All of the EAs incorporated by reference are available upon request.

The following environmental impact categories are not analyzed in this EA in detail for the reasons stated:

- Department of Transportation Act, Section 4(f):** The 2013 NASA EA for the multi-use of LC-39A and LC-39B (NASA 2013) assessed the potential impacts on Section 4(f) properties from Falcon 9 and Falcon Heavy launches at LC-39. The 2013 EA and FAA's FONSI (FAA 2016) stated launch operations would not result in a physical use (direct taking) or constructive use of any Section 4(f) property. The Proposed Action is similar to operations analyzed in the 2013 EA, with the exception of the Falcon 9 breaking up downrange (which would not affect a Section 4(f) property because the vehicle parts would land in the ocean and either sink or be recovered). The Proposed Action would not result in any physical use of a 4(f) property and is a one-time event that would not have the potential to substantially impair any 4(f) properties. Therefore, the FAA has determined the Proposed Action would not result in a use of a Section 4(f) property and

therefore would not invoke Section 4(f) of the Department of Transportation Act.

- **Farmlands:** The Proposed Action does not involve ground-disturbing activities (i.e., construction), and there are no designated agricultural lands at KSC. Therefore, the Proposed Action would not impact farmlands.
- **Floodplains, Groundwater, and Wetlands:** The Proposed Action does not involve ground-disturbing activities. The Proposed Action would not introduce contaminants into floodplains, groundwater, or wetlands. Therefore, the Proposed Action would not impact floodplains, groundwater, or wetlands.
- **Historical, Architectural, Archeological, and Cultural Resources:** The 2013 NASA EA for the multi-use of LC-39A and LC-39B (NASA 2013) assessed the potential impacts on Section 4(f) properties from launches of several launch vehicles at LC-39, including the Falcon 9 and Falcon Heavy. The 2013 EA and FAA's FONSI (FAA 2016) stated KSC has a stewardship responsibility for managing the cultural resources on NASA-owned lands. To this end, KSC has developed an Integrated Cultural Resources Management Plan (ICRMP) that reflects NASA's commitments to the protection of its significant cultural resources. The ICRMP provides an inventory of significant cultural resources and a plan of action to identify, assess, manage, preserve, and protect these resources. It also includes a guide for impact analysis review and a set of standard operating procedures for ongoing cultural resource management activities. NASA continually follows stipulations identified in the ICRMP, existing memoranda of agreements, and the 2009 *Programmatic Agreement Among the National Aeronautics and Space Administration, John F. Kennedy Space Center, Advisory Council on Historic Preservation, and the Florida State Historic Preservation Officer Regarding Management of Historic Properties at the Kennedy Space Center, Florida* (2009 PA). During preparation of the 2013 EA, NASA determined its action would constitute an adverse effect on LC-39A in accordance with the 2009 PA and consulted the State Historic Preservation Officer (SHPO). The SHPO concurred with NASA's finding and noted that KSC has previously completed and will be following the appropriate mitigation stipulations of the 2009 PA. The SHPO did not recommend any additional mitigation. Therefore, because the abort test would occur at KSC and NASA complies with the 2009 PA for the protection of historic properties, the FAA's Proposed Action would not result in significant impacts on historical, architectural, archeological, and cultural resources.
- **Land Use:** The Proposed Action would not change the existing or planned use of land at KSC. Therefore, the Proposed Action would not impact land use.
- **Natural Resources and Energy Supply:** KSC owns and maintains their voltage distribution system, which serves the facilities at LC-39A. Impacts to electricity, natural gas, communications, and solid waste infrastructure at KSC would be negligible. These utilities and services are currently available at or in close proximity to LC-39A. No additional infrastructure, electrical connections, or wastewater discharge would be needed. Water supply impacts would be minimal since potable water resources are available at the site. The KSC water distribution system is sized to

accommodate short-term, high-volume flows required for launches. Therefore, impacts to natural resources and energy supply would be negligible and insignificant.

- **Socioeconomics, Environmental Justice, and Children’s Environmental Health and Safety:** The abort test would not have a socioeconomic impact on the region because of its low frequency (once) and short duration. The area around KSC would be closed to the public during launch, similar to other launch operations at KSC. There would be no impacts that disproportionately adversely affect environmental justice populations. Additionally, the Proposed Action would not result in a disproportionate health and safety risk to children.
- **Wild and Scenic Rivers:** There are no wild and scenic rivers located near KSC. Therefore, the Proposed Action would not impact wild and scenic rivers.

3.1 VISUAL EFFECTS

3.1.1 BACKGROUND

Visual effects deal broadly with the extent to which the Proposed Action would either:

- Produce light emissions that create annoyance or interfere with activities; or
- Contrast with, or detract from, the visual resources and/or the visual character of the existing environment (FAA Order 1050.1F Desk Reference).

Visual effects can be difficult to define and assess because they involve subjectivity. For clarity and uniformity, visual effects are broken into two categories: 1) light emission effects; and 2) visual resources and visual character. Light emissions include any light that emanates from a light source into the surrounding environment. Visual resources include buildings, sites, traditional cultural properties, and other natural or manmade landscape features that are visually important or have unique characteristics. Visual resources may include structures or objects that obscure or block other landscape features. Visual character refers to the overall visual makeup of the existing environment where the proposed project would be located.

3.1.2 EXISTING CONDITIONS

The ROI for visual effects includes the area around the launch site and areas where the launch trajectory is visible, which includes areas of KSC, CCAFS, and Brevard and Volusia counties. The existing conditions at KSC and CCAFS are characterized as having low visual sensitivity, because the sites are currently industrialized areas that support rocket launches. The visual resources at KSC are typical of an administrative and industrial campus. The LC-39 area is characterized by launch vehicle assembly, testing, and processing facilities, while the Industrial Area includes various administrative, payload and launch vehicle processing, and research facilities.

3.2 COASTAL RESOURCES

Coastal resources include all natural resources occurring within coastal waters and their adjacent shorelands. Coastal resources include islands, transitional and intertidal areas, salt marshes, wetlands,

floodplains, estuaries, beaches, dunes, barrier islands, and coral reefs, as well as fish and wildlife and their respective habitats within these areas.

The Coastal Zone Management Act (CZMA) of 1972 provides for management of the United States' coastal uses and resources. The CZMA encourages coastal states to develop and implement comprehensive management programs that balance the need for coastal resource protection with the need for economic growth and development in the coastal zone. Once a management program is developed and approved by the National Oceanic and Atmospheric Administration (NOAA), the state is authorized to review certain federal activities affecting the land or water uses or natural resources of its coastal zone for consistency with the program. This authority is referred to as "federal consistency."

The Florida Coastal Management Program was approved by NOAA in 1981 and is codified in Chapter 380, Part II, Florida Statute. Florida's Coastal Management Program, executed by the Florida Department of Environmental Protection (FDEP), oversees activities occurring in or affecting the coastal zone and is based on a network of agencies implementing 24 statutes protecting coastal resources. Florida's coastal zone is the area encompassed by the entire state and its territorial seas. The seaward boundary extends three miles into the Atlantic Ocean (FDEP 2017). KSC is explicitly excluded from the Florida CMP, but still voluntarily complies with it. The ROI includes LC-39, the beaches near KSC and CCAFS, and the ocean waters out to three miles.

The FAA may not issue a license or permit to an applicant unless an applicant's proposal meets the consistency requirements of the state's CMP. A license or permit means any authorization that an applicant is required by law to obtain in order to conduct activities affecting any land or water use or natural resource of the coastal zone and that any federal agency is empowered to issue to an applicant. If the applicant's proposal has the potential for impacts within a coastal zone, the applicant must initiate consultation with the relevant state agency to ensure their proposal is consistent with the state's CMP. If the state agency concurs with the applicant's consistency certification, the FAA may issue the license or permit. The federal consistency review for proposals in Florida is coordinated through the Florida State Clearinghouse.

3.3 AIR QUALITY

Air quality is the measure of the condition of the air expressed in terms of ambient pollutant concentrations and their temporal and spatial distribution. Air quality regulations in the United States are based on concerns that high concentrations of air pollutants can harm human health, especially for children, the elderly, and people with compromised health conditions; as well as adversely affect public welfare by damage to crops, vegetation, buildings, and other property.

The entire abort test—from launch to Dragon's main chute deployment—would occur from LC-39A to approximately 42 miles offshore of KSC. This section describes air quality in and around KSC at altitudes below 3,000 feet, which contains the atmospheric boundary layer. 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 (CAA) (EPA 1992). Since the abort test would launch from KSC and Dragon reentry and recovery operations would primarily occur in the Atlantic Ocean and Port Canaveral, Florida or CCAFS, the ROI for air quality is Brevard County, Florida.

The ambient air quality at KSC is predominantly influenced by daily operations such as vehicle traffic, utilities, fuel combustion, and standard refurbishment and maintenance operations. Other operations occurring infrequently throughout the year, including launches and prescribed fires, also play a role in air quality as occasional events.

3.3.1 REGULATORY BACKGROUND

Air quality at KSC is regulated under CAA regulations (40 CFR Parts 50–99) and Florida Administrative Code (FAC) Chapters 62-200 through 62-299. NASA holds a Title V Air Operation Permit which governs the air emissions from its activities at KSC. KSC operates under the Title V permit for the potential to emit the criteria pollutant oxides of nitrogen (NO_x), which exceed the Title V major source threshold of 100 tons per year. KSC is considered a minimal source for carbon monoxide (CO), volatile organic compounds (VOCs), particulate matter (PM), sulfur dioxide (SO₂), and lead emissions. The Title V permit provides a list of emissions units and also shows insignificant emissions units and/or activities. NASA-operated air emission sources are listed on the Title V permit.

3.3.2 NATIONAL AMBIENT AIR QUALITY STANDARDS

Under the CAA, the NAAQS for criteria pollutants include CO, SO₂, nitrogen dioxide, ozone, PM less than or equal to 10 microns in diameter (PM₁₀), PM less than or equal to 2.5 microns in diameter (PM_{2.5}), and lead. CO, SO₂, lead, NO_x, and some particulates are emitted directly into the atmosphere from emissions sources. Ozone is 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. Primary standards are established to provide public health protection and secondary standards are established to provide public welfare protection, including protection against decrease visibility and damage to animals, crops, vegetation, and buildings.

KSC is located in Brevard County which is classified as attainment for all NAAQs. The FDEP has exclusively adopted the NAAQS (Table 3-1).

Table 3-1. National Ambient Air Quality Standards

Pollutant	Primary/ Secondary	Averaging Time	Level	Form
Carbon monoxide	primary	8 hours	9 ppm	Not to be exceeded more than once

			1 hour	35 ppm	per year
Lead		primary and secondary	Rolling 3 month average	0.15 µg/m ³ ⁽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)	PM _{2.5}	primary	1 year	12.0 µg/m ³	Annual mean, averaged over 3 years
		secondary	1 year	15.0 µg/m ³	Annual mean, averaged over 3 years
		primary and secondary	24 hours	35 µg/m ³	98th percentile, averaged over 3 years
	PM ₁₀	primary and secondary	24 hours	150 µg/m ³	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

Source: 40 CFR Part 50.

Notes: 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; PM_{2.5} = 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.

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.

3.3.3 CONFORMITY

Under 40 CFR Part 93 and the provisions of Part 51, Subchapter C, Chapter I, Title 40, Appendix W of the CFR of the CAA as amended, federal agencies are required to demonstrate that their actions conform with the state's applicable goals that will achieve compliance with the NAAQS. The EPA general conformity rule applies to federal actions occurring in non-attainment or maintenance areas. Because Brevard County is in attainment, general conformity does not apply.

3.3.4 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 VOCs. Mobile sources of air emissions include launch vehicles, commercial ships, recreational boats, cruise ships, and aircraft. 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 were identified as having the greatest influence on health, including 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).

3.3.5 EXISTING CONDITIONS

Air monitoring data for Florida in 2017 showed the state continued to be in attainment for all criteria pollutants, with the exception of Tampa's nonattainment designation for lead, and SO₂ nonattainment areas in Hillsborough County (Tampa area), Nassau County (Jacksonville area), and Polk County (Lakeland area) (EPA 2017). Below is a summary of the 2015, 2016, and 2017 ambient air quality measurement data

for the local region. Table 3-2 shows that ground-level concentrations of criteria pollutants in the ROI are

Table 3-2. Measured Ambient Air Concentrations of Criteria Pollutants in the Region

Pollutant	Averaging Time	Nearest Monitoring Station	Maximum Measured Concentration (ppm, except PM in $\mu\text{g}/\text{m}^3$)		
			2015	2016	2017
O ₃	8 Hours	Palm Bay- Melbourne- Titusville	0.059 (4 th max)	0.059 (4 th max)	0.061 (4 th max)
CO	8 Hour	Orlando- Kissimmee-	1.3	1.3	1.8
	1 Hour	Sanford	1.6	1.5	2.4
NO ₂	1 Hour	Orlando- Kissimmee	0.025 (98 th Percentile)	0.029 (98 th Percentile)	0.0295 (98 th Percentile)
	Annual	Sanford	0.035	0.040	0.0371
SO ₂	1 Hour	Palm Bay- Orlando- Kissimmee-	0.003	0.002	0.0046
	3 Hour	Sanford	0.001	0.001	0.001
PM ₁₀	24 Hour	Palm Bay- Melbourne- Titusville	47 (2 nd max)	38 (2 nd max)	49 (2 nd max)
PM _{2.5}	24 Hour	Palm Bay-	12.4	9.5	20
	Annual	Melbourne- Titusville	12.4	9.5	20
Lead	Quarterly	No lead monitors are located within 100 miles of LC-39A	-	-	-

Source: EPA 2017

Notes: CO = carbon monoxide; NO₂ = nitrogen dioxide; O₃ = ozone; PM₁₀ = particulate matter less than or equal to 10 microns in diameter; PM_{2.5} = fine particulate matter 2.5 microns or less in diameter; ppm = parts per million; SO₂ = sulfur dioxide; µg/m³ = micrograms per cubic meter.

Each maximum is measured as defined by the respective standard.

A summary of air emissions for years 2010 through 2015 for KSC is shown in Table 3-3.

Table 3-3. Estimated Annual Emissions at KSC, 2009–2016 (tons per year)

Pollutant	2016	2015	2014	2013	2012	2011	2010	2009
CO	3.21	4.61	6.12	7.22	9.57	10.77	10.39	11.17
NO _x	10.48	15.35	23.11	24.98	33.99	38.69	36.86	40.12
Lead	0	0	0	0	0	0.0001	0.0003	0.001
PM ₁₀	0.68	1.08	1.44	1.69	2.35	2.67	2.56	2.80
PM _{2.5}	0.53	0.86	1.25	1.44	2.05	2.35	2.236	2.49
SO ₂	0.01	0.02	0.02	0.03	0.44	0.52	0.496	0.50
VOC	4.58	4.72	3.56	4.37	4.68	6.28	10.69	11.16
HAPs	0.48	0.62	0.49	0.55	0.55	0.66	0.60	1.16

Source: FDEP 2017.

Notes: CO = carbon monoxide; HAPs = hazardous air pollutants; NO_x = nitrogen oxides; PM₁₀ = particulate matter less than or equal to 10 microns in diameter; PM_{2.5} = fine particulate matter 2.5 microns or less in diameter; SO₂ = sulfur dioxide; VOC = volatile organic compounds

3.4 CLIMATE

3.4.1 BACKGROUND

Greenhouse gases (GHGs) are gases that trap heat in the atmosphere. The primary GHGs of concern are carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride (SF₆). These emissions occur from natural processes and human activities.

Each GHG is assigned a global warming potential. The global warming potential is the ability of a gas or aerosol to trap heat in the atmosphere. The global warming potential rating system is standardized to CO₂, which has a value of one. For example, CH₄ has a global warming potential of 21, which means that it has a global warming effect 21 times greater than CO₂, on an equal-mass basis. The equivalent CO₂ rate is calculated by multiplying the emission of each GHG by its global warming potential and adding the results together to produce a single, combined emission rate representing all GHGs, and this value is represented by CO₂e, which is defined as the carbon dioxide equivalent.

3.4.2 EXISTING CONDITIONS

Research has shown there is a direct correlation between fuel combustion and GHG emissions. At KSC, CO₂ emissions in 2016 were estimated at 99,025.2 metric tons, which was a 54 percent reduction in

sources controlled by the government and a 32 percent reduction from non-government sources from 2008 baseline emission statistics (NASA 2016).

3.5 NOISE AND NOISE-COMPATIBLE LAND USE

3.5.1 BACKGROUND

Sound is a physical phenomenon consisting of pressure fluctuations that travel through a medium, such as air, and are sensed by the human ear. 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.

Compatible land use means the use of the land is normally compatible with the outdoor noise environment at the location or an adequately attenuated noise level reduction for any indoor activities (14 CFR § 150.7). In particular, 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.

3.5.2 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 (e.g., the quietest sound that can be heard). It is a logarithmic unit that accounts for the large variations in amplitude. 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. Various noise metrics are used to assess and correlate the various effects of noise on humans, including land use compatibility, sleep and speech interference, annoyance, hearing loss, and startle effects. To correlate the frequency characteristics from typical noise sources to human response, several frequency weighting scales have been developed. Sound levels that have been adjusted to correspond to the frequency response of the human hearing mechanism are referred to as A-weighted (dBA) sound pressure levels. The long-term equivalent A-weighted sound level (Leq) is an A-weighted sound level that is “equivalent” to an actual time-varying sound level. Although derived for humans, these descriptors can also be used to qualitatively assess the effects of noise on wildlife. A-weighted sound levels are typically measured between 20 hertz and 20 kilohertz. If structural damage is a concern, then the overall sound pressure level (OASPL) is used. This quantity has no frequency weighting and therefore includes low frequencies which may induce vibration in structures. The largest portion of the total acoustic energy produced by a launch vehicle is usually contained in the low-frequency end of the spectrum (1 to 100 hertz).

3.5.3 DAY-NIGHT AVERAGE NOISE LEVEL

FAA Order 1050.1F requires the FAA to assess noise impacts on noise sensitive areas using the Day-Night Average Sound Level (DNL) metric to determine if significant impacts would occur. 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)).

The 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.) to account 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.

3.5.4 EXISTING CONDITIONS

The ROI for noise and noise-compatible land use includes KSC and CCAFS and approximately 2–4 miles off the Atlantic coastline where the majority of noise from the first stage breakup would occur. KSC is a relatively isolated facility, which reduces the potential for noise impacts on adjacent communities. The nearest residential area/city is Titusville to the west, across the Indian River. Open space lies to the north. Land just to the south-southwest of KSC is largely undeveloped with low density housing located approximately 9 miles from LC-39. The beach cities of Cape Canaveral and Cocoa Beach are also to the south, immediately south of Port Canaveral, approximately 15 miles from LC-39. The noise produced by current rocket launches is noticed in all these areas, and these perimeter locations are commonly visited by the public for launch viewing. In the cities of Merritt Island and Cape Canaveral, ambient noise levels are normally low, with higher noise levels occurring in the communities' industrial areas, and lower noise levels (normally about 45 to 55 A-weighted decibels [dBA]) in the residential areas and along the beaches. Aircraft fly-overs and rocket launches from CCAFS and KSC increase noise levels for short periods of time. Sonic booms from returning first stage boosters also cause very short noise events.

KBRWyle (2018; see Appendix B) estimated the existing noise environment (DNL) for 2017 launch operations and other typical noise events occurring at KSC, which can be used to determine how the abort test is expected to influence the DNL. To accurately describe the DNL at KSC, a detailed study would be required involving either the modeling of all major noise sources or conducting noise monitoring throughout these areas for a period of time that adequately represents the different types of launch vehicles and frequency of launches conducted. The DNL estimates presented here are basic and serve to identify whether launch operations at CCAFS and KSC are expected to have a significant noise impact per the guidelines in FAA Order 1050.1F.

Before estimating DNL for KSC properties and surrounding cities, it is important to note that these areas have a variety of land uses. KSC has areas that should be considered rural or remote, except where NASA or other launch facilities are located. KSC has a wildlife refuge. Populated areas of Merritt Island could be considered rural or quiet suburban residential areas whereas Titusville and the city of Cape Canaveral are more urban areas with mixed residential and industrial uses. It is therefore important to consider the land use category and associated background noise levels when determining if launch operations would have a significant noise impact.

To estimate DNL for 2017, KBRwyle estimated background noise levels and the DNL from all 2017 launch operations at KSC. Background DNL was estimated using ANSI/ASA S12.9-2013/Part3 which provides estimated background noise levels for different land use categories and population density. Table 3-4 shows the DNL estimated for rural or remote areas and several different categories of suburban and urban residential land use which can be used to represent DNL for the various land uses within CCAFS, KSC, and surrounding areas. According to these estimates, many of the remote areas within CCAFS and KSC would be expected to have a DNL less than 49 dBA, while parts of Titusville and the city of Cape Canaveral would be expected to have a DNL as high as 59 dBA. The DNL values provide an estimate of the background levels expected in typical noise environments and do not include noise from launch operations. However, because the annual number of launches is relatively low and of short duration, existing noise levels including launch noise would not be much different than the values shown in Table 3-4.

Table 3-4. Estimated Background Noise Levels

Example Land Use Category	Average Residential Intensity (people per acre)	DNL (dBA)	Leq (dBA)	
			Daytime	Nighttime
Rural or remote areas	<2	<49	<48	<42
Quiet suburban residential	2	49	48	42
	4	52	53	47
	4.5	52	53	47
Quiet urban residential	9	55	56	50
Quiet commercial, industrial, and normal urban residential	16	58	58	52
	20	59	60	54

3.6 BIOLOGICAL RESOURCES

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 support 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. The biological resources ROI includes areas potentially impacted by noise (including LC-39A and offshore areas) and debris (Figure 3-1).

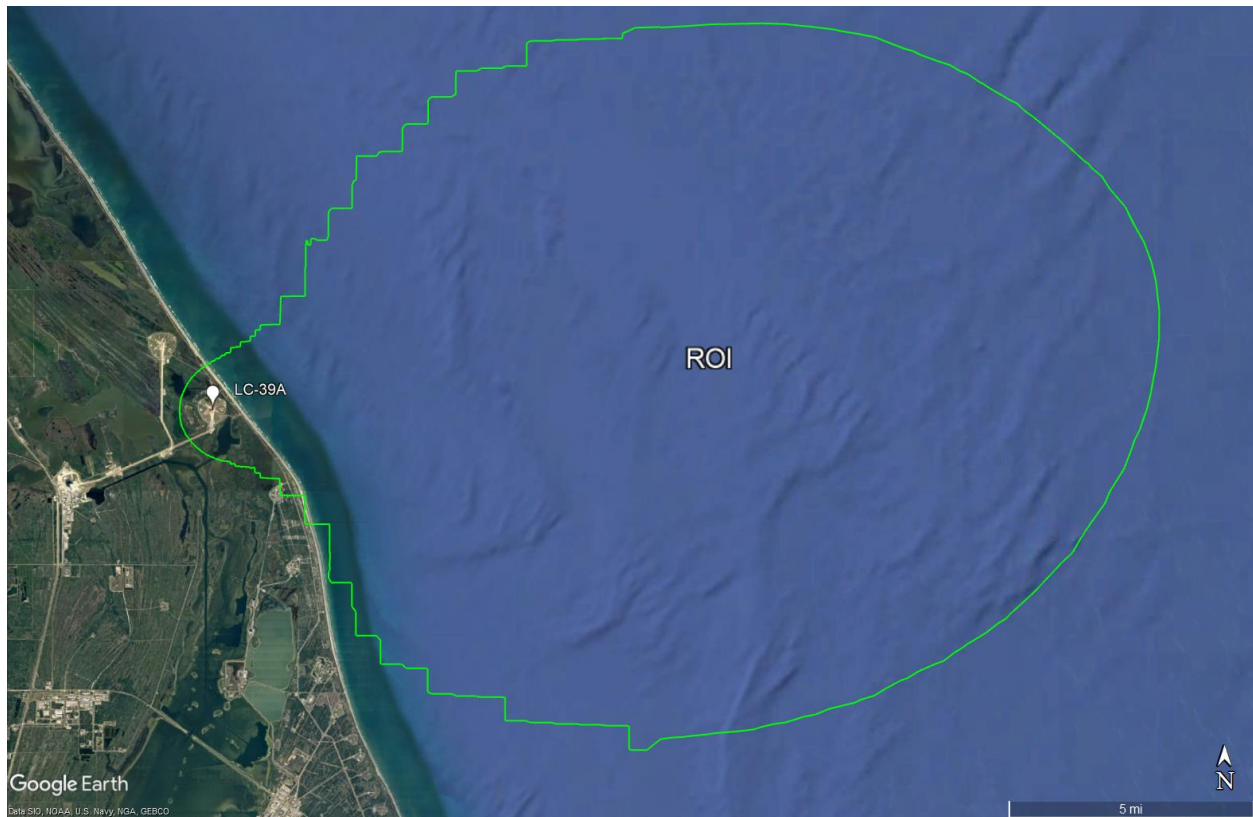


Figure 3-1. Biological Resources ROI

3.6.1 REGULATORY BACKGROUND

Under Section 7 of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 et seq.), federal agencies are required to assess the effect of any project on species that are federally threatened, endangered, or proposed for listing. Section 7 consultations with the USFWS and NMFS are required for federal projects if such actions have the potential to affect listed species or critical habitat. Critical habitat is specific geographic areas that contain features essential to the conservation of an endangered or threatened species and that may require special management and protection. Implementation of the ESA is a joint effort between NMFS and USFWS. NMFS is responsible for the management and conservation of marine species, while USFWS is responsible for land and freshwater species.

The Marine Mammal Protection Act (MMPA) of 1972 (16 U.S.C. §§ 1361–1407) restricts the taking of marine mammals. Taking includes injuring, killing, or harassing a marine mammal stock in the wild. The MMPA defines harassment as any act of pursuit, torment, or annoyance that has the potential to injure a marine mammal or marine mammal stock in the wild, or has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited

to, migration, breathing, nursing, breeding, feeding, or sheltering. Like the ESA, implementation of the MMPA is a joint effort between NMFS and USFWS. USFWS is responsible for sea and marine otters, walruses, polar bears, three species of manatee, and the dugongs. NMFS is responsible for all other marine mammals.

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

The Migratory Bird Treaty Act of 1918 (MBTA) (16 U.S.C. §§ 703-712) protects migratory birds, including their eggs, active nests, and bird parts. Unless permitted by regulation, the MBTA prohibits the taking and killing of migratory birds.

The Bald and Golden Eagle Protection Act (16 U.S.C. § 668 et seq.) protects bald and golden eagles from the unauthorized capture, purchase, or transportation of the birds, their nests, or their eggs.

3.6.2 EXISTING CONDITIONS

The existing conditions for biological resources were determined by considering all areas potentially impacted by visual disturbance, noise, and debris. Because no ground-disturbing activities would occur, plants would not be affected from the abort test and are therefore not considered further in this EA. While general wildlife species are noted here, the discussion focuses on special status species and habitat (i.e., species and habitat protected by the ESA, MMPA, and Magnuson-Stevens Fishery Conservation and Management Act) given the one-time abort test. The USFWS’s Information for Planning and Consultation system and the NMFS Southeast Region’s listed species for Florida’s Atlantic Coast were reviewed to assess the potential occurrence and distribution of special status wildlife species and critical habitat in the ROI (NMFS 2018; USFWS 2018a).

3.6.3 GENERAL WILDLIFE SPECIES

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 pomarine jaeger, northern gannet, band-rumped storm petrel, Audubon’s shearwater, laughing gull and herring gull (Peake and Elwonger 1996). Marine wildlife in the ROI include mammals, fish, reptiles, and invertebrate species. The ROI is composed of pelagic open ocean and the beaches of KSC and CCAFS. Common fish species found within the ROI include marlins, sailfish, swordfish, tunas, wahoos, bull shark, lemon shark, and blacktip shark (Franks 2005). 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). The benthic habitat of the ROI’s nearshore area consists primarily of topographically elevated sand ridges. This high energy environment drives the food availability, larval recruitment, and habitat structure for benthic organisms along the Florida coast. Benthic communities provide an important food or energy resource for higher trophic levels, including fish and larger organisms.

3.6.4 EAGLES

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 present in the ROI (Cornell 2017a). 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 ROI's coastal areas (Cornell 2017b). The closest active eagle nest is located approximately 3 miles away from LC-39A and is not located in the ROI (FWC 2017a).

3.6.5 THREATENED AND ENDANGERED SPECIES

Terrestrial

Fifteen wildlife species are listed under the ESA in Brevard County, Florida (Table 3-5). All but one of these species (West Indian manatee) are entirely or partially terrestrial species. A few of these protected species are only incidentally present near LC-39A, including the snail kite, Audubon's crested caracara, and piping plover (FWC 2018). The Atlantic saltmarsh snake historically occurred along the coastline from Volusia County through Brevard County south into Indian River County. It is now believed to be restricted to a limited coastal strip in Volusia County (USFWS 2005) and is no longer expected to be found at KSC.

Table 3-5. Federally Listed Terrestrial Species for Brevard County

Species	Status	Distribution/Habitat	Threats
Mammals			
Southeastern Beach Mouse (<i>Peromyscus polionotus niveiventris</i>)	T	Inhabits sand dunes along the Florida Atlantic Coast.	Disturbance of habitat and predation
Birds			
Audubon's Crested Caracara (<i>Polyborus plancus audubonii</i>)	T	In dry or wet prairie areas with scattered cabbage palms and lightly wooded areas.	Disturbance of habitat for agriculture and residential development; collision with motor-vehicles.
Everglade Snail Kite (<i>Rostrhamus sociabilis plumbeus</i>)	E	Shallow freshwater marshes and shallow grassy shorelines of lakes	Loss and degradation of wetlands
Florida Scrub-jay (<i>Aphelocoma coerulescens</i>)	T	Inhabit sand pine and xeric oak scrub, scrubby flatwoods, and highest and driest areas of Florida	Habitat destruction, fragmentation, and degradation from development and agriculture
Piping Plover (<i>Charadrius melodus</i>)	T	Wide, flat, open, sandy beaches with very little grass or other vegetation	Habitat Loss or Degradation; nest disturbance; predation
Red Knot (<i>Calidris canutus rufa</i>)	T	Coastal marine and estuarine habitats with large areas of exposed intertidal sediments	Habitat loss and degradation due to sea level rise; shoreline stabilization
Red-cockaded Woodpecker (<i>Picoides borealis</i>)	E	Longleaf pine, pond pine, pitch pine, and Virginia pine ecosystems	Loss and deterioration of habitat
Wood Stork	T	Mixed hardwood swamps, sloughs, mangroves, and cypress domes/strands	Agricultural expansions and altered hydrocycles

Table 3-5. Federally Listed Terrestrial Species for Brevard County

Species	Status	Distribution/Habitat	Threats
(<i>Mycteria americana</i>)			
Reptiles			
Atlantic Salt Marsh Snake (<i>Nerodia clarkii taeniata</i>)	T	Saltmarsh tidal flats that contain grasses	Habitat loss and degradation
Eastern Indigo Snake (<i>Drymarchon corais couperi</i>)	T	Pine flatwoods, hardwood forests, moist hammocks, and areas that surround cypress swamps	Habitat destruction, fragmentation, and degradation
Sea Turtles			
Green sea turtle (<i>Chelonia mydas</i>)	T	Known to nest on beaches in the ROI	Harvest of eggs and turtles; incidental capture in fishing gear; disease; marine debris; environmental contamination
Hawksbill turtle (<i>Eretmochelys imbricate</i>)	E	Not known to nest in ROI	Habitat loss of coral reef communities; harvest of eggs; increased recreational and commercial use of nesting beaches in the Pacific; incidental capture in fishing gear
Leatherback sea turtle (<i>Dermochelys coriacea</i>)	E	Known to nest on beaches in the ROI	Harvest of eggs and turtles; incidental capture in fishing gear; marine debris; environmental contamination
Loggerhead turtle (<i>Caretta caretta</i>)	T	Known to nest on beaches in the ROI	Incidental capture in fishing gear; direct harvest; marine debris; environmental contamination

Source: USFWS 2018a

Aquatic

ESA-listed marine species occurring or potentially occurring in the ROI are presented in Table 3-6.

Table 3-6. Federally Listed Marine Species in the ROI

Species	Status	Distribution/Habitat	Threats
Mammals			
Blue whale (<i>Balaenoptera musculus</i>)	E	In the North Atlantic Ocean, range extends from the subtropics to the Greenland Sea; although they are rare in the shelf waters of the eastern U.S., blue whales are occasionally seen off Cape Cod, MA; migrate seasonally between summer and winter	Collisions with vessels; entanglement in fishing gear; reduced zooplankton production due to habitat degradation; disturbance from low-frequency noise
Fin whale (<i>Balaenoptera physalus</i>)	E	Found in deep, offshore waters of all major oceans, primarily in temperate to polar latitudes, and less commonly in the tropics	Collisions with vessels; reduced prey abundance due to overfishing and/or climate Change; illegal whaling;

Table 3-6. Federally Listed Marine Species in the ROI

Species	Status	Distribution/Habitat	Threats
			increasing anthropogenic ocean noise
North Atlantic right whale (<i>Eubalaena glacialis</i>)	E	Inhabit the Atlantic Ocean, particularly between 20° and 60° latitude; for much of the year, their distribution is strongly correlated to the distribution of their prey; in the coastal waters off Georgia and northern Florida, calving occurs from December through March	Collisions with vessels; entanglement in fishing gear; habitat degradation; contaminants; climate and ecosystem change; disturbance from whale-watching activities; noise
Sei whale (<i>Balaenoptera borealis</i>)	E	Prefer subtropical to subpolar waters on the continental shelf edge and slope worldwide; usually observed in deeper waters of oceanic areas far from the coastline	Collisions with vessels; entanglement in fishing gear; reduced prey abundance due to climate change; increasing anthropogenic ocean noise
Sperm Whale (<i>Physeter microcephalus</i>)	E	Inhabit all oceans of the world; tend to inhabit areas with a water depth of 600 meters or more, and are uncommon in waters less than 300 meters deep; overall distribution along the U.S. east coast is centered along the shelf break and over the slope; high densities occur in inner slope waters north of Cape Hatteras, NC seaward of the 1,000 m isobath during summer months	Collisions with vessels; reduced prey abundance due to climate change; contaminants and pollutants; increasing anthropogenic ocean noise
Sea Turtles			
Green sea turtle (<i>Chelonia mydas</i>)	T	Pelagic; in U.S. Atlantic and Gulf of Mexico waters, found in inshore and nearshore waters from Texas to Massachusetts, the U.S. Virgin Islands, and Puerto Rico; important feeding areas in Florida include the Indian River Lagoon, the Florida Keys, Florida Bay, Homosassa, Crystal River, Cedar Key, and St. Joseph Bay.	Harvest of eggs and turtles; incidental capture in fishing gear; disease; marine debris; environmental contamination
Hawksbill turtle (<i>Eretmochelys imbricate</i>)	E	Pelagic; widely distributed throughout the Caribbean Sea and western Atlantic Ocean, regularly occurring in southern Florida and the Gulf of Mexico (especially Texas)	Habitat loss of coral reef communities; harvest of eggs; increased recreational and commercial use of nesting beaches in the Pacific; incidental capture in fishing gear
Kemp's Ridley sea turtle (<i>Lepidochelys kempii</i>)	E	Pelagic; distributed throughout the Gulf of Mexico and U.S. Atlantic seaboard, from Florida to New England; depending on their breeding strategy, male Kemp's ridleys appear to occupy many different areas within the Gulf of Mexico	Harvest of eggs; incidental capture in fishing gear; marine debris; environmental contamination
Leatherback sea turtle (<i>Dermochelys coriacea</i>)	E	Pelagic; adults are capable of tolerating a wide range of water temperatures and have been sighted along the entire continental east coast of the U.S. as far north as the Gulf of Maine and south to Puerto Rico, the U.S. Virgin Islands	Harvest of eggs and turtles; incidental capture in fishing gear; marine debris; environmental contamination
Loggerhead turtle	T	Pelagic; predominate foraging areas for western North Atlantic adult loggerheads are	Incidental capture in fishing gear; direct harvest; marine debris; environmental

Table 3-6. Federally Listed Marine Species in the ROI

Species	Status	Distribution/Habitat	Threats
<i>Caretta caretta</i>		found throughout the relatively shallow continental shelf waters of the U.S., Bahamas, Cuba, and the Yucatán Peninsula, Mexico; migration routes from foraging habitats to nesting beaches (and vice versa) for a portion of the population are restricted to the continental shelf, while other routes involve crossing oceanic waters to and from the Bahamas, Cuba, and the Yucatán Peninsula	contamination
Fish			
Shortnose sturgeon (<i>Acipenser brevirostrum</i>)	E	Anadromous fish; spawn in the coastal rivers along the east coast of North America from the St. John River in Canada to the St. Johns River in Florida; prefer the nearshore marine, estuarine, and riverine habitat of large river systems	Construction of dams may have resulted in substantial loss of suitable habitat; pollution; habitat alterations from discharges; dredging or disposal of material into rivers; related development activities involving estuarine/ riverine mudflats and marshes
Atlantic sturgeon (<i>Acipenser oxyrinchus oxyrinchus</i>)	E	Anadromous fish; found in river systems from Louisiana to Florida, in nearshore bays and estuaries, and in the Gulf of Mexico	Construction of water control structures, such as dams and sills; exacerbated habitat loss; dredging; groundwater extraction; irrigation; flow alterations; poor water quality contaminants, primarily from industrial sources
Smalltooth sawfish (<i>Pristis pectinate</i>)	E	Inhabit shallow coastal waters of tropical seas and estuaries throughout the world; in the U.S., found in the peninsula of Florida, common only in the Everglades region at the southern tip of the state	Bycatch in various fisheries, especially in gill nets; loss of juvenile habitat
Nassau grouper (<i>Epinephelus striatus</i>)	T	Tropical and subtropical waters of the western North Atlantic	Fishing
Oceanic whitetip shark (<i>Carcharhinus longimanus</i>)	T	Near the surface in warm waters in the open ocean, usually well offshore	Catch in pelagic fisheries; trade of fins
Giant manta ray (<i>Manta birostris</i>)	T	Tropical, subtropical, and temperate bodies of water and is commonly found offshore, in oceanic waters, and near productive coastlines	Commercial and artisanal fishing, harvest for international trade

Notes: Marine mammals are also protected by the MMPA.

Source: NMFS Southeast Region List for Florida's Atlantic Cost Threatened and Endangered Species

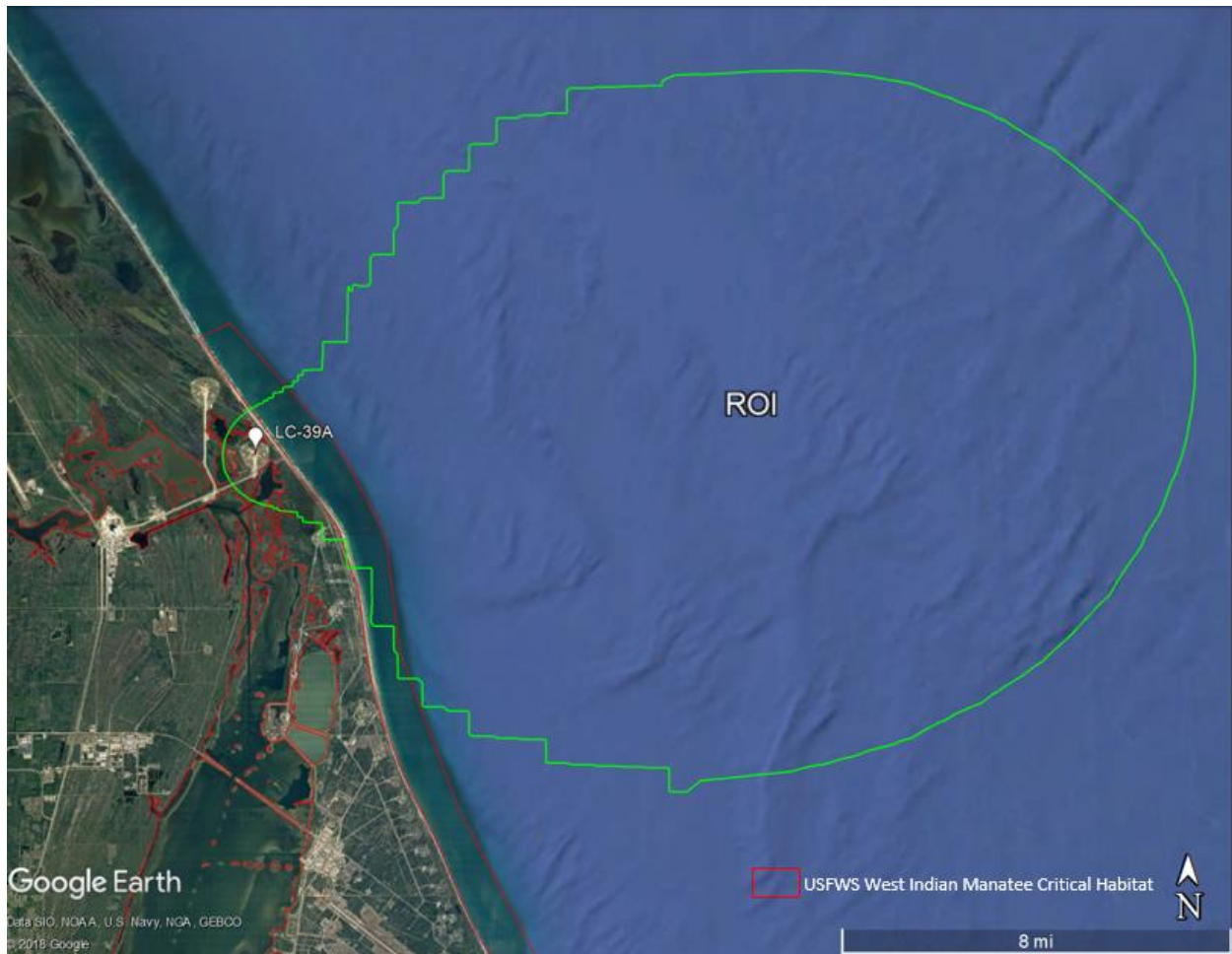
3.6.6 ESSENTIAL FISH HABITAT AND CRITICAL HABITAT

Essential Fish Habitat

EFH is defined as “those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity” and specifies that each federal agency shall consult with NOAA with respect to any action that may adversely affect any EFH. Ocean waters off KSC and CCAFS have several areas designated as EFH that are of particular importance to sharks and other game fish, as well as several species of lobsters, shrimp, and crabs. These habitats include: sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters, from the surf to the shelf break zone, and from the Gulf Stream shoreward, including Sargassum. In addition, the northern boundary of Oculina Bank, a unique strip of coral reefs not duplicated elsewhere on Earth, is located approximately 20 nautical miles off of Cape Canaveral. The entire reef is 90 miles long. There are restrictions on many types of fishing in most of the area and fishing for snapper and grouper species is prohibited in part of the area (South Atlantic Fishery Management Council 2012).

Critical Habitat

Designated critical habitat for the West Indian manatee, Northern Atlantic right whale, and loggerhead sea turtle is located within the ROI. The estuarine waters surrounding KSC provide year-round safe harbor and foraging areas for West Indian manatees. Manatees can be found at KSC during all months of the year, except when winter cold fronts drop water temperatures below 66 degrees Fahrenheit. KSC generally experiences a spring peak in manatee numbers followed by a fairly consistent number of animals in summer, another increase each fall, and then a drop each winter. The West Indian Manatee critical habitat (Unit LOGG-N-17) in the ROI is shown in Figure 3-4.

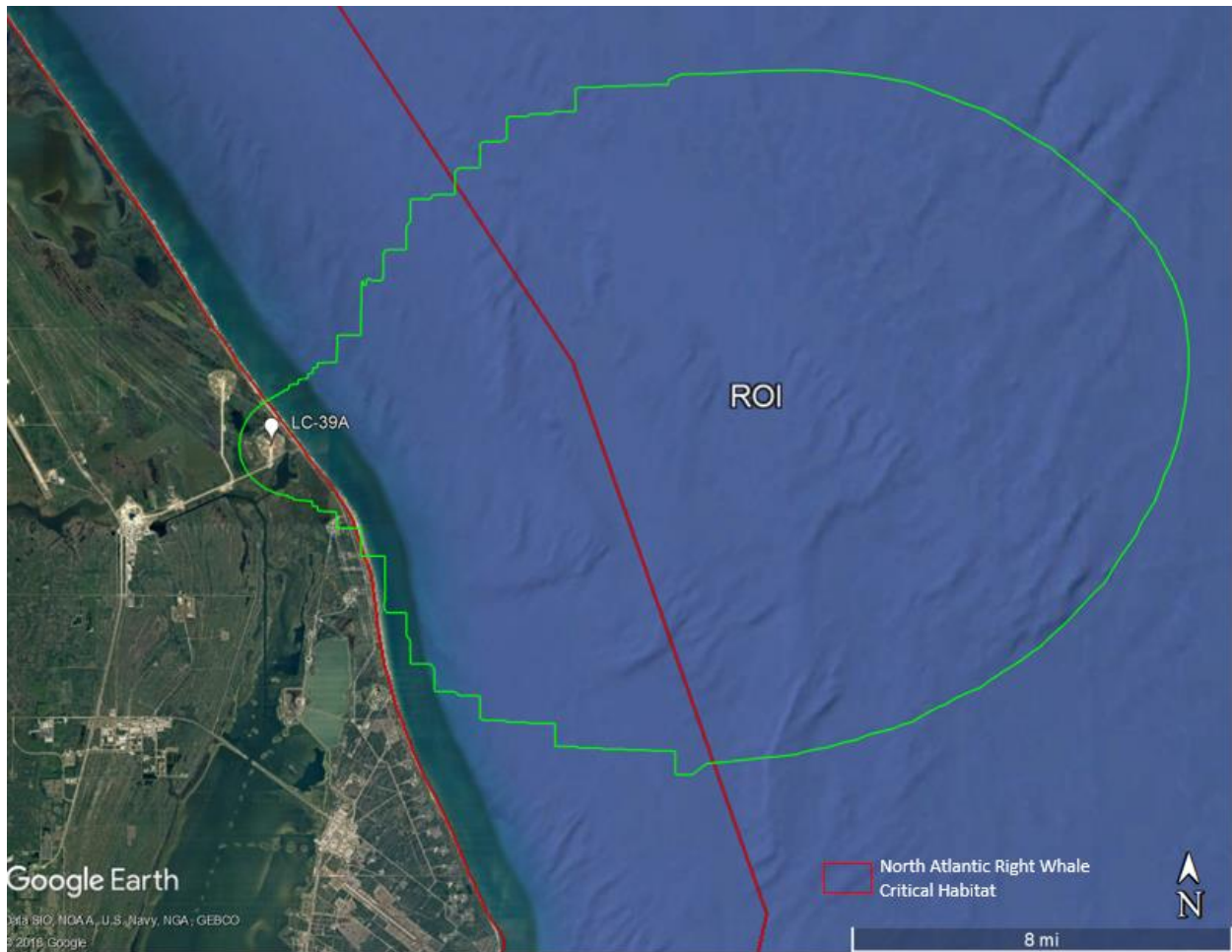


Source: USFWS 2018b.

Figure 3-2. West Indian Manatee Critical Habitat

NMFS designated two units of critical habitat for the North Atlantic right whale. Unit 1 is for foraging habitat and does not occur in the ROI. 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 (Figure 3-4). Unit 2 occurs off the coast of CCAFS and extends seaward approximately 5 nautical miles off the coast north of CCAFS. The following essential features are present in Unit 2:

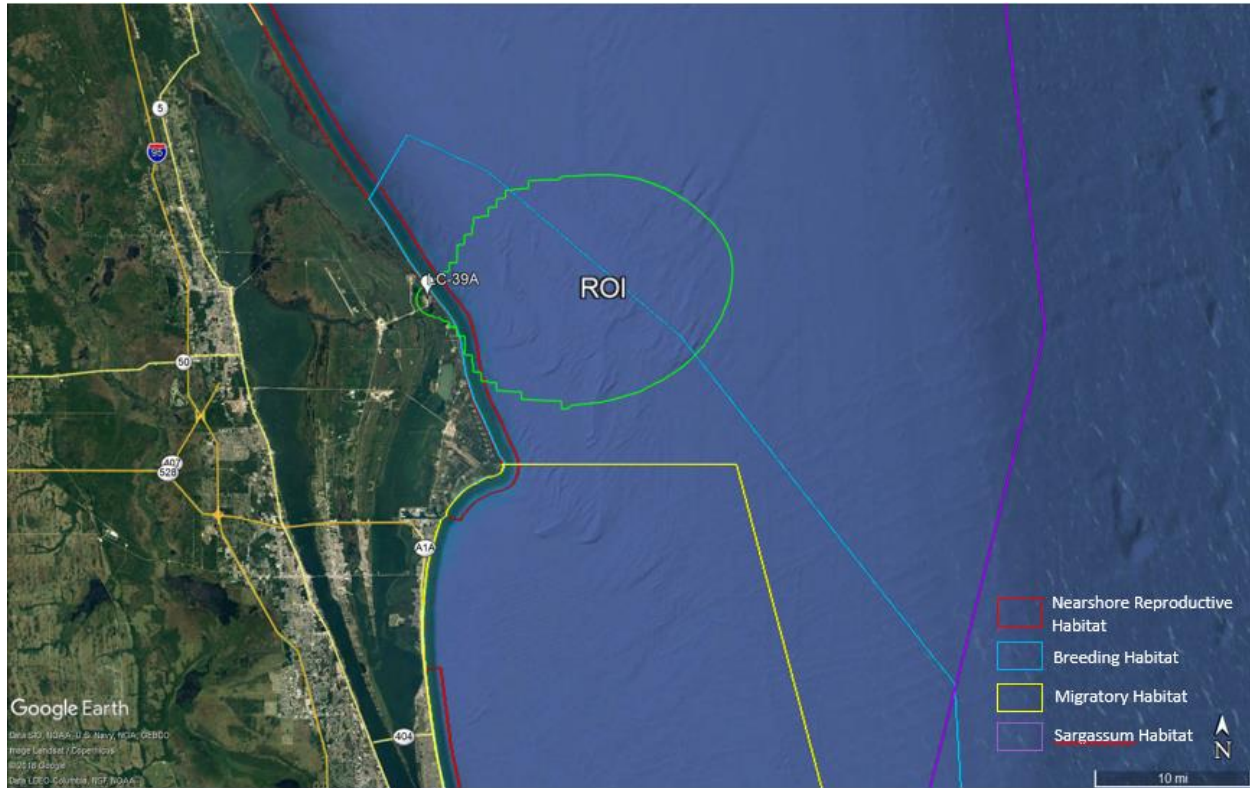
- Sea surface conditions associated with Force 4 or less on the Beaufort Wind Scale
- Sea surface temperatures of 7°C to 17°C
- Water depths of 6 to 28 meters, where these features simultaneously co-occur over contiguous areas of at least 231 square nautical miles of ocean waters during the months of November through April.



Source: NMFS 2016.

Figure 3-3. North Atlantic Right Whale Critical Habitat Unit 2

The loggerhead sea turtle critical habitat (Unit LOGG-N-17) in the ROI is shown in Figure 3-5. This unit includes overlapping areas of nearshore reproductive habitat, constricted migratory habitat, breeding habitat, and Sargassum habitat (refer to Appendix A for a description of these habitat types).



Source: NMFS 2016.

Figure 3-4. Loggerhead Sea Turtle Critical Habitat: LOGG-N-17

3.7 WATER RESOURCES

3.7.1 BACKGROUND

Water resources are surface waters and groundwater that are vital to society; they are important in providing drinking water and in supporting recreation, transportation and commerce, industry, agriculture, and aquatic ecosystems. As noted at the beginning of this chapter, groundwater (and wetlands and floodplains) is dismissed from detailed analysis. Therefore, this section focuses on surface waters.

3.7.2 EXISTING CONDITIONS

OCEAN WATERS

The ROI for ocean waters includes the area approximately 2–19 miles off the KSC coastline (see Figure 2-7). Ocean waters within the ROI include offshore, deep high salinity waters that are defined by prevailing currents. Water quality in ocean waters is characterized by temperature, salinity, dissolved oxygen, and nutrient levels.

INLAND SURFACE WATERS

The ROI for inland surface waters includes the area directly adjacent to LC-39A. Surface waters in the ROI include shallow estuarine lagoons. All surface waters within Merritt Island National Wildlife Refuge are designated as Outstanding Florida Waters as required by Florida Statutes for waters within national

wildlife refuges. Surface water quality at KSC is generally good, with the best water quality being found adjacent to undeveloped areas of the Indian River Lagoon, such as Mosquito Lagoon and the northernmost portions of the Indian and Banana Rivers (NASA 2015a).

3.8 HAZARDOUS MATERIALS, SOLID WASTE, AND POLLUTION PREVENTION

3.8.1 BACKGROUND

Hazardous materials, solid waste, and pollution prevention as an impact category includes an evaluation of the following:

- Waste streams that would be generated by a project, potential for the wastes to impact environmental resources, and the impacts on waste handling and disposal facilities that would likely receive the wastes;
- Potential hazardous materials that could be used during construction and operation of a project, and applicable pollution prevention procedures;
- Potential to encounter existing hazardous materials at contaminated sites during construction, operation, and decommissioning of a project; and
- Potential to interfere with any ongoing remediation of existing contaminated sites at the proposed project site or in the immediate vicinity of a project site.

The terms *hazardous material*, *hazardous waste*, and *hazardous substance* are often used interchangeably when used informally to refer to contaminants, industrial wastes, dangerous goods, and petroleum products. Each of these terms, however, has a specific technical meaning based on the relevant regulations.

Solid waste is defined by the implementing regulations of the Resource Conservation and Recovery Act (RCRA) generally as any discarded material that meets specific regulatory requirements, and can include such items as refuse and scrap metal, spent materials, chemical by-products, and sludge from industrial and municipal waste water and water treatment plants (see 40 CFR § 261.2 for the full regulatory definition).

Hazardous waste is a type of solid waste defined under the implementing regulations of RCRA. A hazardous waste (see 40 CFR § 261.3) is a solid waste that possesses at least one of the following four characteristics: ignitability, corrosivity, reactivity, or toxicity as defined in 40 CFR part 261 subpart C, or is listed in one of four lists in 40 CFR part 261 subpart D, which contains a list of specific types of solid waste that the EPA has deemed hazardous. RCRA imposes stringent requirements on the handling, management, and disposal of hazardous waste, especially in comparison to requirements for non-hazardous wastes.

Hazardous substance is a term broadly defined under Section 101(14) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (see 42 U.S.C. § 9601(14)). Hazardous substances include:

- any element, compound, mixture, solution, or substance designated as hazardous under Section 102 of CERCLA;
- any hazardous substance designated under Section 311(b)(2)(A) or any toxic pollutant listed under Section 307(a) of the Clean Water Act (CWA);
- any hazardous waste under Section 3001 of RCRA;
- any hazardous air pollutant listed under Section 112 of the Clean Air Act (CAA); and
- any imminently hazardous chemical substance or mixture for which the EPA Administrator has “taken action under” Section 7 of the Toxic Substances Control Act (TSCA).

The definition of hazardous substances under CERCLA excludes petroleum products, unless specifically listed or designated there under.

Hazardous material is any substance or material that has been determined to be capable of posing an unreasonable risk to health, safety, and property when transported in commerce. The term hazardous materials includes both hazardous wastes and hazardous substances, as well as petroleum and natural gas substances and materials (see 49 CFR § 172.101).

Pollution prevention describes methods used to avoid, prevent, or reduce pollutant discharges or emissions through strategies such as using fewer toxic inputs, redesigning products, altering manufacturing and maintenance processes, and conserving energy.

3.8.2 EXISTING CONDITIONS

The ROI for this impact category includes LC-39A, the near shore area on the KSC-CCAFS property border, and the KSC and CCAFS beaches where debris might wash ashore (if not properly collected at sea). Hazardous materials and solid and hazardous wastes are managed and controlled in accordance with federal, state, and local regulations. KSC has established plans and procedures to implement these regulations. The use, management, and disposal of hazardous materials on KSC is further described in Kennedy NASA Procedural Requirement 8500.1 - KSC Environmental Requirements.

KSC and CCAFS each have their own pollution prevention programs. SpaceX is compliant with those programs and also strives to prevent and reduce various forms of pollution. KSC has a program generally called the Installation Restoration Program to evaluate sites where contamination is present under RCRA and its Hazardous and Solid Waste Amendments. KSC has been working with the EPA and FDEP to identify potential release sites and implement corrective action at those sites as warranted. EPA's Solid Waste Management Unit (SWMU) Assessment initially identified 16 sites for investigation under the corrective action program. More sites were also identified by KSC as the program was implemented. In addition to corrective action sites, the NASA Remediation Group also manages petroleum contamination sites. To date, KSC has identified and investigated approximately 200 sites.

81 SWMUs and Potential Release Locations are generally concentrated in operational areas such as the Vehicle Assembly Building, LC-39, Industrial Area, and facilities on CCAFS currently or formerly operated by NASA. The most prevalent soil contaminants are petroleum hydrocarbons, RCRA metals, and

polychlorinated biphenyls (PCB); and the most prevalent groundwater contaminants are chlorinated solvents and associated degradation products. LC-39A has been designated as SWMU 8. RCRA Facility Investigation activities were performed at LC-39A from early 1998 through mid-2000. Groundwater impacts due to VOCs were observed. Surface water inside and outside of the perimeter fence contained polycyclic aromatic hydrocarbons, metals, and some pesticides were detected. An interim measure was conducted in 2000, which removed soils contaminated with PCBs and PAHs (NASA 2013).

Routine operations at Port Canaveral and CCAFS wharfs 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 by the Port 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.

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. 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 sulfur oxide and nitrogen oxide emissions from ship exhausts and prohibits deliberate emissions of ozone depleting substances.

Cape 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 storm water outfalls. Efforts to decrease contaminants include sweeping piers after cargo operations, cleaning pipes, installing storm water treatment boxes and educating tenants on managing potential pollutants.

4 ENVIRONMENTAL CONSEQUENCES

This chapter presents the environmental consequences associated with the Proposed Action and No Action Alternative. As noted at the beginning of Chapter 3, the environmental consequences of launch and Dragon reentry operations in the Atlantic Ocean have been previously analyzed in EAs (USAF 2007, 2013). In particular, the environmental consequences of launch activities from LC-39A were previously analyzed in NASA's LC-39 multi-use EA (NASA 2013). The FAA was a cooperating agency in the preparation of these USAF and NASA EAs. The FAA formally adopted the EAs and issued independent FONSI's (FAA 2009, 2013, 2016). These EAs are incorporated by reference in this EA. Therefore, in accordance with 40 CFR §1502.21, to cut down on bulk without impeding agency and public review of the Proposed Action, this chapter summarizes the environmental consequences of the Falcon 9 takeoff from LC-39A and Dragon reentry operation previously analyzed and focuses on the potential impacts from the abort test and activity not previously analyzed (i.e., Falcon 9 mid-air breakup and debris fall-out). The FONSI's incorporated by reference are available on the FAA's website: https://www.faa.gov/about/office_org/headquarters_offices/ast/environmental/nepa_docs/.

In determining whether a potential impact would be significant under NEPA, the analysis in this chapter considers the FAA's significance thresholds and factors to consider presented in FAA Order 1050.1F, Exhibit 4-1. For those impact categories for which the FAA has not identified a significance threshold, but has identified the factors to consider, note that the 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 their context and intensity to determine if there are significant impacts. As explained at the beginning of Chapter 3, several environmental impact categories are excluded from detailed analysis. Therefore, this chapter includes only those impact categories for which existing conditions are discussed in Chapter 3.

4.1 VISUAL EFFECTS

4.1.1 SIGNIFICANCE THRESHOLD

The FAA has not established a significance threshold for visual effects in FAA Order 1050.1F; however, the FAA has identified factors to consider when evaluating the context and intensity of potential environmental impacts for visual effects. Factors to consider that may be applicable to visual effects include, but are not limited to:

- Light Emissions Effects
 - The degree to which the action would have the potential to create annoyance or interfere with normal activities from light emissions; and

- The degree to which the action would have the potential to affect the visual character of the area due to the light emissions, including the importance, uniqueness, and aesthetic value of the affected visual resources.
- Visual Resources and Visual Character Effects
 - The degree to which the action would have the potential to affect the nature of the visual character of the area, including the importance, uniqueness, and aesthetic value of the affected visual resources;
 - The degree to which the action would have the potential to contrast with the visual resources and/or visual character in the study area; and
 - The degree to which the action would have the potential to block or obstruct the views of visual resources, including whether these resources would still be viewable from other locations.

4.1.2 PROPOSED ACTION

There would be no impacts related to light emissions because the abort test would occur during the day. Dragon separation from the Falcon 9 would occur approximately 1–4 miles offshore at 9–17 miles altitude. The breakup of the first stage would occur approximately 2–4 miles offshore at an altitude of approximately 11–19 miles altitude. The Proposed Action would not permanently change or degrade the existing visual character or quality of the site and its surroundings and is consistent with other activities that have occurred and currently occur at KSC. The visual sensitivity is low because KSC and CCAFS are located in industrialized areas. Therefore, the Proposed Action would not have significant impacts related to visual effects.

4.1.3 NO ACTION ALTERNATIVE

Under the No Action Alternative, SpaceX would not conduct the abort test. Therefore, there would be no project-related visual effects.

4.2 COASTAL RESOURCES

4.2.1 SIGNIFICANCE THRESHOLD

The FAA has not established a significance threshold for coastal resources in FAA Order 1050.1F; however, the FAA has identified factors to consider when evaluating the context and intensity of potential environmental impacts on coastal resources. Factors to consider that may be applicable to coastal resources include, but are not limited to, situations in which the Proposed Action would have the potential to:

- Be inconsistent with the relevant state coastal zone management plan(s);
- Impact a coastal barrier resources system unit (and the degree to which the resource would be impacted);

- 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.

4.2.2 PROPOSED ACTION

Takeoff of the Falcon 9 would not affect coastal resources (NASA 2013, FAA 2016). Some debris from the Falcon 9 breakup is expected to land within the aquatic portion of the ROI (i.e., the ocean within 3 miles of the coastline; refer to Figure 2-7). Much of the debris is expected to sink. The pieces that would float are primarily made up of COPVs and LOX transfer tubes. SpaceX has performed successful recovery of these floating items during at-sea recovery operations after water and unsuccessful barge landings. The debris would be collected in the ocean immediately following the abort test for up to 8 hours using recovery boats and aerial support to identify debris. The northern boundary of KSC would be monitored by aerial support to identify any debris that could potentially drift north of KSC property. The recovery vessels would be notified to collect the debris immediately. An assessment of debris drift by the U.S. Coast Guard would be used to inform retrieval effort search patterns. Given SpaceX's proposed recovery actions and their past success, no debris is expected to reach the shoreline.

In accordance with the CZMA-implementing regulations and the Florida CMP, SpaceX has submitted a federal consistency certification to the FDEP for review. Also, the FAA has submitted this Draft EA to the Florida State Clearinghouse for public review and comment. The FAA does not expect any significant impacts to coastal resources. The Final EA will document FDEP's review of the project.

4.2.3 NO ACTION ALTERNATIVE

Under the No Action Alternative, SpaceX would not conduct the abort test. Therefore, there would be no impact to coastal resources.

4.3 AIR QUALITY

4.3.1 SIGNIFICANCE THRESHOLD

Air quality impacts would be considered significant if the Proposed Action would cause pollutant concentrations to exceed one or more of the NAAQS, as established by the EPA under the CAA, for any of the time periods analyzed, or to increase the frequency or severity of any such existing violations (FAA Order 1050.1F).

4.3.2 PROPOSED ACTION

Brevard County, including KSC, is located in an area classified as in attainment with respect to the NAAQS. Emissions resulting from the Proposed Action would originate from short-term activities only; operation (long-term) emissions would not occur because the Proposed Action consists of a one-time abort test. Therefore, there would be no long-term emissions associated with the project. Short-term emissions would occur within the jurisdiction of the FDEP's Central District.

MSATs would be the primary HAPs emitted by mobile sources during pad launch activity and recovery operations. The recovery vessel, RHIB, and helicopter used during recovery operations would likely vary in age and have a range of emission controls. SpaceX anticipates that recovery equipment and vehicles would be operated for approximately 8 hours and would produce negligible ambient pollutant emissions in a widely dispersed area. HAPs 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.

Emissions resulting from support vehicles and equipment needed for Dragon recovery were previously assessed and were found to have no significant impacts (USAF 2007; FAA 2007).

Air emissions from a Falcon 9 launch include CO₂, CO, water vapor, NO_x, and carbon particulates. Most CO emitted is oxidized to CO₂ during after-burning in the exhaust plume. Only a small proportion of launch emissions would have the potential to affect ambient air quality (i.e., the area below the mixing height, defined as 3,000 feet above ground level), because the launch vehicle reaches the mixing height quickly after liftoff (NASA 2013).

Dragon would separate from the Falcon 9 first stage at an altitude of approximately 9–17 miles, and the first stage would briefly continue on a ballistic path. At the point of breakup, the first stage would be carrying less than 10,000 pounds of RP-1. The extra LOX carried as ballast for this test would provide an environment that is oxidizer rich, and would promote complete combustion of RP-1. SpaceX expects all fuel onboard the stage to be consumed during the breakup, which results when LOX and RP-1 mix, both initially in the tanks and afterwards in the air. The breakup would occur at approximately 11–19 miles altitude in less than a minute. This elevation is outside the mixing height of approximately 3,000 feet above ground level in Brevard County. Emissions above the mixing height are not likely to impact ground level pollutant concentrations. Additionally, most of the emissions would occur offshore, beyond state boundaries, where attainment status is unclassified and the NAAQs do not apply. The air emissions resulting from an explosion during a Falcon 9 launch were estimated in the USAF 2007 EA, which concluded NAAQS would not be exceeded.

SpaceX would recover the Falcon 9 first stage debris using boats that would originate from Port Canaveral. Additionally, a helicopter would support recovery efforts. Estimated emissions from operation of the vessels and helicopter are summarized in Table 4-1. Emissions within Brevard County would be minimal and would not be expected to have adverse air quality impacts in the county.

Table 4-1. Air Emissions from Vessels Used in the Debris Recovery

Mobile Emissions Source	Operating Time (hours)	Emissions pounds)						
		CO	VOC	NO _x	SO _x	PM ₁₀	PM _{2.5}	CO _{2e}
Vessel (Two 1,000 HP engines)	24	352.80	113.82	554.82	44.52	65.94	63.84	54,851.16
Vessel (Two 1,500 HP engines)								
Five Vessels (each with 355 HP engine)	24	3,051.39	344.78	127.39	3.58	1.34	1.25	17,733.48
Total (tons)		1.70	0.23	0.34	0.02	0.03	0.03	32.92

Notes: CO = carbon monoxide; CO_{2e} = carbon dioxide equivalent; HP = horsepower; NO_x = nitrogen oxides; PM₁₀ = particulate matter less than or equal to 10 microns in diameter; PM_{2.5} = fine particulate matter 2.5 microns or less in diameter; ppm = parts per million; SO_x = sulfur oxides; VOC = volatile organic compound.

The total operation emissions in Table 4-1 are compared to the General Conformity Rule basic *de minimis* thresholds, which are 100 tons per year for each of the pollutants. Conformity determinations are not required since KSC and CCAFS are in attainment with the NAAQS for all criteria pollutants. However, these values are useful for assessing the scale of the operational emissions. All of the emissions would be well below the General Conformity Rule *de minimis* thresholds and would be expected to have little or no impact on regional air quality. In summary, the Proposed Action would not result in significant air quality impacts.

4.3.3 NO ACTION ALTERNATIVE

Under the No Action Alternative, SpaceX would not conduct the abort test. Therefore, there would be no air quality impacts.

4.4 CLIMATE

4.4.1 SIGNIFICANCE THRESHOLD

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. CEQ has noted that “it is not currently useful for the NEPA analysis to attempt to link specific climatological changes, or the environmental impacts thereof, to the particular project or emissions, as such direct

linkage is difficult to isolate and to understand” (CEQ 2010). Accordingly, it is not useful to attempt to determine the significance of such impacts. 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 Order 1050.1F).

4.4.2 PROPOSED ACTION

A Falcon 9 launch would result in GHG emissions. Though emissions from the launch would increase the yearly levels of GHGs at KSC, the emissions would still be well below the EPA mandatory reporting threshold for stationary sources of 25,000 metric tons of CO₂e, and would represent a negligible fraction of GHG emission from KSC, the United States, or the world. Based on the anticipated one-time event and the short time frame of the activities that would occur, GHG emissions would be minimal. Therefore, the Proposed Action would not result in significant impacts related to climate.

4.4.3 NO ACTION ALTERNATIVE

Under the No Action Alternative, SpaceX would not conduct the abort test. Therefore, there would be no climate-related impacts.

4.5 NOISE AND NOISE-COMPATIBLE LAND USE

4.5.1 SIGNIFICANCE THRESHOLD

Significant noise impacts 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 1.5 dB or greater increase, when compared to the No Action Alternative for the same timeframe (FAA Order 1050.1F).

4.5.2 PROPOSED ACTION

Noise levels from the launch would be of short duration and diminish quickly as the vehicle rises. On behalf of SpaceX, KBRwyle (2018; see Appendix B) has estimated noise levels for a Falcon 9 (Block 5) launch at LC-39A (refer to Figure 8 in Appendix B). When a Falcon 9 Block 5 launch occurs during the day, when background levels are in the 50 dB to 60 dB range, residents of Titusville, Merritt Island, and Cape Canaveral may notice launch noise levels above 70 dB.

NASA’s 2013 EA assessed launch noise levels from the Space Launch System (SLS), because of all the launch vehicles analyzed in the 2013 EA, the SLS has the greatest thrust and thus would produce the loudest noise during launch. The SLS has more thrust than, and thus is louder than, the Falcon 9. The FAA’s FONSI (FAA 2016) based on the 2013 EA concluded that Falcon 9 and Falcon Heavy launches at LC-39A would not result in significant noise impacts. Therefore, the Falcon 9 launch as part of the abort test would not result in significant noise impacts.

SpaceX expects that at the time Falcon 9 reaches approximately 3–7 miles down-range and altitude of 11–19 miles, the breakup may be heard several miles away. The noise would be a muffled “roar” and rumbling, not a sharp high-frequency sound. Typically, this produces a “startle response,” similar to that from a sudden thunder clap. To prevent the “startle response,” SpaceX would issue public awareness

announcements in the media in advance of the abort test. SpaceX expects there would be public desire to observe the event from existing launch-viewing locations, thereby minimizing any surprised response. Given the distance from the anticipated Falcon 9 breakup to the shore and noise sensitive areas, the abort test would not result in significant noise impacts. That is, the abort test would not result in an increase in 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 1.5 dB or greater increase.

4.5.3 NO ACTION ALTERNATIVE

Under the No Action Alternative, SpaceX would not conduct the abort test. Therefore, there would be no impacts related to noise and noise-compatible land use.

4.6 BIOLOGICAL RESOURCES

4.6.1 SIGNIFICANCE THRESHOLD

Impacts on biological resources would be considered significant if the USFWS or NMFS determines 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 (FAA Order 1050.1F).

4.6.2 PROPOSED ACTION

Wildlife species in the vicinity of LC-39A would be affected by noise generated during the Falcon 9 launch. Animal species differ greatly in their response to noise. Wildlife exposed to launch noise would likely have a startle response that could interfere with normal behaviors, including breeding, feeding, and sheltering. However, temporary noise impacts on wildlife are not expected to affect local or regional populations of wildlife, especially since this area is accustomed to launch operations. Because the noise associated with a rocket launch is of short duration, wildlife species are expected to return to normal behavior within a few minutes to hours following the disturbance.

Given the altitude at which the Falcon 9 first stage would breakup and the distance from shore, no adverse effects to biological resources from the breakup noise are expected. 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 (low frequency sound events), indicating there is no risk of harassment for protected marine species in water (U.S. Air Force Research Laboratory 2000).

The abort test was one of the aspects discussed in ESA Section 7 consultation between the FAA, NASA, and NMFS in 2016, and again in 2017 between the FAA and NMFS (see Appendix A for the correspondence). In both consultations, NMFS concurred with NASA's and the FAA's determinations that launch operations, including the one-time abort test, "may affect, but are not likely to adversely affect" federally listed species and critical habitat. SpaceX would comply with all of the protective measures

contained in the ESA consultations. The FAA is currently updating these consultations to add two species (giant manta ray and oceanic whitetip shark) that have recently been listed by NMFS (Appendix A). The Final EA will include NMFS's response to FAA's re-initiation of consultation.

The abort test may coincide with the North Atlantic right whale migration season. Therefore, in addition to complying with the North Atlantic right whale protective measures identified in the ESA consultations, SpaceX plans to place spotter boats and aircraft to the north and south of the anticipated debris fall-out area to scan for North Atlantic right whales. If a North Atlantic right whale was identified in the area, SpaceX would delay the abort test until the whale is out of the expected debris area. Once the spotters determine it is safe to conduct the abort test, an "all clear" signal would be broadcasted. The North Atlantic right whale is one of the world's most endangered large whale species, with only an estimated 450 remaining along the east coast of the United States (NMFS 2012). Given the relatively low number of North Atlantic right whales, and the one-time aspect of the event, no adverse effects to the North Atlantic right whale or other protected species (including species protected by the ESA and MMPA) are anticipated.

Currently, the abort test is not expected to coincide with the sea turtle nesting season in Florida. However, if the abort test is delayed, it may coincide with the sea turtle nesting season. Green, leatherback, and loggerhead sea turtles have recently nested on beaches in Brevard County (FWC 2017b). The FAA is conducting ESA Section 7 consultation with USFWS to address potential effects on nesting sea turtles (Appendix A). Nesting sea turtles would only have the potential to be affected if debris washed ashore at the time a turtle was present on the beach. Given the debris recovery strategy that SpaceX would implement, the fact the abort test would occur once, and the low probability of debris washing ashore and affecting an individual turtle, the FAA determined the abort test "may affect, but is not likely to adversely affect" nesting sea turtles. The Final EA will include the USFWS's response to the FAA's request for concurrence and document the completion of the ESA consultation process.

Denser debris that would not float on the surface is anticipated to sink relatively quickly and is composed of inert materials that would not change the characteristics of the bottom substrate. Potential impacts of the seafloor and biological resources from debris from breakup of rocket stages have been previously analyzed (NASA 2013) and discussed in ESA Section 7 consultation between the FAA, NASA, and NMFS in 2016. Any effects on critical habitat from sinking and settling of rocket and fairing components are expected to be insignificant and discountable.

SpaceX plans to recover all parachutes deployed by Dragon, as possible, including the two drogue and four main parachutes. Biological impacts from the drogue and main parachutes were analyzed in NASA's and FAA's ESA consultations with NMFS (see Appendix A). As stated in the consultations, the unrecovered parachute(s) could present 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. 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. Similarly, given the one-time nature of the abort test and the debris recovery strategy that SpaceX would implement, no effects to West Indian manatee critical habitat are expected.

In summary, given the results of the ESA consultations with NMFS and USFWS, the Proposed Action would not result in significant impacts on biological resources.

4.6.3 NO ACTION ALTERNATIVE

Under the No Action Alternative, SpaceX would not conduct the abort test. Therefore, there would be no impacts on biological resources.

4.7 WATER RESOURCES

4.7.1 SIGNIFICANCE THRESHOLD

Impacts on surface waters would be considered significant if the Proposed 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.

4.7.2 PROPOSED ACTION

4.7.3 OCEAN WATERS

SpaceX would collect the floating debris generated by the breakup of the Falcon 9 first stage before the debris can wash ashore. The debris that sinks to the ocean floor is composed of inert materials which would not change the characteristics of inert solids in ocean sediment. The rate of deposition would vary by piece of debris, but none are so dense or large that benthic communities would be degraded.

No discharge of hazardous waste into the ocean would occur from the breakup of the first stage. All RP-1 is expected to be completely consumed due to the oxidizer rich environment from the extra LOX carried as ballast. The extra LOX would promote complete combustion of the RP-1. Additionally, the debris produced from the first stage breakup would not contain hazardous waste. Therefore, the Proposed Action is not expected to result in any significant impacts to ocean waters.

4.7.4 IN-LAND SURFACE WATERS

Air emissions from Falcon launch operations include CO₂, CO, water vapor, NO_x, and carbon particulates. Most CO emitted is oxidized to CO₂ during after-burning in the exhaust plume. Therefore, the Falcon 9 launch is not expected to adversely affect surface waters from pollutant deposition.

The deluge water used during the abort test is not expected to impact surface water quality. There are drainage ditches at LC-39A that direct storm water offsite; however, SpaceX would capture any potential water discharge in the existing containment basins on site. The deluge water is considered industrial wastewater that is currently permitted through FDEP. The permit allows the water to settle over time in the containment basins and land applied onsite. This disposal area has above grade berms, which is operated as a sprayfield. The water would remain in the basins to settle any particulate and the pH

stabilizes. This is a practice that has been conducted since 2015, when SpaceX first launched from LC-39A, and is permitted by FDEP. Therefore, no adverse effects to in-land surface waters would occur.

In summary, the Proposed Action would not result in significant impacts on water resources.

4.7.5 NO ACTION ALTERNATIVE

Under the No Action Alternative, SpaceX would not conduct the abort test. Therefore, there would be no impacts on water resources.

4.8 HAZARDOUS MATERIALS, SOLID WASTE, AND POLLUTION PREVENTION

4.8.1 SIGNIFICANCE THRESHOLD

The FAA has not established a significance threshold for hazardous materials, solid waste, and pollution prevention in FAA Order 1050.1F; however, the FAA has identified factors to consider in evaluating the context and intensity of potential environmental impacts. 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 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 surface area within the boundaries of a contaminated site are contaminated, which leaves space for potentially siting a facility on non-contaminated land within the boundaries of a contaminated site. An 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; or
- 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

4.8.2 PROPOSED ACTION

Hazardous materials and solid and hazardous wastes are managed and controlled in accordance with federal and state regulations. KSC has established plans and procedures to implement these regulations. The use, management, and disposal of hazardous materials for operations are described in KNPR 8500.1, KSC Environmental Requirements. An active pollution prevention program is in place to reduce the use of hazardous materials and generation of hazardous waste.

All wastes generated by commercial entities must be properly containerized, stored, labeled, manifested, shipped, and disposed of in full regulatory compliance. Hazardous wastes generated by commercial

entities and their contractors must be manifested, shipped, and disposed of under the company's EPA identification number. Commercial entities are required to maintain copies of waste management records and manifests onsite and provide them for NASA review upon request.

Dragon would contain approximately 2,400 pounds of residual propellant after the abort test. 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. MMH and NTO 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. 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).

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), unused explosives, and lead-acid batteries. As stated in USAF's 2013 EA (USAF 2013), these activities are not expected to result in significant impacts related to hazardous materials, pollution prevention, or solid waste. Continued implementation of existing handling and management procedures for hazardous materials, hazardous wastes, and solid wastes generated would limit the potential for impacts.

During this one-time planned event, in addition to the risk of direct contact with reentry debris, some vehicle parts would likely break apart upon water impact and sink within minutes. SpaceX estimates that due to the conflagration of the first and second stage vehicle destruction, no fuel would remain. Any impacts would be minimal due to the ocean's dilution effects. Although unlikely, if the booster remained intact, it would float at or near the surface for longer periods of time. Since the Range Control would have cleared the airspace and ocean surface for the duration of the abort test and SpaceX would be tracking and recovering debris, the booster would not present navigation and debris hazards. All vehicle elements are planned for recovery. Some small pieces may dissipate and become buried in the ocean bottom.

Recovery efforts would be pre-deployed to the planned splash down site in the Atlantic Ocean. After the event, debris would be collected, rendered safe, and then prepared for return to CCAFS. The environment could also be impacted by a recovery ship accident, or as a result of jettisoned components hitting a ship or aircraft. This possibility or risk would be minimized to an acceptable level by the issuance of NOTAMS and NOTMARs, as described in Chapter 2.

In summary, the Proposed Action would not result in significant impacts related to hazardous materials, solid waste, and pollution prevention.

4.8.3 NO ACTION ALTERNATIVE

Under the No Action Alternative, SpaceX would not conduct the abort test. Therefore, there would be no impacts related to hazardous materials, solid waste, and pollution prevention.

5 CUMULATIVE IMPACTS

Cumulative impacts are defined by CEQ in 40 CFR § 1508.7 as “...the impact on the environment which results 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.” Cumulative impacts can result from individually minor but collectively significant actions taking place over time. The CEQ regulations require that NEPA environmental analyses address connected, cumulative, and similar actions in the same document (40 CFR § 1508.25).

Additionally, CEQ further explained in *Considering Cumulative Effects Under the National Environmental Policy Act* 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 a time frame, including past actions and foreseeable future actions, in order to capture these additional effects.

5.1 PAST, PRESENT, AND REASONABLY FORESEEABLE FUTURE ACTIONS

Due to the nature of the Proposed Action (i.e., a one-time abort test) and its location on the coast within KSC, only present and reasonably foreseeable launch-related actions occurring at KSC would meaningfully interact in time and space with the Proposed Action such that potential cumulative impacts could result. Ongoing projects and planned projects at KSC are listed in Table 5-1 and discussed in the following paragraphs.

Table 5-1: Ongoing and Planned Projects at KSC

Project	Location	Status
Ground Systems Development and Operations	KSC	Ongoing.
Multi-Use of Launch Complexes 39A and 39B	LC-39A and LC-39B	NEPA compliance complete (NASA 2013). Construction and operations ongoing.
Small Class Vehicle Launch Pad 39C	Southside of LC-39B	Ongoing.
Evolved Expendable Launch Vehicle Program	LC-41 and LC-37	NEPA compliance complete (USAF 1998, 2000). Operations ongoing.
KSC Shoreline Protection Project	KSC Shoreline	NEPA compliance complete (NASA 2015). Operations ongoing.

SpaceX Roberts Road Operation Area	KSC	Future plan. EA being developed.
Ground Systems Development and Operations Program	LC-48	Future plan.
Ascent Abort-2 test mission of Orion	LC-46	Future plan.

The future land use plan for KSC promotes the most efficient use of land area resources balanced with an understanding of development suitability and capacity (NASA 2017). KSC's transition to a multi-user spaceport advocates compatible relationships between adjacent land uses, encourages infill development, and preserves environmentally sensitive areas. Current actions at KSC include the Ground Systems Development and Operations (GSDO) Program, leading KSC's transformation from a historically government-only launch complex to a spaceport with activity involving government and commercial vehicles alike. The program's primary objective is to prepare KSC to process and launch the next-generation vehicles and spacecraft designed to achieve NASA's goals for space exploration.

Under a 20-year Commercial Space Launch Act agreement between NASA and SpaceX, LC-39A is being used for processing and launch of Falcon 9 and Falcon Heavy launch vehicles. In 2015, SpaceX constructed a 50,000 square-foot Falcon Integration Hangar at the entrance to LC-39A. Primary components of the hangar include dual overhead bridge cranes, embedded integration rail, and an oversized door for access of flight hardware and ground support equipment.

LC-39B is under the process of redevelopment for the SLS rocket and Orion spacecraft. The pad was returned to a clean design after removal of the Fixed Service Structure. This will allow multiple types of vehicles to launch from LC-39B arriving at the pad with service structures on the mobile launch platform rather than custom structures on the pad. NASA has announced LC-39B would be available to commercial users during times when it is not needed by SLS.

KSC's newest launch pad, designated LC-39C, is designed to accommodate small class launch vehicles. Located in the southeast area of the LC-39B perimeter, this new concrete pad measures about 50 feet wide by about 100 feet long. LC-39C will serve as a multi-purpose site allowing companies to test vehicles and capabilities in the smaller class of rockets, making it more affordable for smaller companies to break into the commercial spaceflight market. As part of this capability, NASA's GSDO Program developed a universal propellant servicing system, which can provide LOX and liquid methane fueling capabilities for a variety of small class rockets.

With the addition of LC-39C, KSC can offer the following processing and launching features for companies working with small class vehicles (maximum thrust up to 200,000 pounds):

- Processing facilities (e.g., Vehicle Assembly Building)
- Vehicle/payload transportation (KAMAG, flatbed trucks, tugs, etc.) from integration facility to pad
- Launch site

- Universal propellant servicing system (LOX, liquid methane)
- Launch control center/mobile command center options

The GSDO plans to construct a new launch complex, LC-48, as a multi-use launch complex for small class launch vehicles. This launch complex would be located approximately 6,500 feet southeast of LC-39A and 5,220 feet north of LC-41. Development could also include construction of a Horizontal Integration Facility, Manufacturing and Refurbishment Facility, and Vertical Landing Facility near the launch complex, on other undeveloped areas at KSC.

LC-41 is currently used by United Launch Alliance for Atlas V launches. Northrop Grumman Innovation Systems (formerly Orbital ATK) unmanned resupply Cygnus spacecraft was flown from LC-41 to the ISS in April 2017. An unmanned orbital flight test of the Starliner capsule to the ISS is scheduled for 2018.

Minotaur IV rockets are to be launched from LC-46. LC-46 will also be used by NASA for the Ascent Abort-2 test mission of Orion planned for 2018.

NASA KSC is responsible for its real property assets and infrastructure in support of the NASA mission of human spaceflight and continued exploration of space. The KSC shoreline restoration project reduces shoreline erosion, thereby protecting both critical launch infrastructure and valuable threatened and endangered species habitat along the KSC coastline from storm wave and sea level rise damage. The project establishes a new secondary dune immediately inland of the existing dune, and allow the existing dune and beach to serve as an erosion buffer. The project is currently underway.

5.2 APPROACH TO CUMULATIVE IMPACT ANALYSIS

In accordance with FAA Order 1050.1F and the CEQ regulations, the FAA analyzed the potential cumulative impacts on the resources that would be adversely affected by the Proposed Action. Based on the findings and potential impacts described in Chapter 4, this cumulative impacts analysis focuses on air quality and noise and noise-compatible land use, which are the impact categories for which cumulative impacts have the potential to occur, when analyzed in the context of the one-time abort test.

The FAA has determined there are no potential cumulative impacts for all other impact categories analyzed in Chapter 4 because the Proposed Action's impacts would not meaningfully interact in time and space with the potential effects of other past, present, and reasonably foreseeable future actions.

5.3 AIR QUALITY

The Proposed Action, in addition to the present and reasonably foreseeable actions at KSC, would result in a minor, temporary increase in air emissions. Only a small proportion of launch emissions during any launch has the potential to affect ambient air quality (i.e., the area below the mixing height, defined as 3,000 feet above ground level), because the launch vehicle reaches the mixing height quickly after liftoff. The cumulative emissions would not exceed any thresholds established under the Clean Air Act or jeopardize the attainment status of the region. Brevard County, including KSC, is located in an area classified as in attainment with respect to the NAAQS. All government and commercial launches at KSC occur individually, i.e., no launch overlaps in time or space with another launch. This avoids the potential

for simultaneously combining impacts associated with exhaust plumes from multiple launch vehicles. Therefore, no significant cumulative impacts on air quality are expected to occur.

5.4 NOISE AND NOISE COMPATIBLE LAND USE

The Proposed Action, in addition to the present and reasonably foreseeable future actions at KSC, would result in a temporary increase in noise levels in the area surrounding KSC. Rocket launches would occur separately, avoiding combined noise impacts from more than one launch at a time. The noise associated with the Falcon 9 breakup during the abort test would be short in duration (less than one second) and originate 2–4 miles offshore at 11–19 miles altitude. The noise from aircraft and boats used for Dragon and debris recovery would be temporary in duration and would not be a major contributor to ambient noise levels in the area. Cumulative noise levels would not exceed the FAA’s noise significance threshold. In summary, the Proposed Action would not result in significant cumulative impacts related to noise and noise-compatible land use.

6 LIST OF PREPARERS

Federal Aviation Administration

Daniel Czelusniak

Environmental Protection Specialist

Office of Commercial Transportation

SpaceX

Matthew Thompson

Director, Environmental Health and Safety

Katy Smith

Environmental Engineer

Julia Black

Integrated Launch Operations Engineer

7 PERSONS AND AGENCIES CONTACTED

Patrick S. Giniewski, Chief
Installation Management Flight
45 CES/CEI
1224 Jupiter Street
Patrick AFB, FL 32925-2231

Eva Long
NEPA Specialist, Environmental Planning and
Conservation
45 CES/CEIE
1224 Jupiter Street
Patrick AFB, FL 32925-2231

Angy Chambers
Natural Resources Program Manager
45 CES/CEIE
1224 Jupiter Street
Patrick AFB, FL 32925-2231

Lauren P. Milligan / Chris Stahl
Office of Intergovernmental Programs
Florida Dept. of Environmental Protection
3900 Commonwealth Boulevard
Tallahassee, Florida 32399-3000

Donald Dankert
Environmental Management Branch
SI-E3, NASA Kennedy Space Center
Florida

Timothy Parsons
Florida Division of Historical
Resource
Bureau of Historic Preservation
R.A. Gray Building
500 South Bronough Street
Tallahassee, Florida 32399

Myrna Palfrey
National Parks Service
Canaveral National Seashore
212 S. Washington Ave.
Titusville, Florida 32796

Gretchen R. Kelley, P.E. and Susan Moor
St Johns River Water Management District
Division of Regulatory, Engineering, &
Environmental Services
525 Community College Parkway
Palm Bay, FL 32909

Andrew Phillips
Department of the Army,
Jacksonville District Corps of
Engineers, Cocoa Permits
Section, 400 High Point
Drive, Suite 600
Cocoa, FL 32926

Rory Boyle
US Coast Guard
MST2, Sector Jacksonville
Waterways Management
10426 Alta Drive
Jacksonville, FL 32226

Eugene (Gene) Stratton
US Coast Guard
Planning, Marine Information &
Waterways Management
Seventh Coast Guard District
Miami, FL 32781

Layne Hamilton
Project Leader/Refuge Manager
Merritt Island National Wildlife Complex
U.S. Fish and Wildlife Service
P.O. Box 2683
Titusville, Florida 32781-2683

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APPENDIX A: AGENCY COORDINATION



UNITED STATES DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration

NATIONAL MARINE FISHERIES SERVICE

Southeast Regional Office

263 13th Avenue South

St. Petersburg, Florida 33701-5505

<http://sero.nmfs.noaa.gov>

F/SER31: NMB

Donald Dankert
Environmental Management Branch
National Aeronautics and Space Administration
John F. Kennedy Space Center
Mail Code: SI-E3
Kennedy Space Center, Florida 32899

AUG 08 2016

Daniel Czelusniak
Environmental Specialist
Federal Aviation Administration
800 Independence Avenue Southwest
Suite 325
Washington, DC 20591

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

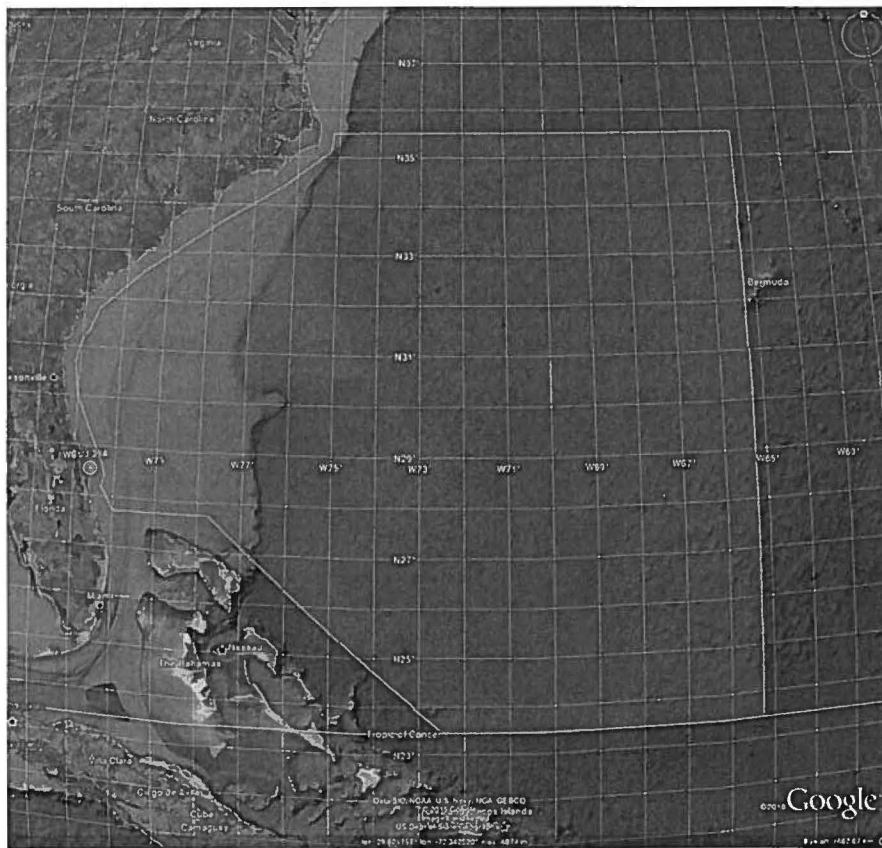
Consultation History

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 Cape 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 ascent 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 ascent. 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 descent 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 (ft²) 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 descent. 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 ascent 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.nmfs@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 inhabitation 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 ft²), 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,

A handwritten signature in black ink, appearing to read "Roy E. Crabtree".

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



U.S. Department
of Transportation
**Federal Aviation
Administration**

Office of Commercial Space Transportation

800 Independence Ave., SW.
Washington, DC 20591

August 25, 2017

Jacqueline Pearson Meyer
ESA Interagency Cooperation Division
Office of Protected Resources
National Marine Fisheries Service
1315 East-West Highway
Silver Spring, MD 20910

RE: Endangered Species Act Consultation for SpaceX Operations

Dear Ms. Meyer,

The Federal Aviation Administration (FAA) is proposing to issue licenses to Space Exploration Technologies Corp. (SpaceX) for launch operations that occur in the Pacific and Atlantic Oceans and Gulf of Mexico. This letter is to request Endangered Species Act (ESA) concurrence from your office for project activities discussed in the attached Biological Evaluation (BE). The FAA has determined project activities "may affect, but would not likely adversely affect" the following ESA-listed species:

- blue whale (*Balaenoptera musculus*), fin whale (*B. physalus*), humpback whale (*Megaptera novaeangliae*), North Atlantic right whale (*Eubalaena glacialis*), sei whale (*B. borealis*), sperm whale (*Physeter microcephalus*), scalloped hammerhead shark (*Sphyrna lewini*), Guadalupe fur seal (*Arctocephalus townsendi*), green sea turtle (*Chelonia mydas*), hawksbill sea turtle (*Eretmochelys imbricata*), Kemp's ridley sea turtle (*Lepidochelys kempii*), leatherback sea turtle (*Dermochelys coriacea*), loggerhead sea turtle (*Caretta caretta*), olive ridley sea turtle (*L. olivacea*), Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*), Gulf sturgeon (*A. oxyrinchus desotoi*), green sturgeon (*A. medirostris*), shortnose sturgeon (*A. brevirostrum*), Nassau grouper (*Epinephelus striatus*), and smalltooth sawfish (*Prisids pectinata*)

A complete description of the project, action area, and effects analysis is provided in the attached BE. The FAA is requesting NMFS's written concurrence with the effect determinations. Please contact Daniel Czelusniak, FAA Environmental Specialist, at Daniel.Czelusniak@faa.gov or (202) 267-5924 to discuss any questions or concerns.

Sincerely,

Daniel Murray
Manager, Space Transportation Development Division

Attachment

**Federal Aviation Administration
Office of Commercial Space Transportation**

Biological Evaluation

**SpaceX Landing and Recovery Operations in the
Atlantic Ocean, Pacific Ocean, and Gulf of Mexico**

August 25, 2017

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1. Introduction and Background

The mission of the Federal Aviation Administration (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 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 Space Exploration Technologies Corp. (SpaceX).

This Biological Evaluation (BE) has been prepared to address the effects of the FAA Office of Commercial Space Transportation issuing licenses to SpaceX on species listed as threatened or endangered under the Endangered Species Act (ESA) of 1973 and any associated critical habitat. Section 7 of the ESA assures that, through consultation (or conferencing for species proposed to be listed under the ESA) with the National Marine Fisheries Service (NMFS) and/or the U.S. Fish and Wildlife Service (USFWS), federal actions do not jeopardize the continued existence of any threatened, endangered, or proposed species, or result in the destruction or adverse modification of critical habitat.

SpaceX operates their Falcon family of vehicles, which includes the Falcon 9 and soon-to-be launched Falcon Heavy, from launch complexes at three sites: the National Aeronautics and Space Administration (NASA) Kennedy Space Center (KSC), the U.S. Air Force (USAF) Cape 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. Eventually, all Dragon missions (cargo and humans) would use the Dragon-2. Most of SpaceX's payloads are non-governmental (i.e., commercial); however, some of SpaceX's launches are government sponsored (e.g., launches for NASA or the Department of Defense). After completing its mission at the ISS, the Dragon returns to Earth and lands in the ocean. SpaceX is currently evaluating Dragon landings in the Pacific Ocean, Gulf of Mexico, and Atlantic Ocean.

One of SpaceX's goals 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 on December 21, 2015 was a major milestone toward SpaceX's goal of fully recovering and reusing every aspect of the 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 (nose cones) after launches.

Last year, NASA and the FAA conducted informal ESA consultation (SER-2016-17894) with NMFS to assess the potential effects of waterborne landings (splashdowns) of rockets, rocket parts, and spacecraft on ESA-listed species and critical habitat in the Atlantic Ocean and the Gulf of Mexico (see Appendix A). Federally listed species covered under that consultation included the green, Kemp's ridley, leatherback, hawksbill, and loggerhead sea turtles; smalltooth sawfish; Gulf, shortnose, and 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. In a letter dated August 8, 2016, NMFS concluded that all potential effects of SpaceX's open-water splashdowns in the Atlantic Ocean and Gulf of Mexico to ESA-listed species and critical habitat were discountable or insignificant, and concurred with NASA's and the FAA'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. SpaceX is implementing and will continue to implement those measures during marine operations.

Subsequent to concluding the 2016 consultation (SER-2016-17894), 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 recovered by SpaceX. The FAA also recently learned the parachutes associated with Dragon reentry are not always recovered by SpaceX. These aspects of the project were not considered in the 2016 consultation (SER-2016-17894). The 2016 consultation assumed all parachutes and parafoils would be recovered. In addition, the 2016 consultation did not consider operations in the Pacific Ocean.

The FAA prepared this BE to address the potential effects to ESA-listed species and critical habitat from 1) weather balloon deployment for Falcon booster landings and fairing recovery, 2) Dragon reentry and recovery operations, and 3) payload fairing recovery operations that were not considered in the 2016 consultation with NMFS. This BE is intended to supplement the 2016 consultation and focus specifically on the activities to occur in the Atlantic Ocean, Pacific Ocean, and Gulf of Mexico that are outside the scope of the 2016 consultation. This BE 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 lead by the FAA, NASA, or USAF. Such consultations will continue to be coordinated with NMFS at the regional or local level on a project-by-project basis. Any future changes to SpaceX's operations in the marine environment that could affect ESA-listed species or critical habitat in a manner not considered in this consultation will require reinitiating this consultation.

2. Project Description

This section discusses all of SpaceX's current and proposed activities that are the subject of this consultation.

2.1. Weather Balloon Deployment for Falcon Booster Landings and Fairing Recovery

Falcon 9 uses an 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. SpaceX measures wind speed in the landing zone using weather balloons. Measurements are taken at various intervals before landing events and used to create the required profiles of expected wind conditions during the landing event. A radiosonde, which is powered by a 9 volt battery, is attached to the weather balloon that transmits data to SpaceX. The balloon, which is made of latex, rises to approximately 20–30 kilometers and bursts. The balloon is shredded in many pieces that fall back to Earth, along with the radiosonde, and lands in the ocean. The radiosonde does not have a parachute. The pieces of the balloon and the radiosonde are not recovered. The radiosonde will sink to the ocean floor. During a droneship (i.e., at-sea landing on a barge) landing event, SpaceX typically releases three to four weather balloons per launch count down. Weather balloons are not typically released for land landings; however, if a fairing recovery operation is planned, weather balloons would be released.

Commonly cited research (Burchette 1989) asserts that nearly all latex balloons at burst altitude rupture into small, ribbon-like fragments. This was recently confirmed by researchers at the University of

Colorado and National Oceanic and Atmospheric Administration (University of Colorado and NOAA 2017). As such, it is assumed the weather balloons would land in the Pacific and Atlantic Oceans in small shreds. 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).

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).

2.2. Dragon Reentry and Recovery Operations

Dragon (both versions) is composed of two main elements: the capsule for pressurized crew and cargo and the unpressurized cargo module or "trunk" (see Exhibit 1). 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 17 feet and a base width of 13 feet. Dragon's propulsion system uses nitrogen tetroxide (NTO) and monomethylhydrazine (MMH) propellant combination.

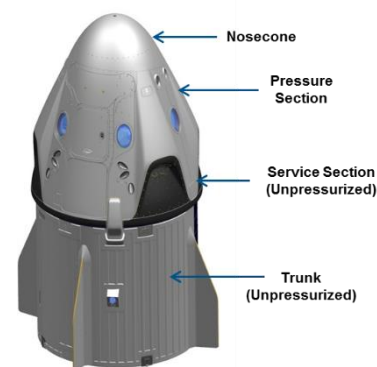


Exhibit 1. Dragon-2

Dragon reentry, splashdown, and recovery are the three elements of a Dragon landing operation. After completing its mission in space, Dragon travels back to Earth where it completes a deorbit burn and reenters the atmosphere. During reentry, Dragon creates a sonic boom. 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. 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 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.

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 Exhibit 2). 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 1–2 kilometers from Dragon. Similar to the main parachutes, the drogues float on the surface of the water.

Shortly after the drogue parachutes are deployed, they are released and the main parachutes are deployed (see Exhibit 3). The main parachutes would slow Dragon to a speed of approximately 13 miles per hour allowing for a “soft” splashdown in the water.¹ 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.



**Exhibit 2. Dragon-1 Main Parachutes with Released Drogue Parachutes
in the Background**

¹ For example, see: <https://www.youtube.com/watch?v=4HPQxVhXgz0>.



Exhibit 3. Dragon-1 Main Parachute Deployment

Dragon would reenter Earth's atmosphere at a pre-planned trajectory and would be tracked to a splashdown zone within a larger recovery zone. Following splashdown, an electronic locator beacon on Dragon would assist SpaceX in locating and recovering Dragon by a pre-positioned recovery vessel. The recovery vessel is an approximate 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 hypergolic vapors, which can be fatal if inhaled, and ensuring the capsule is floating in an upright and stable position. Up to 1,000 kilograms of hypergolic fuels may be on Dragon during splashdown. Dragon propellant storage is designed to retain residual propellant, so any propellant remaining in Dragon is not expected to be released into the ocean. A propellant leak is not likely. In an event the propellant tank ruptures on impact, the fuel would almost immediately form nitric and nitrous acid on contact with water, and would be quickly diluted and buffered by seawater.

The recovery vessel would then arrive and recovery personnel would lower a hydraulic lift mechanism into the water in order to prepare for Dragon pick-up (see Exhibit 4). The lift would bring Dragon gently out of the water and onto the deck of the recovery vessel (see Exhibit 5). While Dragon is loaded on to the recovery vessel, the RHIB would recover all parachutes deployed, including the two drogue and three/four main parachutes. However, it's possible some or all of the parachutes are not recovered due to sea or weather conditions. With the capsule secured in the on-deck hangar, egress equipment would be positioned in front of the capsule, capsule pressure would be equalized, and the side hatch would be opened. Crew egress would then begin. Crew would be helped from the capsule into shipboard medical evaluation quarters, and medical assessment would begin. The crew and time-critical cargo would be transported via helicopter to the nearest airport.



Exhibit 4. Dragon Recovery Following Reentry



Exhibit 5. Dragon on Recovery Vessel Following Reentry

For Dragon recovery in the Atlantic Ocean, Dragon would be shipped to SpaceX facilities located at the Port of Cape Canaveral or a CCAFS-located wharf. For Dragon recovery in the Gulf of Mexico, Dragon would be shipped to a commercially available port/wharf on the Gulf coast. If a local port is not available in the Gulf, the recovery vessel would travel to SpaceX facilities located at the Port of Cape Canaveral or a CCAFS-located wharf. For Dragon recovery in the Pacific Ocean, Dragon would be shipped to the Port of Long Beach or Port of Los Angeles. SpaceX would be responsible for coordinating local approvals with the relevant state and local agencies, including port authorities. Upon arriving at a port, Dragon 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.

The recovery zones for the Atlantic Ocean, Gulf of Mexico, and Pacific Ocean are described below.

2.2.1. 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 and excludes North Atlantic right whale critical habitat in the Atlantic Ocean (see Exhibit 6).

The superbox is the current Atlantic Ocean recovery zone for Dragon-1, which was included in 2016 consultation (SER-2016-17894). For Dragon-2, the superbox would be used mainly for contingency landings.

Because Dragon-2 would contain astronauts, 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” (see Exhibit 7). 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 5 nautical miles from the coast in order to avoid critical habitat for the North Atlantic right whale.

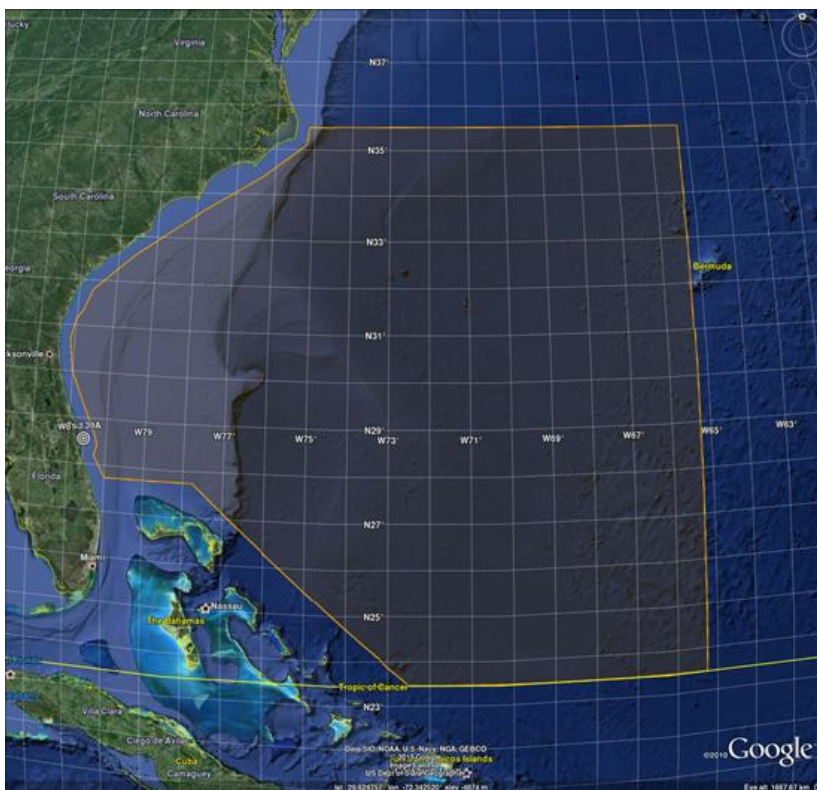


Exhibit 6. Atlantic Ocean Recovery Zone for Dragon – Superbox

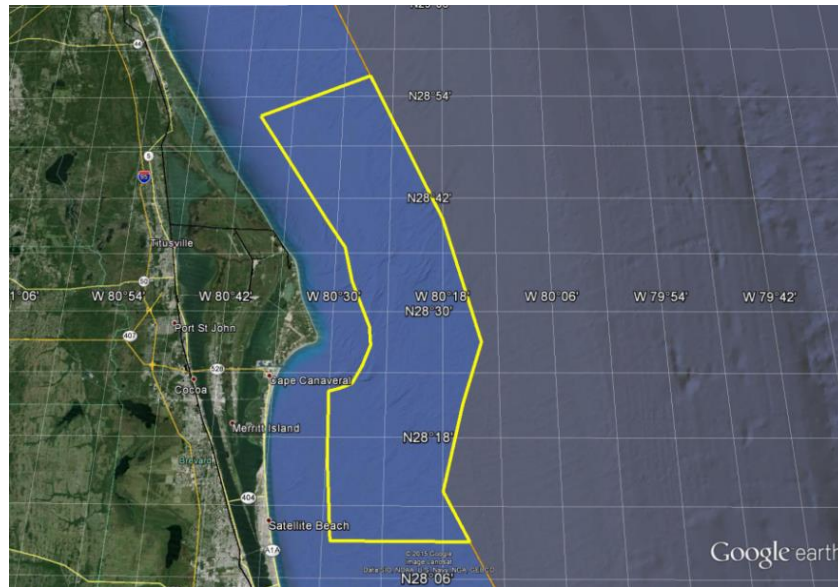


Exhibit 7. Nominal Recovery Zone for Dragon-2 – The Bulb

2.2.2. 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 (see Exhibit 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.

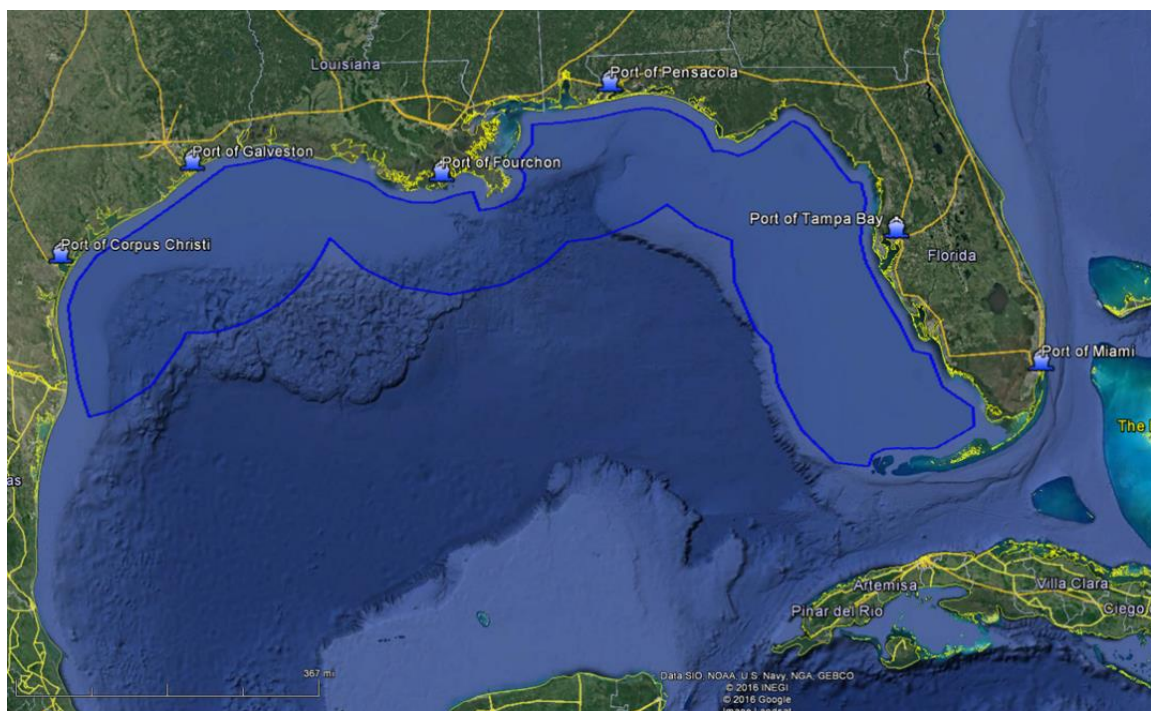


Exhibit 8. Gulf of Mexico Recovery Zone for Dragon

2.2.3. Pacific Ocean Recovery Zone

The eastern boundary of the Pacific Ocean recovery zone starts a minimum of five nautical miles offshore (see Exhibit 9). It includes the Monterey Bay National Marine Sanctuary. However, in previous consultation with the FAA and NMFS, SpaceX agreed to never locate the nominal splashdown location in a marine sanctuary (see Appendix B). Previous Dragon-1 splashdown locations in the Pacific Ocean are shown in Exhibit 10. The Pacific Ocean recovery zone would be a contingency splashdown location for Dragon-2 missions.

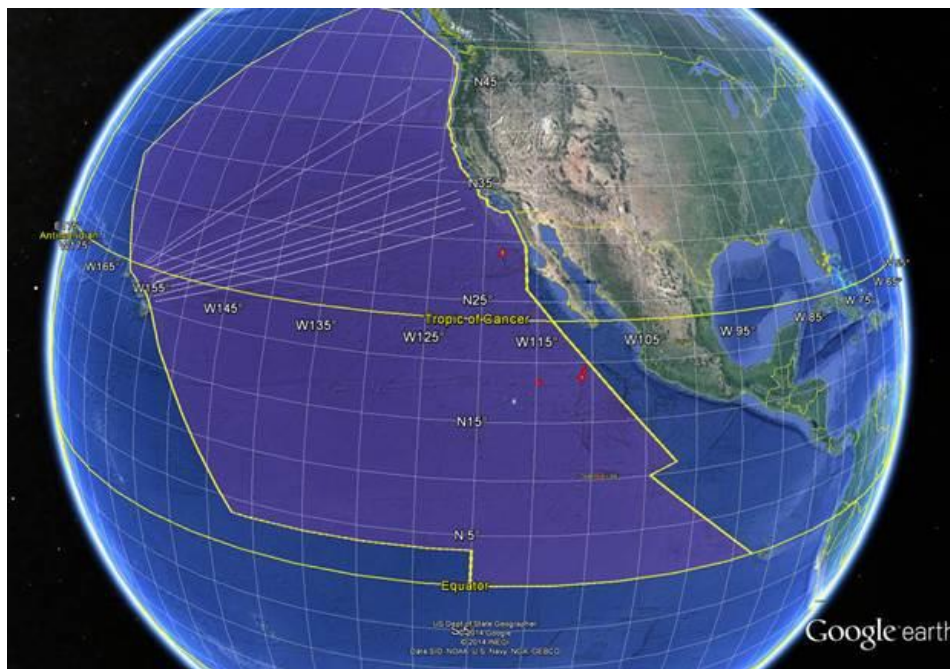


Exhibit 9. Pacific Ocean Recovery Zone for Dragon



Exhibit 10. Previous Dragon-1 Splashdown Locations in the Pacific Ocean

2.2.4. Fate of Unrecovered Dragon Drogue and Main Parachutes

The Dragon parachutes (drogue and main) remain floating on the surface enabling the recovery operations described previously. Due to sea and weather conditions, there have, however, been two instances where Dragon's main parachutes were not recovered. Similarly, there have been four instances where Dragon's drogue parachutes were not recovered. A record of Dragon-1 parachute recovery is shown in Table 1.

Table 1. Record of Dragon-1 Parachute Recovery

Date	Mission	Drogue Recovery	Main Recovered	Distance from Shore	Distance from Port
October 2012	CRS-1	Yes	Yes	275 nm	305 nm
March 2013	CRS-2	Yes	Yes	190 nm	210 nm
March 2014	CRS-3	Yes	Yes	270 nm	300 nm
September 2014	CRS-4	No	No	140 nm	235 nm
December 2014	CRS-5	No	No	110 nm	225 nm
April 2015	CRS-6	Yes	Yes	135 nm	130 nm
June 2015	CRS-7 ^a	n/a	n/a	n/a	n/a
April 2016	CRS-8	No	Yes	165 nm	170 nm
July 2016	CRS-9	No	Yes	215 nm	340 nm
February 2017	CRS-10	Yes	Yes	175 nm	205 nm
June 2017	CRS-11	Yes	Yes	80 nm	175 nm

^a CRS-7 was a failed mission.

nm = nautical mile

As SpaceX makes further progress towards achieving their reusability goals, additional resources are being dedicated to recovering all Dragon-related parachutes. Various engineering solutions are being explored, along with the following measures to maximize the chances of successful recovery:

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

Additional debris related to parachute deployment includes 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.

2.3. Payload Fairing Recovery Operations

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 fairing consists of two halves which separate at the desired moment in order to facilitate the deployment of the payload at the desired orbit. In the past, following the fairing separation, both halves of the fairing were left to splash down in the ocean, break apart, and sink. In order to further improve fairing re-entry survivability and to learn lessons that can be incorporated into an improved design for future fairings, SpaceX has added a parachute system to one of the fairing halves. The parachute system consists of one drogue parachute and one parafoil (see Exhibits 11 and 12). Also, a nitrogen cold gas attitude control



Exhibit 11. Fairing Parafoil

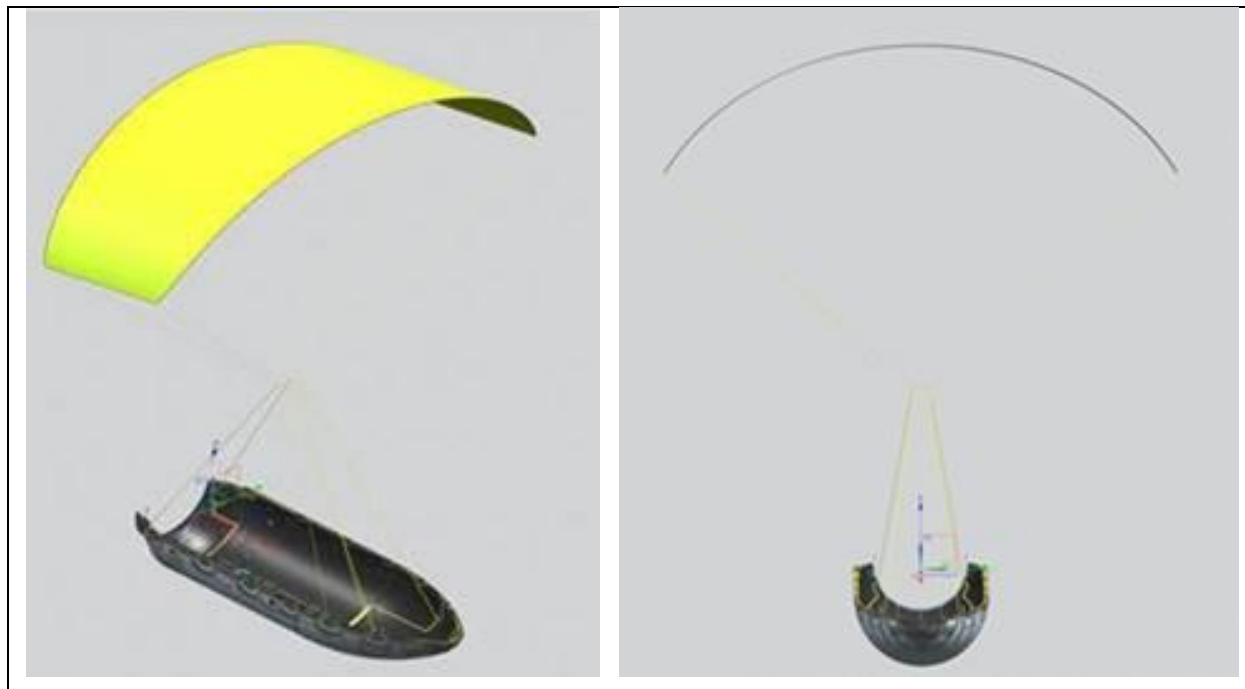


Exhibit 12. Payload Fairing Half with Parafoil Deployed

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. Along with this, SpaceX began staging a team to recover the fairing and parafoil after splashdown in the ocean. SpaceX's long-term goal is to control the parafoil to return both fairing halves to either a pre-positioned dronship 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. A record of fairing recovery is shown in Table 2.

Table 2. Record of Payload Fairing Recovery

Date	Mission	Drogue Recovered	Main Recovered	Distance from Shore (nm)
March 2017	SES 10	No	Yes	~425
May 2017	NROPL-76	No	Yes	~425
June 2017	BulgariaSat	No	No	~425
July 2017	IntelSat	No	Yes	~425

nm = nautical mile

The parachute system slows the decent of the fairing to enable a soft splashdown such that the fairing remains intact. Following re-entry of the fairing into Earth's atmosphere, the drogue parachute is deployed at a high altitude (approximately 50,000 feet) 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 (with parafoil) and drogue parachute assembly have been propagated using modeling tools. Both the fairing (with parafoil) and drogue parachute assembly have been modeled to fall within the recovery zones (Exhibits 6, 7, and 9).

SpaceX is currently evaluating two parachute systems for the fairing (Type 1 and Type 2). The specifications of each system are noted below (Tables 3 and 4). The Type 2 system has a similar drogue parachute as the Type 1 system but a larger and lighter parafoil than Type 1.

Type 1 drogue parachute risers are made of Kevlar with nylon overwrap. Type 1 parafoil risers, for which there are four, are made of nylon with Kevlar overwrap. Type 2 drogue parachute risers are made of Kevlar. Type 2 parafoil risers, for which there are four, are made of nylon.

Table 3. Specifications of Type 1 and Type 2 Fairing Drogue Parachutes

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.

ft² = square feet

Table 4. Specifications of Type 1 and Type 2 Fairing Parafoils

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; ft² = square feet

Under nominal conditions, 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 RHIB 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. SpaceX is working on an engineering solution for recovery of the drogue parachute assembly. 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.

2.3.1. Unrecovered Parachute and Parafoil Sink Rates

The projected sink rates for both types of drogue parachutes and parafoils are shown below (Tables 5–8 and Exhibits 13–16). As indicated in the exhibits, both types of drogue parachutes are expected to sink at a rate of approximately 1,000 feet in 46 minutes (or approximately 22 feet per minute). The Type 1 parafoil is expected to sink at a rate of approximately 1,000 feet in 63 minutes (or approximately 16 feet per minute). The Type 2 parafoil is expected to sink at a rate of approximately 1,000 feet in 145.5 minutes (or approximately 7 feet per minute). These estimated sink rates were calculated using a NASA method/spreadsheet for estimating sink rates of parachutes and balloons. The spreadsheet provides steady-state sink rates in water for parameters inputted by the user. There are conservative assumptions built in the spreadsheet, such as assuming the parachute remains open during the entire in-water descent, slowing the descent velocity, when, in actuality, the parachute could either collapse or become entangled in the other flight train components. The calculations present the most conservative (slowest) sink rates.

Table 5. Projected Sink Rate for Type 1 Drogue Parachute

Properties	
Sum of masses:	18.2 pounds
Sum of buoyancy forces:	8.73 pounds
Sum of drag areas:	73 square feet
Sink Rate	
Terminal velocity of system in water:	0.36 feet/second
Sink time per 1,000 ft of depth:	46.2 minutes
Sink time per 100 m of depth:	15.17 minutes

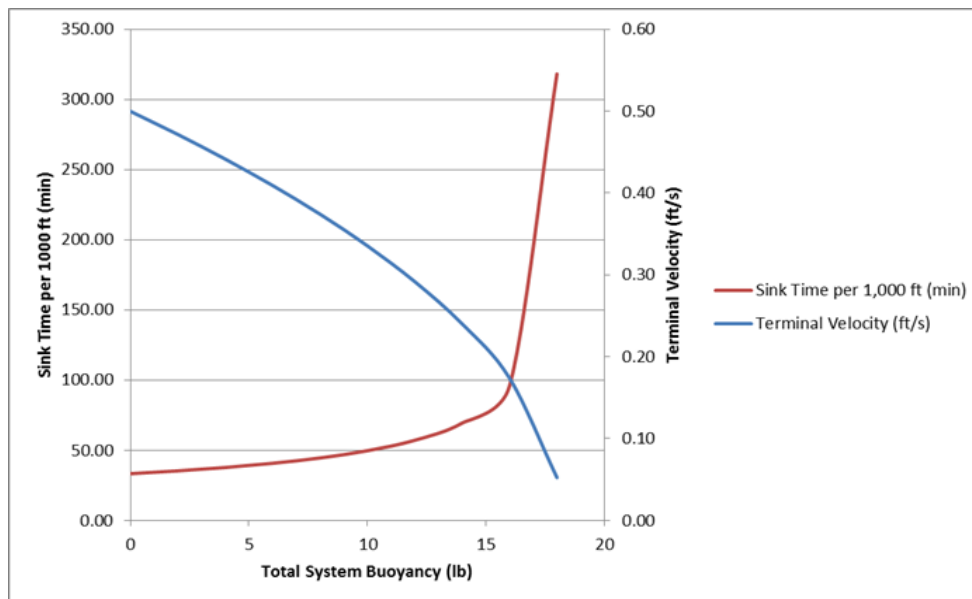


Exhibit 13. Sink Rate Chart for Type 1 Drogue Parachute

Table 6. Projected Sink Rate for Type 1 Parafoil

Properties	
Sum of masses:	181 pounds
Sum of buoyancy forces:	84 pounds
Sum of drag areas:	1,426 square feet
Sink Rate	
Terminal velocity of system in water:	0.26 feet/second
Sink time per 1,000 ft of depth:	63.7 minutes
Sink time per 100 m of depth:	20.91 minutes

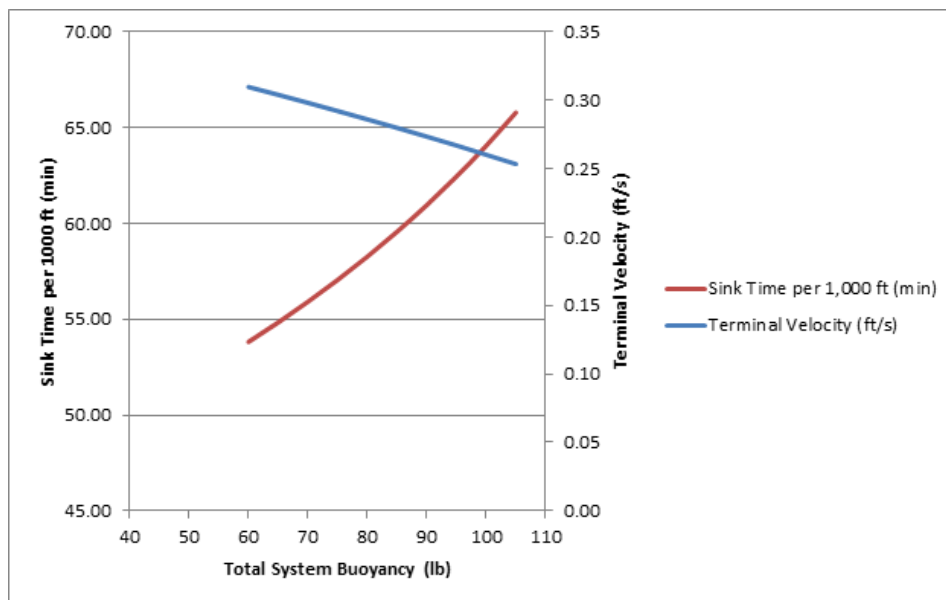


Exhibit 14. Sink Rate Chart for Type 1 Parafoil

Table 7. Projected Sink Rate for Type 2 Drogue Parachute

Properties	
Sum of masses:	18.2 pounds
Sum of buoyancy forces:	6.36 pounds
Sum of drag areas:	90 square feet
Sink Rate	
Terminal velocity of system in water:	0.36 feet/second
Sink time per 1,000 ft of depth:	45.9 minutes
Sink time per 100 m of depth:	15.07 minutes

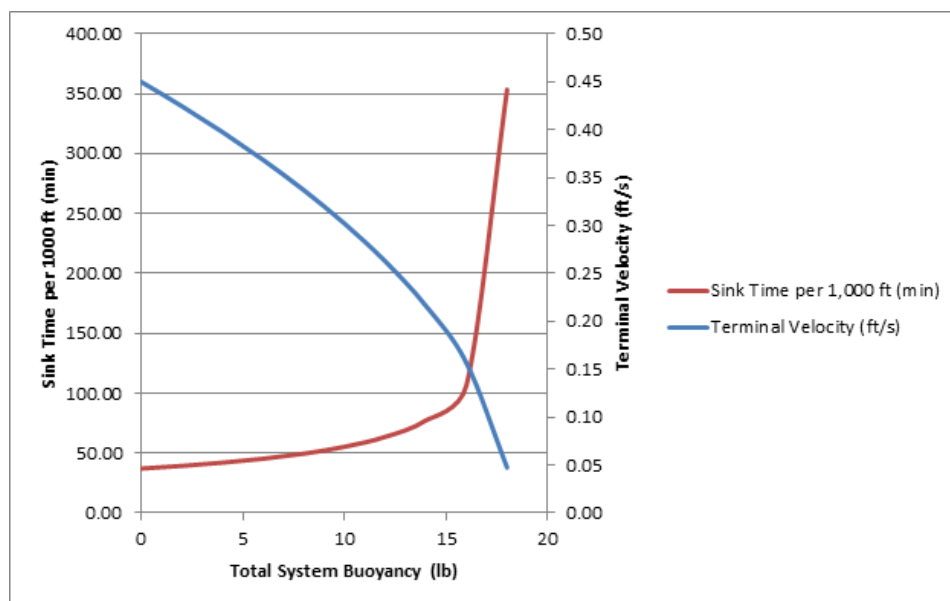


Exhibit 15. Sink Rate Chart for Type 2 Drogue Parachute

Table 8. Projected Sink Rate for Type 2 Parafoil

Properties	
Sum of masses:	70 pounds
Sum of buoyancy forces:	39.01 pounds
Sum of drag areas:	2,376 square feet
Sink Rate	
Terminal velocity of system in water:	0.11 feet/second
Sink time per 1,000 ft of depth:	145.5 minutes
Sink time per 100 m of depth:	47.75 minutes

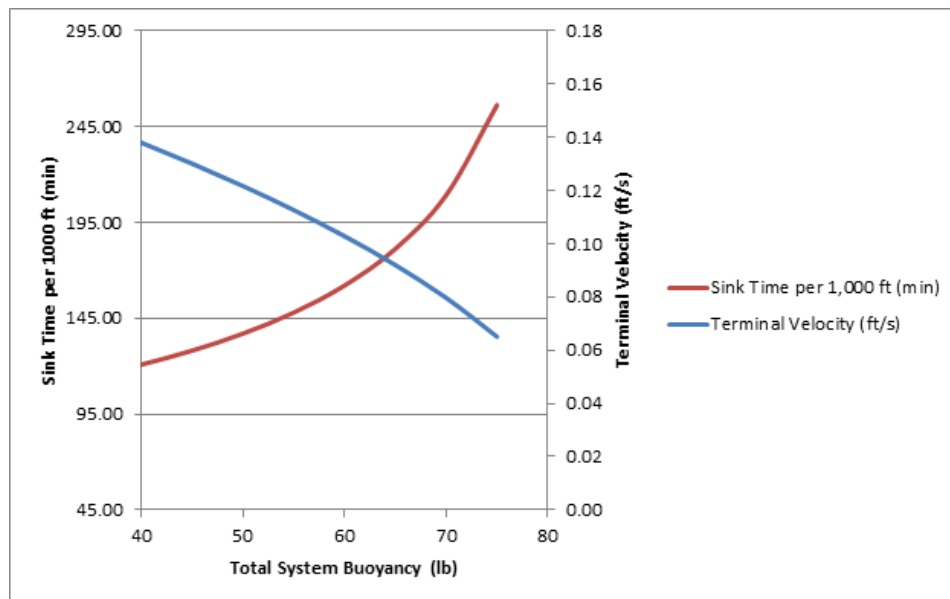


Exhibit 16. Sink Rate Chart for Type 2 Parafoil

2.3.2. Fate of Unrecovered Firing Drogue Parachutes and Parafoils

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 Atlantic Ocean 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).

Polymers can fragment in the environment as a consequence of prolonged exposure to UV light and physical abrasion (Andrady et al. 2003; Thompson et al. 2004). This is particularly evident on shorelines where photodegradation, elevated temperatures, and abrasion through wave action make plastic items brittle, increasing their potential for fragmentation (Andrady 2011; Barnes et al. 2009). In consideration of the fact the nylon parachute would not undergo substantial chemical or physical degradation prior to or following landing in the ocean, and the depth at which it would ultimately rest would not be subjected to abrasive physical processes, it is expected that any resultant fragmentation into smaller pieces, while inevitable over an indeterminate period of time, would be at a very slow, gradual rate.

Even when the nylon fragments into smaller pieces in the long term, it is likely that not all pieces would be positively buoyant due to fouling and/or sediment deposition. Furthermore, once in the water column, the particles could again return to the seafloor. Van Cauwenberghe et al. (2013) suggest that, once in the water column, small pieces of plastic could reach the sea floor as marine snow, which is produced as a biologically enhanced aggregation of small organic and inorganic particles (Alldredge and Silver 1988). Sinking rates of marine snow are estimated to range from 1 to 368 meters (3 to 1,200 feet) per day (Alldredge and Silver 1988). Therefore, considering this sink rate, the return of the smaller

plastic particles to the seafloor once at the surface could take as little as several months to several years.

While polymers will eventually biodegrade in the marine environment, the rate of this process, even in the benthic sediment, is several orders of magnitude slower compared to light-induced oxidative degradation (Andrady 2011). The ultimate degradation endpoint for polymers is when all organic carbon is converted into carbon dioxide, water, and biomass by microorganisms (referred to as complete mineralization [Andrady 1994]), the kinetics of which are not well understood (Andrady 2011). Estimates regarding the amount of time required for such a fate in the marine environment are highly variable, spanning several orders of magnitude from hundreds to even thousands of years (Barnes et al. 2009), particularly in deep, cold, dark oceans (Barnes et al. 2009; Bergmann and Klages 2012).

Based on the expected rapid descent toward the light-deficient ocean floor, fouling of a nylon parachute by photosynthetic organisms would be minimal. However, once on the seafloor, the parachute may provide hard substrata for the attachment of opportunistic sessile biota, increasing local diversity (Mordecai et al. 2011; Morét-Ferguson et al. 2010), though at the cost of replacing existing species and leading to non-natural alterations of community composition (Bergmann and Klages 2012).

2.4. Dragon Abort Test – Florida

SpaceX is planning 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, resulting in 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 2016 consultation; however, that consultation did not assess potential effects from potentially unrecovered parachutes. This 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. To date, SpaceX has conducted one Dragon pad abort test (May 2015) which involved launching Dragon-1 directly from the LC-40 (CCAFS) launch mount.² Although recovery of the parachutes did not go as planned, SpaceX eventually recovered the three main parachutes 12 days after the test. The drogue chutes landed on land and were recovered. SpaceX sent a letter to NMFS documenting the testing operation and parachute recovery. No known adverse effects to listed species occurred from this test.

2.5. Anticipated Frequency of Operations

2.5.1. Weather Balloon Deployment for Falcon Landings and Fairing Recovery Operations

SpaceX typically releases 3–4 weather balloons during a dronship landing event to measure wind speed in the landing zone. Weather balloons are necessary for every mission when a dronship landing is planned. Also, SpaceX launches weather balloons when a fairing recovery is planned. From now through March 2018, SpaceX plans to release about 36 weather balloons. This corresponds to four weather balloons released for each mission identified in Table 9 that involves either a dronship landing and/or a fairing recovery.

SpaceX estimates the frequency of weather balloon deployments to potentially double in 2018 (i.e., approximately two missions per month involving the release of 4 weather balloons each mission [= approximately 96 weather balloons in 2018]) and then triple in 2019 through 2024 (approximately three

² See: https://www.youtube.com/watch?v=1_FXVjf46T8.

missions per month involving the release of 4 weather balloons each mission [= approximately 144 weather balloons each year from 2019–2024]). Thus, from now through 2024, SpaceX estimates releasing approximately 1,000 weather balloons.

2.5.2. Dragon Reentry and Splashdown Operations

From now through the end of 2017, SpaceX has one launch scheduled involving Dragon (see Table 9). Dragon reentries are expected to occur in November of 2017. This Dragon splashdown would occur in the Pacific Ocean.

Starting 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). Of the three Dragon-2 splashdowns in the Atlantic Ocean, one of these could occur in the Gulf of Mexico (contingency splashdown site for Dragon-2). Within the next few years, all Dragon missions would phase to Dragon-2 missions—five per year and expected to land in the bulb or superbox. The superbox and the recovery areas in the Gulf of Mexico and Pacific Ocean would be contingency landing areas.

SpaceX intends to recover all Dragon drogue and main parachutes, but it is possible some of the parachutes will not be recovered due to sea or weather conditions at the time of recovery. The following is an estimate of the total number of Dragon parachutes expected to be recovered between now and 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

2.5.3. Payload Fairing Recovery Operations

Over the next 12–15 months (through 2018), SpaceX anticipates 15 launches involving fairing recovery attempts. Of those 15 launches, four launches might involve attempting to recover both halves of the fairing (and thus these four launches 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) over the next 12–15 months. SpaceX intends to recover all 19 parafoils, but it is possible some of the parafoils will not be recovered due to sea or weather conditions at the time of recovery. All 19 drogue parachutes are not expected to be recovered. As noted above, SpaceX is working on an engineering solution to enable recovery of the drogue parachutes. Of the 15 launches involving fairing recovery attempts within the next 12–15 months, SpaceX anticipates approximately five would occur at VAFB, where the fairing would splash down in the Pacific Ocean. The other 10 launches involving fairing recovery would occur in the Atlantic Ocean.

SpaceX anticipates the frequency of launches involving fairing recovery to increase from 2019 through 2024. In 2018, SpaceX anticipates approximately two recovery attempts per month involving recovery of both halves of the fairing. In 2019 through 2024, SpaceX anticipates approximately three recovery attempts per month involving recovery of both halves of the fairing. Thus, during these 7 years, SpaceX anticipates up to 480 drogue parachutes and up to 480 parafoils would land in the ocean. SpaceX intends to recover all drogue parachutes and parafoils over this time period, 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.

SpaceX's anticipated schedule of operations from now through March 2018 is shown in Table 9.

Table 9. SpaceX Schedule of Operations, August 2017 through March 2018

	Late Aug	Late Aug	Late Sept	Early Oct	Early Nov	Early Nov	Early Dec	Jan 2018	Feb 2018	March 2018
Operation	FR DS	FR DS	FR DS	FR DS	FR DS	DR(P)	FR	FR	FR	FR DS
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; DS = dronship landing; 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.

2.5.4. Dragon Abort Test

SpaceX is planning to conduct one Dragon-2 abort test in the second quarter of 2018 (April–June). This would involve four main parachutes and two drogue parachutes. This operation would occur outside the North Atlantic right whale calving season (December through March).

2.6. 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 2016 consultation (see Appendix A). Additionally, as it relates to “reporting,” the FAA proposes to submit a report to NMFS by December 31 of each year documenting the outcome of each launch mission (commercial and NASA-sponsored) involving a payload fairing recovery attempt, Dragon reentry, and/or Dragon abort test. 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.

3. 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.” Because activities are proposed to occur in the Pacific Ocean, Gulf of Mexico, and Atlantic Ocean, we have identified three separate action areas. For operations occurring in the Pacific Ocean, the action area is defined as the

Pacific Ocean recovery zone (Exhibit 9). For operations occurring in the Gulf of Mexico, the action area is defined as the Gulf of Mexico recovery zone (Exhibit 8). For operations occurring in the Atlantic Ocean, the action area is defined as the “superbox” and the “bulb” (Exhibits 6 and 7). The following sections discuss the ESA-listed species that are known or have the potential to occur in the three action areas, as well as critical habitat within the action areas.

4. Listed Species and Critical Habitat in the Action Area

4.1. Pacific Ocean Action Area

4.1.1. Species

Landing of weather balloon fragments and radiosondes, Dragon reentry and recovery, and payload fairing recovery operations would occur within the broad ocean area where ESA-listed species might occur. The Pacific Ocean action area starts a minimum of 5 nautical miles offshore. Several ESA-listed marine mammals sea turtles are known to occur or have the potential to occur in the Pacific Ocean action area (Table 10).

Table 10. ESA-Listed Species for the Pacific Ocean Action Area

y	Status	Distribution/Habitat	Threats
Mammals			
Blue whale <i>Balaenoptera musculus</i>	E	Inhabits and feeds in both coastal and pelagic environments; frequently found on the continental shelf (e.g., in areas off the California coast)	Collisions with vessels; entanglement in fishing gear; reduced zooplankton production due to habitat degradation; disturbance from low-frequency noise
Fin whale <i>Balaenoptera physalus</i>	E	Observed year-round off central and southern California, with peak numbers in summer and fall	Collisions with vessels; reduced prey abundance due to overfishing and/or climate Change; illegal whaling; increasing anthropogenic ocean noise
Humpback whale <i>Megaptera novaeangliae</i>	E	Migrate through southern California waters during autumn and spring; feed in the Gulf of Farallones and nearby offshore banks (central California)	Entrapment and entanglement in fishing gear; collisions with vessels; noise from ships, boats, and aircraft; habitat degradation
Sei whale <i>Balaenoptera borealis</i>	E	Observed off central California along the continental slope	Collisions with vessels; entanglement in fishing gear; reduced prey abundance due to climate change; increasing anthropogenic ocean noise
Sperm whale <i>Physeter macrocephalus</i>	E	Present year-long off California; reach peak abundance from April through mid-June and again from the end of August through mid-November	Collisions with vessels; reduced prey abundance due to climate change; contaminants and pollutants; increasing anthropogenic ocean noise
Scalloped hammerhead shark	E	Coast of southern California, including Gulf of California	Targeted fisheries (shark fin trade); bycatch

Table 10. ESA-Listed Species for the Pacific Ocean Action Area

y	Status	Distribution/Habitat	Threats
<i>Sphyrna lewini</i>			
Guadalupe fur seal <i>Arctocephalus townsendi</i>	T	Tropical waters of the southern California/Mexico region; during breeding season, found in coastal rocky habitats and caves; little is known about their whereabouts during the non-breeding season	Entanglement in fishing gear
Sea Turtles			
Green sea turtle <i>Chelonia mydas</i>	T	Pelagic; observed from Baja California to southern Alaska, but most commonly occur from San Diego south	Harvest of eggs and turtles; incidental capture in fishing gear; disease; marine debris; environmental contamination
Hawksbill turtle <i>Eretmochelys imbricata</i>	E	Pelagic; most commonly associated with healthy coral reefs; along the Pacific Rim, nest sporadically in the southern part of the Baja peninsula, while sightings of juveniles and sub-adults foraging along the coast occur more regularly	Habitat loss of coral reef communities; harvest of eggs; increased recreational and commercial use of nesting beaches in the Pacific; incidental capture in fishing gear
Leatherback sea turtle <i>Dermochelys coriacea</i>	E	Pelagic; most migratory and wide ranging of sea turtle species; migrates through action area	Harvest of eggs and turtles; incidental capture in fishing gear; marine debris; environmental contamination
Olive ridley sea turtle <i>Lepidochelys olivacea</i>	T	Pelagic; in Eastern Pacific, occur from southern California to northern Chile	Harvest of eggs; killing turtles; incidental capture in fishing gear; marine debris; environmental contamination
Fish			
Green sturgeon <i>Acipenser medirostris</i>	E	Adults live in oceanic waters, bays, and estuaries when not spawning; known to forage in estuaries and bays ranging from San Francisco Bay to British Columbia	Reduction of the spawning area to a limited section of the Sacramento River

4.1.2. Critical Habitat

NMFS designated critical habitat for the endangered leatherback sea turtle along the U.S. West Coast in January 2012 (77 FR 4170) (Exhibit 17). Portions of this critical habitat is located within the Pacific Ocean action area. The primary constituent element essential for conservation of leatherback sea turtles is the occurrence of prey species, primarily scyphomedusae of the order Semaestomeae (*Chrysaora*, *Aurelia*, *Phacellophora*, and *Cyanea*), of sufficient condition, distribution, diversity, abundance, and density necessary to support individual as well as population growth, reproduction, and development of leatherbacks.

The Pacific Ocean action area also contains critical habitat for the green sturgeon. In October 2009, NMFS designated critical habitat for the Southern Distinct Population Segment (DPS) (74 FR 52299) (Exhibit 18). For nearshore coastal marine areas, the primary constituent elements essential for the conservation of the Southern DPS of green sturgeon are:

- **Migratory corridor.** A migratory pathway necessary for the safe and timely passage of Southern DPS fish within marine and between estuarine and marine habitats.
- **Water quality.** Nearshore marine waters with adequate dissolved oxygen levels and acceptably low levels of contaminants (e.g., pesticides, organochlorines, elevated levels of heavy metals) that may disrupt the normal behavior, growth, and viability of subadult and adult green sturgeon.
- **Food resources.** Abundant prey items for subadults and adults, which may include benthic invertebrates and fishes.

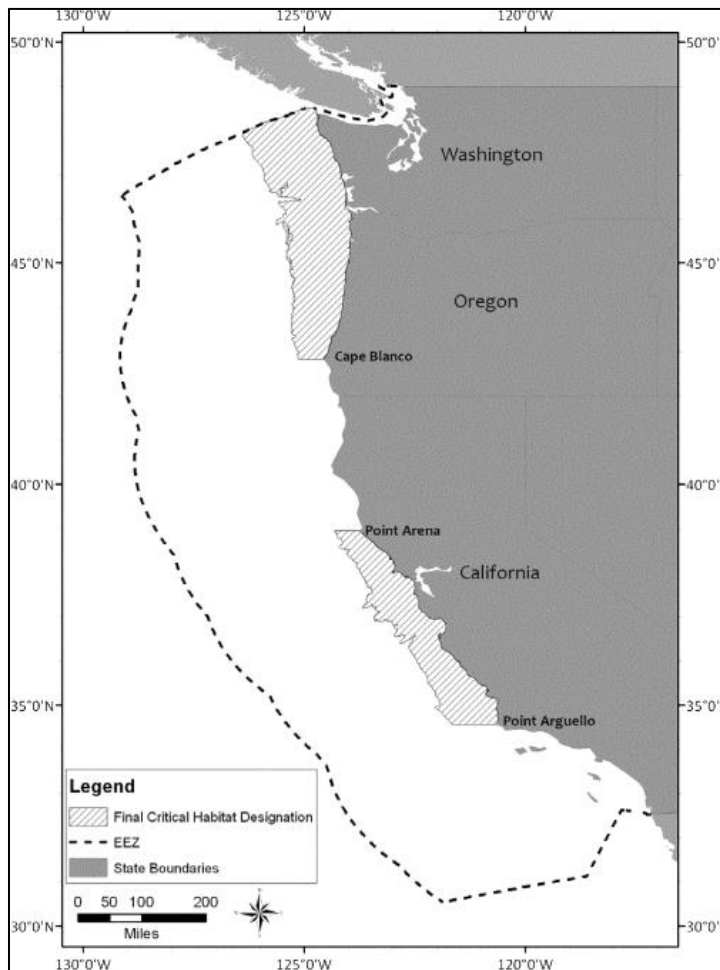


Exhibit 17. Leatherback Sea Turtle Critical Habitat

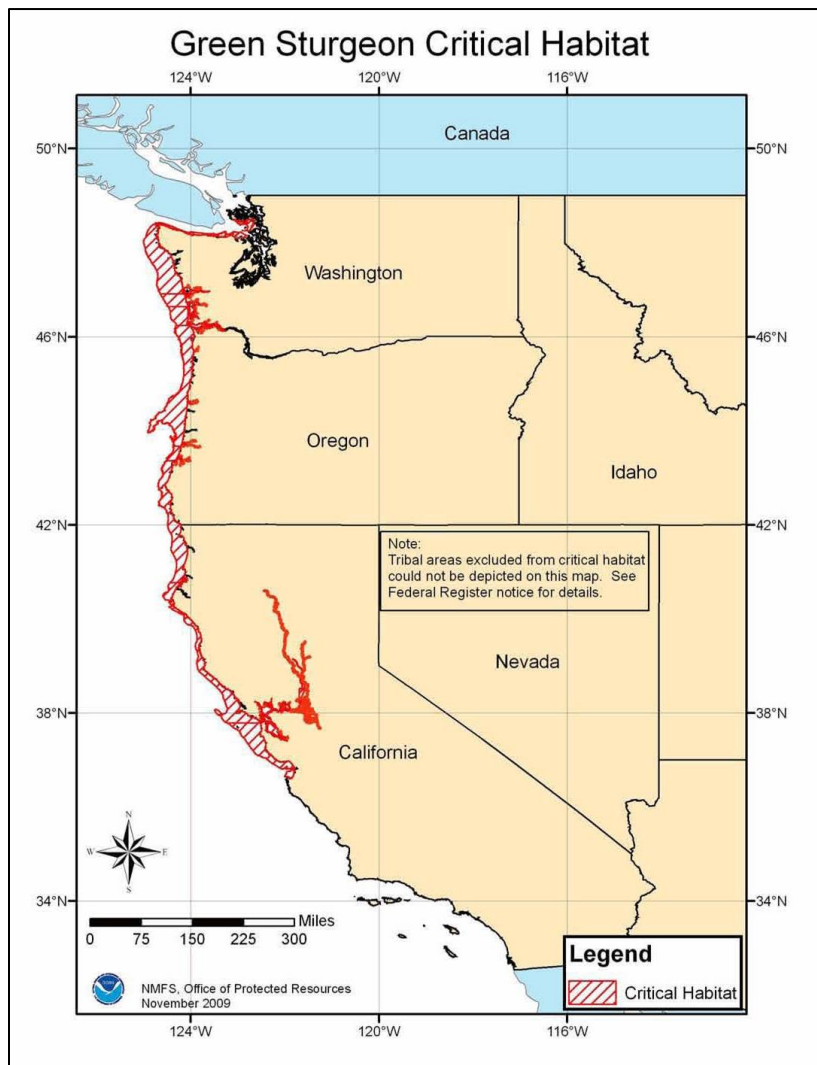


Exhibit 18. Green Sturgeon Critical Habitat

4.2. Gulf of Mexico Action Area

4.2.1. Species

A list of federally threatened and endangered species occurring or potentially occurring in the Gulf of Mexico action area was developed by reviewing online information from the NMFS Southeast Regional Office website, the NMFS Protected Resources Division website, and the USFWS Environmental Conservation Online System. Based on this information, 14 federally listed species occur or potentially occur within the Gulf of Mexico action area (Table 11). Although the Gulf of Mexico contains ESA-listed coral species, corals are not included in this evaluation because the project activities would not affect coral.

Table 11. ESA-Listed Species for the Gulf of Mexico Action Area

Species	Status	Distribution/Habitat	Threats
Mammals			
Blue whale <i>Balaenoptera musculus</i>	E	Infrequent occurrence in the Gulf of Mexico	Collisions with vessels; entanglement in fishing gear; reduced zooplankton production due to habitat degradation; disturbance from low-frequency noise
Fin whale <i>Balaenoptera physalus</i>	E	Infrequent occurrence in the Gulf of Mexico; found in deep, offshore waters	Collisions with vessels; reduced prey abundance due to overfishing and/or climate Change; illegal whaling; increasing anthropogenic ocean noise
Humpback whale <i>Megaptera novaeangliae</i>	E	Infrequent occurrence in the Gulf of Mexico; in the western North Atlantic ocean, humpback whales feed during spring, summer, and fall over a range that encompasses the eastern coast of the U.S. (including the Gulf of Maine), the Gulf of St. Lawrence, Newfoundland/ Labrador, and western Greenland	Entrapment and entanglement in fishing gear; collisions with vessels; noise from ships, boats, and aircraft; habitat degradation
North Atlantic right whale <i>Eubalaena glacialis</i>	E	Infrequent occurrence in the Gulf of Mexico	Collisions with vessels; entanglement in fishing gear; habitat degradation; contaminants; climate and ecosystem change; disturbance from whale-watching activities; noise
Sei whale <i>Balaenoptera borealis</i>	E	Infrequent occurrence in the Gulf of Mexico; usually observed in deeper waters of oceanic areas far from the coastline; tend not enter semi-enclosed water bodies	Collisions with vessels; entanglement in fishing gear; reduced prey abundance due to climate change; increasing anthropogenic ocean noise
Sperm Whale <i>Physeter macrocephalus</i>	E	Most common large cetacean in the northern Gulf of Mexico; occurs in greatest density along and seaward of the 1,000 meter contour; uncommon in waters less than 984 feet (300 m) deep	Collisions with vessels; reduced prey abundance due to climate change; contaminants and pollutants; increasing anthropogenic ocean noise
Sea Turtles			
Green sea turtle <i>Chelonia mydas</i>	T	Pelagic; in U.S. Atlantic and Gulf of Mexico waters, found in inshore and nearshore waters from Texas to Massachusetts, the U.S. Virgin Islands, and Puerto Rico	Harvest of eggs and turtles; incidental capture in fishing gear; disease; marine debris; environmental contamination
Hawksbill turtle <i>Eretmochelys imbricata</i>	E	Pelagic; widely distributed throughout the Caribbean Sea and western Atlantic Ocean,	Habitat loss of coral reef communities; harvest of eggs; increased recreational and

Table 11. ESA-Listed Species for the Gulf of Mexico Action Area

Species	Status	Distribution/Habitat	Threats
		regularly occurring in southern Florida and the Gulf of Mexico (especially Texas)	commercial use of nesting beaches in the Pacific; incidental capture in fishing gear
Kemp's ridley sea turtle <i>Lepidochelys kempii</i>	E	Pelagic; distributed throughout the Gulf of Mexico and U.S. Atlantic seaboard, from Florida to New England; depending on their breeding strategy, male Kemp's ridleys appear to occupy many different areas within the Gulf of Mexico	Harvest of eggs; incidental capture in fishing gear; marine debris; environmental contamination
Leatherback sea turtle <i>Dermochelys coriacea</i>	E	Pelagic; adults are capable of tolerating a wide range of water temperatures and have been sighted along the entire continental east coast of the U.S. as far north as the Gulf of Maine and south to Puerto Rico, the U.S. Virgin Islands, and into the Gulf of Mexico	Harvest of eggs and turtles; incidental capture in fishing gear; marine debris; environmental contamination
Loggerhead turtle <i>Caretta caretta</i>	T	Pelagic; commonly found throughout the Gulf of Mexico	Incidental capture in fishing gear; direct harvest; marine debris; environmental contamination
Fish			
Gulf sturgeon <i>Acipenser oxyrinchus desotoi</i>	T	Anadromous fish, inhabiting coastal rivers from Louisiana to Florida during the warmer months, and the Gulf of Mexico and its estuaries and bays in the cooler months	Construction of water control structures, such as dams and sills, exacerbated habitat loss; dredging; groundwater extraction; irrigation; flow alterations; poor water quality; contaminants, primarily from industrial sources
Atlantic sturgeon <i>Acipenser oxyrinchus oxyrinchus</i>	E	Anadromous fish; found in river systems from Louisiana to Florida, in nearshore bays and estuaries, and in the Gulf of Mexico	Construction of water control structures, such as dams and sills; exacerbated habitat loss; dredging; groundwater extraction; irrigation; flow alterations; poor water quality; contaminants, primarily from industrial sources
Nassau grouper <i>Epinephelus striatus</i>	T	Found from Bermuda and Florida throughout the Bahamas and Caribbean Sea, including the Gulf of Mexico and up the Atlantic coast to North Carolina	Degraded habitat; overutilization; disease; inadequacy of existing regulatory mechanisms
Smalltooth sawfish <i>Pristis pectinata</i>	E	Historically, common throughout the Gulf of Mexico from Texas to Florida, and along the east coast from Florida to North Carolina. Now, in the U.S., found in the peninsula of Florida, common only in the Everglades region at the southern tip of the state.	Bycatch in various fisheries, especially in gill nets; loss of juvenile habitat

4.2.2. Critical Habitat

NMFS designated critical habitat for the Northwest Atlantic Ocean Distinct Population Segment of the loggerhead sea turtle within the Atlantic Ocean and the Gulf of Mexico in July 2014 (79 FR 39855) (Exhibit 19). Portions of this critical habitat, namely Sargassum habitat, is located within Gulf of Mexico action area. Sargassum 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.

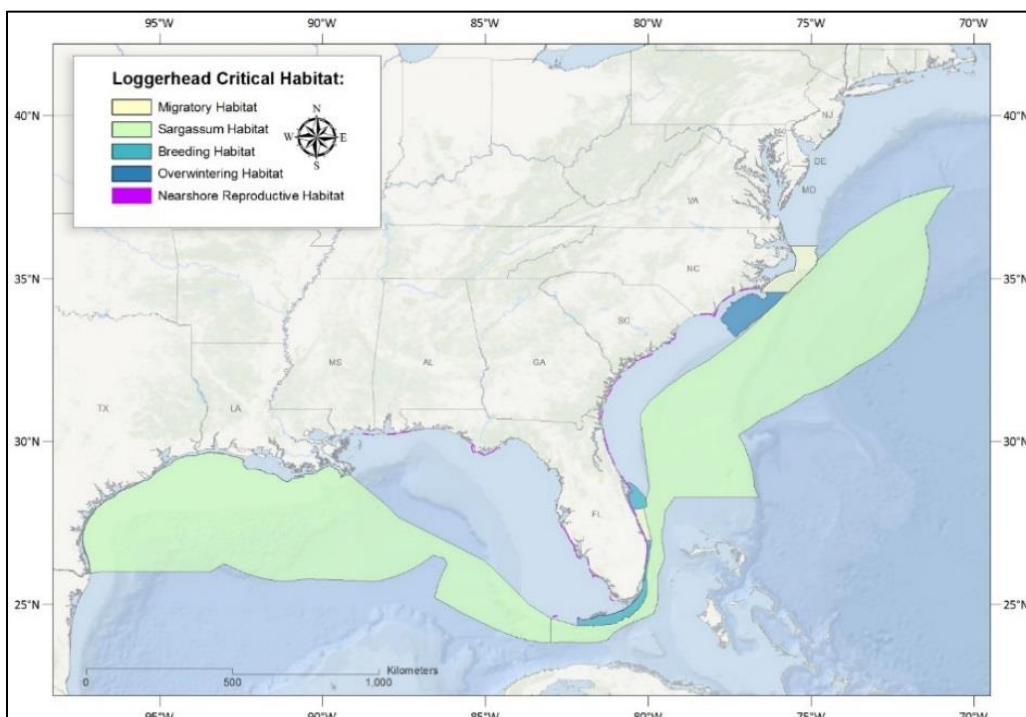


Exhibit 19. Loggerhead Turtle Critical Habitat in the Northwest Atlantic Ocean.

4.3. Atlantic Ocean Action Area

4.3.1. Species

Last year, NASA and the FAA conducted informal ESA consultation (SER-2016-17894) with NMFS to assess the potential effects of waterborne landings of rockets, rocket parts, and spacecraft on ESA-listed species and critical habitat in the “superbox.” Federally listed species covered under that consultation are listed in Table 12.

Table 12. ESA-Listed Species for the Atlantic Ocean Action Area

Species	Status	Distribution/Habitat	Threats
Mammals			
Blue whale <i>Balaenoptera musculus</i>	E	In the North Atlantic Ocean, range extends from the subtropics to the Greenland Sea; although they are rare in the shelf waters of the eastern U.S., blue whales are occasionally	Collisions with vessels; entanglement in fishing gear; reduced zooplankton production due to habitat degradation;

Table 12. ESA-Listed Species for the Atlantic Ocean Action Area

Species	Status	Distribution/Habitat	Threats
Fin whale <i>Balaenoptera physalus</i>	E	seen off Cape Cod, MA; migrate seasonally between summer and winter Found in deep, offshore waters of all major oceans, primarily in temperate to polar latitudes, and less commonly in the tropics	disturbance from low-frequency noise Collisions with vessels; reduced prey abundance due to overfishing and/or climate Change; illegal whaling; increasing anthropogenic ocean noise
Humpback whale <i>Megaptera novaeangliae</i>	E	In the western North Atlantic Ocean, feed during spring, summer, and fall over a range that encompasses the eastern coast of the U.S. (including the Gulf of Maine); in the winter, they migrate to calving grounds in subtropical or tropical waters, such as the Dominican Republic	Entrapment and entanglement in fishing gear; collisions with vessels; noise from ships, boats, and aircraft; habitat degradation
North Atlantic right whale <i>Eubalaena glacialis</i>	E	Inhabit the Atlantic Ocean, particularly between 20° and 60° latitude; for much of the year, their distribution is strongly correlated to the distribution of their prey; in the coastal waters off Georgia and northern Florida, calving occurs from December through March	Collisions with vessels; entanglement in fishing gear; habitat degradation; contaminants; climate and ecosystem change; disturbance from whale-watching activities; noise
Sei whale <i>Balaenoptera borealis</i>	E	Prefer subtropical to subpolar waters on the continental shelf edge and slope worldwide; usually observed in deeper waters of oceanic areas far from the coastline	Collisions with vessels; entanglement in fishing gear; reduced prey abundance due to climate change; increasing anthropogenic ocean noise
Sperm Whale <i>Physeter macrocephalus</i>	E	Inhabit all oceans of the world; tend to inhabit areas with a water depth of 600 meters or more, and are uncommon in waters less than 300 meters deep; overall distribution along the U.S. east coast is centered along the shelf break and over the slope; high densities occur in inner slope waters north of Cape Hatteras, NC seaward of the 1,000 m isobath during summer months	Collisions with vessels; reduced prey abundance due to climate change; contaminants and pollutants; increasing anthropogenic ocean noise
Sea Turtles			
Green sea turtle <i>Chelonia mydas</i>	T	Pelagic; in U.S. Atlantic and Gulf of Mexico waters, found in inshore and nearshore waters from Texas to Massachusetts, the U.S. Virgin Islands, and Puerto Rico; important feeding areas in Florida include the Indian River Lagoon, the Florida Keys, Florida Bay, Homosassa, Crystal River, Cedar Key, and St. Joseph Bay.	Harvest of eggs and turtles; incidental capture in fishing gear; disease; marine debris; environmental contamination
Hawksbill turtle <i>Eretmochelys imbricata</i>	E	Pelagic; widely distributed throughout the Caribbean Sea and western Atlantic Ocean, regularly occurring in southern Florida and the Gulf of Mexico (especially Texas)	Habitat loss of coral reef communities; harvest of eggs; increased recreational and commercial use of nesting beaches

Table 12. ESA-Listed Species for the Atlantic Ocean Action Area

Species	Status	Distribution/Habitat	Threats
			in the Pacific; incidental capture in fishing gear
Kemp's Ridley sea turtle <i>Lepidochelys kempii</i>	E	Pelagic; distributed throughout the Gulf of Mexico and U.S. Atlantic seaboard, from Florida to New England; depending on their breeding strategy, male Kemp's ridleys appear to occupy many different areas within the Gulf of Mexico	Harvest of eggs; incidental capture in fishing gear; marine debris; environmental contamination
Leatherback sea turtle <i>Dermochelys coriacea</i>	E	Pelagic; adults are capable of tolerating a wide range of water temperatures and have been sighted along the entire continental east coast of the U.S. as far north as the Gulf of Maine and south to Puerto Rico, the U.S. Virgin Islands	Harvest of eggs and turtles; incidental capture in fishing gear; marine debris; environmental contamination
Loggerhead turtle <i>Caretta caretta</i>	T	Pelagic; predominate foraging areas for western North Atlantic adult loggerheads are found throughout the relatively shallow continental shelf waters of the U.S., Bahamas, Cuba, and the Yucatán Peninsula, Mexico; migration routes from foraging habitats to nesting beaches (and vice versa) for a portion of the population are restricted to the continental shelf, while other routes involve crossing oceanic waters to and from the Bahamas, Cuba, and the Yucatán Peninsula	Incidental capture in fishing gear; direct harvest; marine debris; environmental contamination
Fish			
Gulf sturgeon <i>Acipenser oxyrinchus desotoi</i>	T	Anadromous fish, inhabiting coastal rivers from Louisiana to Florida during the warmer months, and the Gulf of Mexico and its estuaries and bays in the cooler months	Construction of water control structures, such as dams and sills; dredging; groundwater extraction; irrigation; flow alterations; poor water quality; contaminants, primarily from industrial sources
Shortnose sturgeon <i>Acipenser brevirostrum</i>	E	Anadromous fish; spawn in the coastal rivers along the east coast of North America from the St. John River in Canada to the St. Johns River in Florida; prefer the nearshore marine, estuarine, and riverine habitat of large river systems	Construction of dams may have resulted in substantial loss of suitable habitat; pollution; habitat alterations from discharges; dredging or disposal of material into rivers; related development activities involving estuarine/riverine mudflats and marshes
Atlantic sturgeon <i>Acipenser oxyrinchus oxyrinchus</i>	E	Anadromous fish; found in river systems from Louisiana to Florida, in nearshore bays and estuaries, and in the Gulf of Mexico	Construction of water control structures, such as dams and sills; exacerbated habitat loss; dredging; groundwater extraction; irrigation; flow alterations; poor water quality contaminants, primarily from industrial sources

Table 12. ESA-Listed Species for the Atlantic Ocean Action Area

Species	Status	Distribution/Habitat	Threats
Smalltooth sawfish <i>Pristis pectinata</i>	E	Inhabit shallow coastal waters of tropical seas and estuaries throughout the world; in the U.S., found in the peninsula of Florida, common only in the Everglades region at the southern tip of the state	Bycatch in various fisheries, especially in gill nets; loss of juvenile habitat

4.3.2. Critical Habitat

4.3.2.1. North Atlantic Right Whale

NMFS designated two units of critical habitat for the North Atlantic right whale. Unit 1 is for foraging habitat and 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 (Exhibit 20). Unit 2 occurs off the coast of CCAFS and extends seaward approximately 5 nautical miles off the coast north of CCAFS. 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 meters, where these features simultaneously co-occur over contiguous areas of at least 231 square nautical miles of ocean waters during the

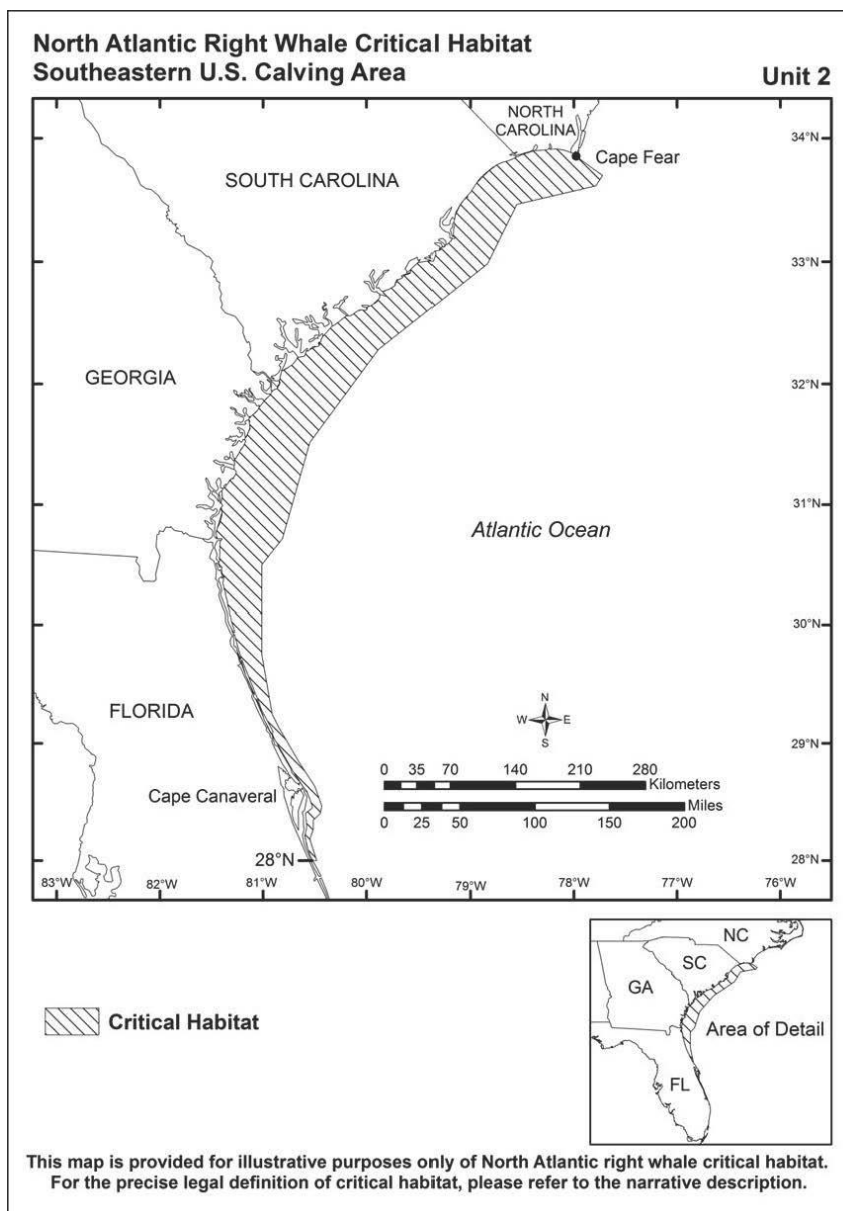


Exhibit 20. North Atlantic Right Whale Critical Habitat Unit 2

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.

4.3.2.2. Loggerhead Sea Turtle

Loggerhead sea turtle critical habitat (Unit LOGG-N-17) occurs within the Atlantic Ocean action area (Exhibit 21). This unit includes overlapping areas of nearshore reproductive habitat, constricted migratory habitat, breeding habitat, and Sargassum habitat (descriptions below). Since the landing/splashdown area begins five nautical miles offshore, nearshore reproductive habitat is not considered within the planned landing/splashdown areas.

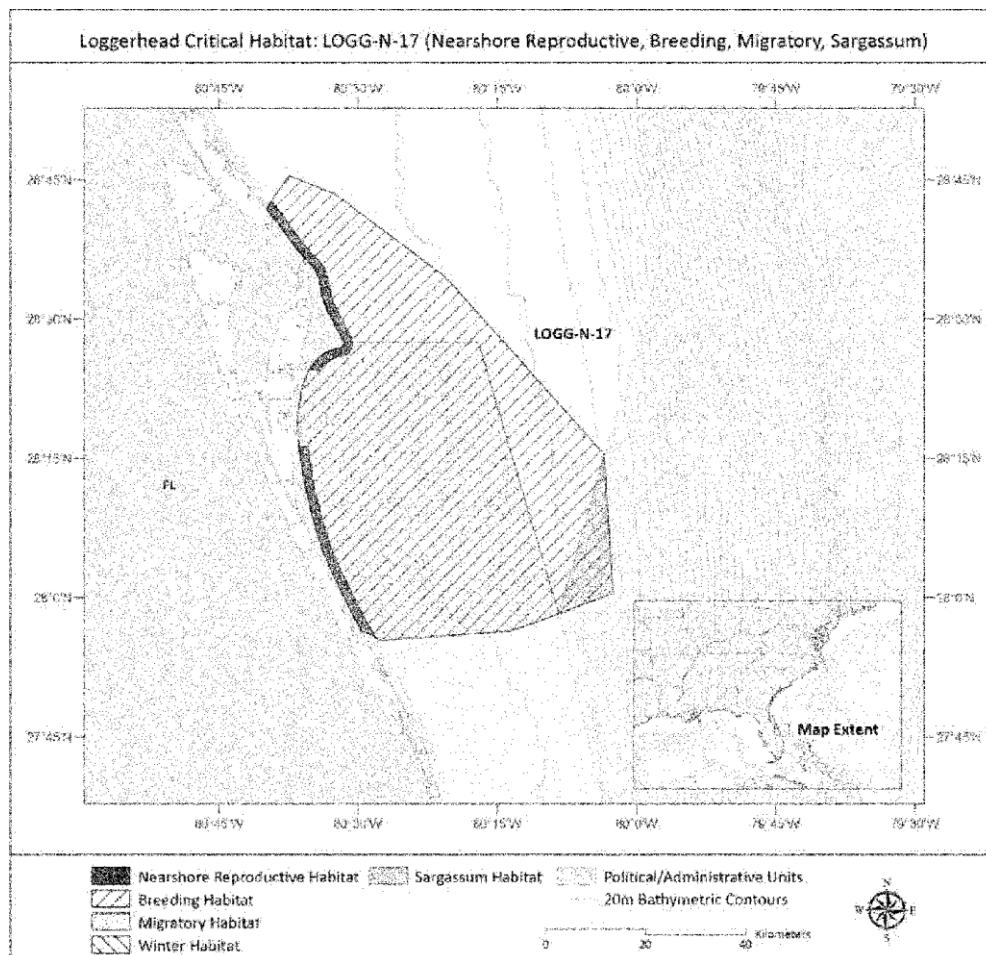


Exhibit 21. Loggerhead Sea Turtle Critical Habitat: LOGG-N-17

- **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.

- **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.
- **Breeding habitat:** 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.
- ***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 inhabitation 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.

5. Potential Effects to Species and Critical Habitat

This section focuses on the potential effects of the project on the ESA-listed species identified in Section 4. No effects to any of the primary constituent elements or essential features of the critical habitat discussed in Section 4 are anticipated from the project activities.

Potential stressors to the ESA-listed species from the project include entanglement in and ingestion of material from unrecovered parachutes and parafoils, as well as potential ingestion of weather balloon fragments. Additional stressors include being struck by falling rocket parts and the sonic boom (overpressure) generated during Dragon reentry. Exposure to hypergolic fuels (NTO and MMH) and debris was addressed in the 2016 consultation and is not repeated here. Potential effects to the ESA-listed species from these stressors are discussed in the following sections.

5.1. Entanglement

According to the literature (major reviews by Laist 1987, 1997), entanglement of marine species can lead to injury, compromised health, or mortality. Entanglement could disadvantage an individual animal by limiting its ability to open and close its jaw when feeding or by restricting its ability to travel through the water for feeding, reproductive, or migratory purposes. Materials entangled tightly around a body part may cut into tissues, enable infection, and severely compromise an individual's health. Such a

compromised individual is less likely to be able to escape predation and would be less likely to be reproductively successful.

Due to their relatively small size and mobility, ESA-listed fish species are not expected to become entangled in parachutes or parafoils floating or sinking through the water column. Regarding whales, given the relative size difference between the (comparatively small) parachutes and parafoils, 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 but for a short period of time during its descent to the ocean floor. Upon reaching the sea floor, whales are not likely to interact with the material as whales would not likely be engaged in foraging behaviors at that depth, and, consequently, would be located higher in the water column. Unrecovered Dragon parachutes do not immediately sink and therefore would be available for a longer period of time for entanglement to occur. Over time, the parachutes would eventually decay and sink. 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 whale becoming entangled in the parachute. Also, the infrequent nature of the action renders the probability of a whale 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, 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 (>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 but 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.

In summary, because ESA-listed species are so unlikely to become entangled, the effects of entanglement on ESA-listed species is discountable and not likely to adversely affect them. Also, as SpaceX develops the technology to locate fairing drogue parachutes, the probability of SpaceX not recovering all parachutes will decrease, and thus the potential for entanglement will become less.

5.2. Ingestion

Foraging individuals at or near the sea surface could ingest portions of the parachutes, parafoils, or weather balloon fragments. 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). Compared to entanglement, 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).

In a comprehensive review of 37 sea turtle debris ingestion studies undertaken since Balazs (1985), Schuyler et al. (2014) found that, while all species had been reported to ingest debris, leatherbacks and greens were the most susceptible to plastic ingestion, likely due to their feeding preferences. Of the multiple stages in a sea turtle's life, the oceanic phase appears to be at greatest risk (Schuyler et al. 2014). Earlier research by Schuyler et al. (2012) on greens and hawksbills found the majority of materials ingested by sea turtles were positively buoyant, resulting in the presence of these items in the portion of the water column occupied by oceanic post-hatchling sea turtles.

The probability of ESA-listed fish, whales, Guadalupe fur seals, or sea turtles ingesting pieces of a parachute, parafoil, or weather balloon is unlikely and discountable. As noted above, Dragon reentry missions and payload fairing recovery attempts would be infrequent, thus limiting the opportunity for aquatic species to encounter the material. Furthermore, as the fairing parachutes and parafoils would sink fairly rapidly, this further limits the opportunity for aquatic species to encounter the material in their foraging zones. 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 marine species encountering a parachute. Also, as SpaceX develops the technology to locate fairing drogue parachutes, the probability of SpaceX not recovering all parachutes will decrease, and thus the potential for ingestion will become less.

5.3. Struck by Falling Object

ESA-listed species may be affected by Dragon reentry and recovery operations or payload fairing recovery operations if they were struck by falling materials or spacecraft. Due to the relative small size of the Dragon capsule, fairing, 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, and therefore effects are discountable. Smalltooth sawfish and sturgeon are bottom dwelling and unlikely to interact with these items at the surface. Sea turtles, whales, and Guadalupe fur seals spend time at the surface to breathe and are thus at a higher risk of interacting with the Dragon, fairing, and other parts. However, turtles and whales spend the majority of their time submerged as opposed to on the surface, thus lowering the risk of interactions. The same is true for Guadalupe fur seals when not on land. Expended materials from

rocket launches have been occurring for decades with no known interactions with these species. Recovery activities associated with the project would be infrequent.

5.4. Exposure to Sonic Boom

A sonic boom would be generated during Dragon reentry. SpaceX conducted a sonic boom analysis for Dragon-1 landings at CCAFS using the single-event prediction model, PCBOOM (BRRRC 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 psf is similar to a thunder clap.

The overpressures from the sonic boom are not expected to affect 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. 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.

6. Conclusion

Because all potential effects to ESA-listed species were found to be discountable, the project is not likely to adversely affect listed species under NMFS's purview. The project would not affect critical habitat. This analysis and conclusion is similar to previous ESA consultations with NMFS involving expended balloons or parachutes, including the following:

- Biological Opinion and Conference Report for U.S. Navy training and testing activities in the Mariana Islands; June 12, 2015; PCTS Tracking Number: FPR-2014-9070.
- NASA launch, flight and recovery of the Low Density Supersonic Decelerators (LDSD) Technology Demonstration Mission from the U.S. Navy's Pacific Missile Range Facility on Kauai, Hawaii; NMFS concurrence letter dated March 10, 2015. PCTS Tracking Number: PIR-2015-9591.
- NASA Ultra Long Duration Balloon (ULDB) Program; NMFS concurrence letter dated August 11, 2014; PCTS Tracking Number: FPR-2014-9097.

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Appendix A. Endangered Species Act Consultation SER- 2016-17894



UNITED STATES DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration

NATIONAL MARINE FISHERIES SERVICE

Southeast Regional Office

263 13th Avenue South

St. Petersburg, Florida 33701-5505

<http://sero.nmfs.noaa.gov>

F/SER31: NMB

Donald Dankert
Environmental Management Branch
National Aeronautics and Space Administration
John F. Kennedy Space Center
Mail Code: SI-E3
Kennedy Space Center, Florida 32899

AUG 08 2016

Daniel Czelusniak
Environmental Specialist
Federal Aviation Administration
800 Independence Avenue Southwest
Suite 325
Washington, DC 20591

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

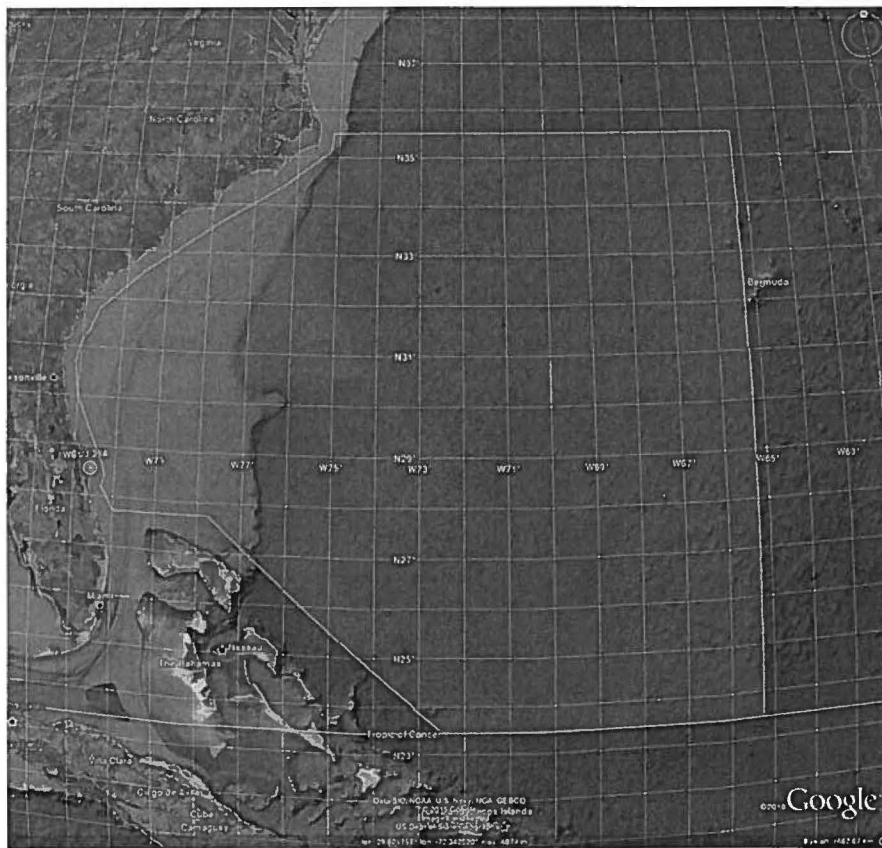
Consultation History

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 Cape 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 ascent 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 ascent. 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 descent 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 (ft²) 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 descent. 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 ascent 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.nmfs@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 inhabitation 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 ft²), 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,

A handwritten signature in black ink, appearing to read "Roy E. Crabtree".

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

Appendix B. Correspondence Regarding Monterey Bay National Marine Sanctuary

From: Deirdre Whalen - NOAA Federal [<mailto:deirdre.whelen@noaa.gov>]
Sent: Monday, October 06, 2014 6:45 PM
To: Czelusniak, Daniel (FAA)
Subject: Re: SpaceX Dragon Pacific Landing - FAA Informal Consult Letter

Daniel,

Thank you for submitting your letter dated October 1, 2014 clarifying the Federal Aviation Administration role in the SpaceX project. Essentially, FAA is recognizing the safety ellipses identified by SpaceX . Monterey Bay National Marine Sanctuary does not object to the establishment of these safety ellipses. given no discharge is planned to occur within this area. We understand the primary goal of identifying these areas will result in air safety. Given this, you are correct in that a permit from this office is not required.

The proposed action is not expected to have incidental impacts to the MBNMS. Should any matter enter the MBNMS, our office will coordinate with SpaceX as sanctuary regulations governing prohibited activities (15 CFR 922.132(a)) and injury to sanctuary resources (16 USC 1443) would apply.

We appreciate your coordination with our office & found our previous conversation to be very helpful in understanding the scope of the proposed project.

Best regards,
Deirdre

Deirdre Whalen
Permit Coordinator &

Government and Community Relations Coordinator
NOAA- Monterey Bay National Marine Sanctuary
P: 831.647.4207
E: deirdre.whelen@noaa.gov



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 dronship 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.

ft² = 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; ft² = 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).

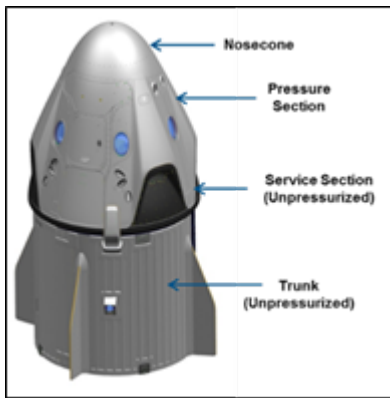


Figure 3. Dragon-2 (FAA 2017)

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 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.

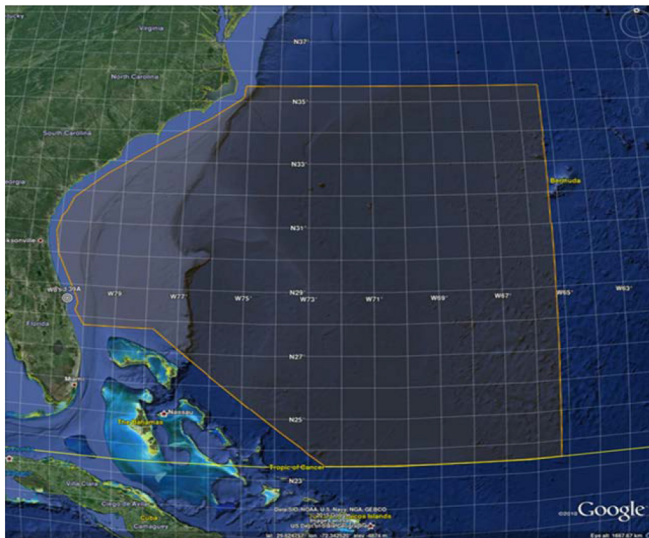


Figure 6. Atlantic Ocean Recovery Zone “Superbox” (FAA 2017)

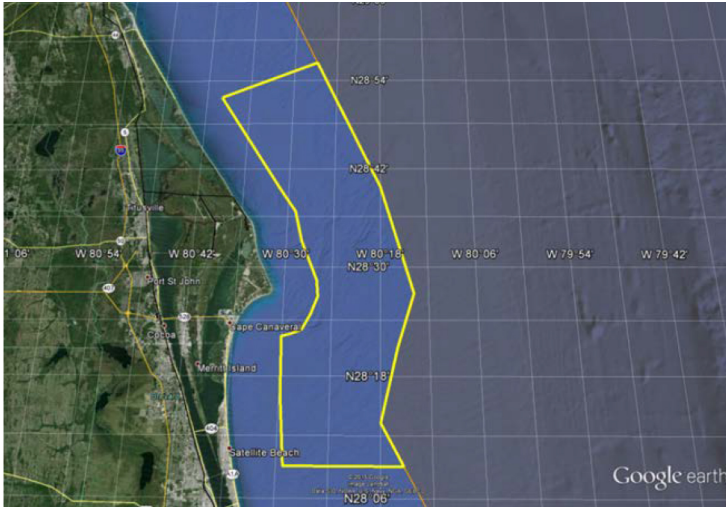


Figure 7. Atlantic Ocean Recovery Zone “Bulb” (FAA 2017)

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.

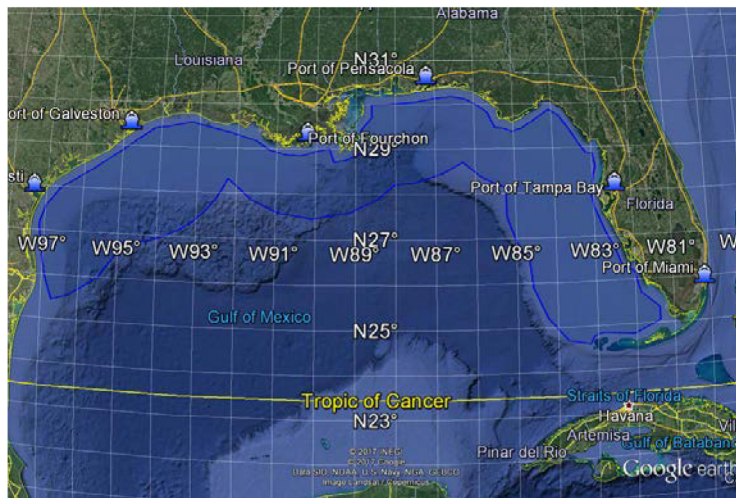


Figure 8. Gulf of Mexico Recovery Zone (FAA 2017)

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.

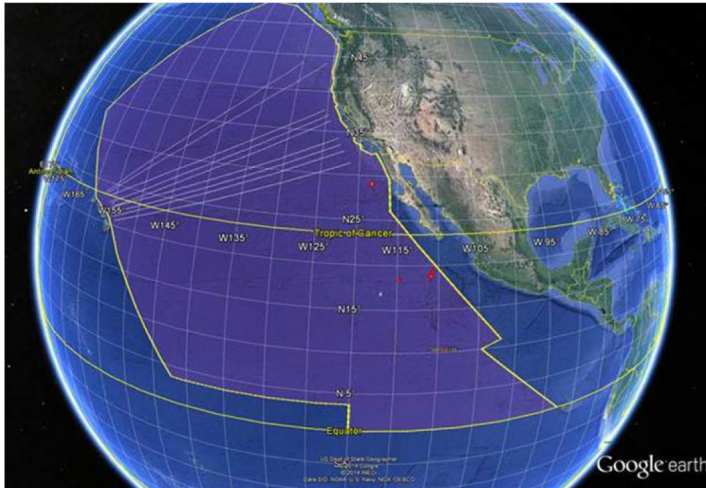


Figure 9. Pacific Ocean Recovery Zone

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	<i>Eubalaena glacialis</i>	March 6, 2008 (73 FR 12024)	July 5, 1994/February 26, 2016 (59 FR 28805/81 FR 4837)	Endangered	NLAA
North Pacific right whale	<i>Eubalaena japonica</i>	December 2, 1970/March 6, 2008 (73 FR 12024)	April 8, 2008 (73 FR 19000)	Endangered	NLAA
Blue whale	<i>Balaenoptera musculus</i>	December 2, 1970 (35 FR 18319)	Not designated	Endangered	NLAA
Gray Whales	<i>Eschrichtius robustus</i>	December 2, 1970 (35 FR 18319)	Not designated	Endangered	NLAA
Humpback whale – Mexico DPS	<i>Megaptera novaeangliae</i>	December 2, 1970/ October 2, 2016 (35 FR 18319/81 FR 62259)	Not designated	Threatened	NLAA
Fin whale	<i>Balaenoptera physalus</i>	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	<i>Balaenoptera borealis</i>	December 2, 1970 (35 FR 18319)	Not designated	Endangered	NLAA
Sperm whale	<i>Physeter macrocephalus</i>	December 2, 1970 (35 FR 18319)	Not designated	Endangered	NLAA
Southern Resident killer whales	<i>Orcinus orca</i>	February 16, 2006 (70 FR 69903)	December 29, 2006 (71 FR 69054)	Endangered	NLAA
Guadalupe fur seal	<i>Arctocephalus townsendi</i>	December 16, 1985 (50 FR 51252)	Not designated	Endangered	NLAA
Sea Turtles					
Green sea turtle – North and South Atlantic DPS	<i>Chelonia mydas</i>	May 6, 2016 (81 FR 20057)	September 2, 1998 (63 FR 46693)	Threatened	NLAA
Green sea turtle - East Pacific DPS	<i>Chelonia mydas</i>	May 6, 2016 (81 FR 20057)	Not designated	Threatened	NLAA
Green sea turtle - Florida and Mexico breeding colonies	<i>Chelonia mydas</i>	May 6, 2016 (81 FR 20057)	September 2, 1998 (63 FR 46693)	Endangered	NLAA
Hawksbill sea turtle	<i>Eretmochelys imbricata</i>	June 2, 1970 (35 FR 8491)	September 2, 1998 (63 FR 46693)	Endangered	NLAA
Loggerhead sea turtle – North Pacific DPS	<i>Caretta caretta</i>	September 22, 2011 (76 FR 58868)	Not designated	Endangered	NLAA
Loggerhead sea turtle - Northwest Atlantic Ocean DPS	<i>Caretta caretta</i>	September 22, 2011 (76 FR 58868)	August 11, 2014 (79 FR 39856)	Endangered	NLAA
Olive Ridley sea turtle	<i>Lepidochelys olivacea</i>	July 28, 1978 (43 FR 32800)	Not designated	Threatened	NLAA
Kemp's ridley sea turtle	<i>Lepidochelys kempii</i>	December 2, 1970 (35 FR 18319)	Not designated	Endangered	NLAA
Leatherback sea turtle – Atlantic and Pacific DPSs	<i>Dermochelys coriacea</i>	June 2, 1970 (35 FR 8491)	Designated (44 FR 17710, 77 FR 4170)	Endangered	NLAA
Fishes					
Atlantic sturgeon – Carolina and South Atlantic DPSs	<i>Acipenser oxyrinchus</i>	April 6, 2012 (77 FR 5879)	June 3, 2016 (81 FR 35701) Proposed	Endangered	NLAA
North American Green sturgeon, Southern DPS	<i>Acipenser medirostris</i>	June 6, 2006 (71 FR 17757)	November 9, 2009 (74 FR 52300)	Threatened	NLAA
Gulf sturgeon (Atlantic sturgeon,	<i>Acipenser oxyrinchus</i>	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)	<i>desotoi</i>	49653)			
Shortnose sturgeon	<i>Acipenser brevirostrum</i>	March 11, 1967 (32 FR 4001)	Not designated	Endangered	NLAA
Nassau grouper	<i>Epinephelus striatus</i>	July 29, 2016 (81 FR 42268)	Not designated	Threatened	NLAA
Scalloped hammerhead shark –Central and Southwest Atlantic DPSs	<i>Sphyrna lewini</i>	September 2, 2014 (79 FR 38213)	Not designated	Threatened	NLAA
Scalloped hammerhead shark Eastern Atlantic, Eastern Pacific DPS	<i>Sphyrna lewini</i>	September 2, 2014, (79 FR 38213)	Not designated	Endangered	NLAA
Oceanic Whitetip shark	<i>Carcharhinus longimanus</i>	December 29, 2016 (81 FR 96304)	Not designated	Proposed for listing as threatened	NLAA
Smalltooth sawfish - U.S. DPS	<i>Pristis pectinata</i>	April 1, 2003 (68 FR 15674)	September 2, 2009 (74 FR 45353)	Endangered	NLAA
Chinook Salmon–California Coastal ESU	<i>Oncorhynchus tshawytscha</i>	August 29, 2005 (70 FR 37160)	January 2, 2006 (70 FR 52488)	Threatened	NLAA
Chinook Salmon Central Valley Spring-Run ESU	<i>Oncorhynchus tshawytscha</i>	August 29, 2005 (70 FR 37160)	January 2, 2006 (70 FR 52488)	Threatened	NLAA
Chinook Salmon – Lower Columbia River ESU	<i>Oncorhynchus tshawytscha</i>	August 29, 2005 (70 FR 37160)	January 2, 2006 (70 FR 52488)	Threatened	NLAA
Chinook Salmon – Puget Sound ESU	<i>Oncorhynchus tshawytscha</i>	August 29, 2005 (70 FR 37160)	January 2, 2006 (70 FR 52629)	Threatened	NLAA
Chinook Salmon–Sacramento River Winter-Run ESU	<i>Oncorhynchus tshawytscha</i>	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	<i>Oncorhynchus tshawytscha</i>	August 29, 2005 (70 FR 37160)	December 28, 1993 (58 FR 68543)	Threatened	NLAA
Chinook Salmon–Upper Columbia River Spring-Run ESU	<i>Oncorhynchus tshawytscha</i>	August 29, 2005 (70 FR 37160)	January 2, 2006 (70 FR 52629)	Endangered	NLAA
Chinook Salmon–Upper Willamette	<i>Oncorhynchus tshawytscha</i>	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	<i>Oncorhynchus keta</i>	August 29, 2005 (70 FR 37160)	January 2, 2006 (70 FR 52629)	Threatened	NLAA
Chum Salmon – Hood Canal Summer-Run ESU	<i>Oncorhynchus keta</i>	August 29, 2005 (70 FR 37160)	January 2, 2006 (70 FR 52629)	Threatened	NLAA
Coho Salmon – Central California Coast ESU	<i>Oncorhynchus kisutch</i>	August 29, 2005 (70 FR 37160)	January 2, 2006 (70 FR 52629)	Endangered	NLAA
Coho Salmon– Lower Columbia River ESU	<i>Oncorhynchus kisutch</i>	August 29, 2005 (70 FR 37160)	January 2, 2006 (70 FR 52629)	Threatened	NLAA
Coho Salmon– Oregon Coast ESU	<i>Oncorhynchus kisutch</i>	73 FR 7816	January 2, 2006 (70 FR 52629)	Threatened	NLAA
Coho Salmon - Southern Oregon and Northern California Coasts ESU	<i>Oncorhynchus kisutch</i>	August 29, 2005 (70 FR 37160)	June 4, 1999 (64 FR 24049)	Threatened	NLAA
Steelhead – California Central Valley DPS	<i>Oncorhynchus mykiss</i>	February 6, 2006 (71 FR 834)	January 2, 2006 (70 FR 52487)	Threatened	NLAA
Steelhead – Central California Coast DPS	<i>Oncorhynchus mykiss</i>	February 6, 2006 (71 FR 834)	January 2, 2006 (70 FR 52487)	Threatened	NLAA
Steelhead – Lower and Columbia River DPSs	<i>Oncorhynchus mykiss</i>	February 6, 2006 (71 FR 834)	January 2, 2006 (70 FR 52629)	Threatened	NLAA
Steelhead – Northern California DPS	<i>Oncorhynchus mykiss</i>	February 6, 2006 (71 FR 834)	January 2, 2006 (70 FR 52487)	Threatened	NLAA
Steelhead - Puget Sound DPS	<i>Oncorhynchus mykiss</i>	June 11, 2007 (72 FR 26722)	March 25, 2016 (81 FR 9251)	Threatened	NLAA
Steelhead – Snake River Basin DPS	<i>(Oncorhynchus mykiss)</i>	February 6, 2006 (71 FR 834)	January 2, 2006 (70 FR 52629)	Threatened	NLAA
Steelhead – South-Central and Central California Coast DPSs	<i>Oncorhynchus mykiss</i>	February 6, 2006 (71 FR 834)	January 2, 2006 (70 FR 52487)	Threatened	NLAA
Steelhead – Upper Columbia and Upper Willamette River DPSs	<i>Oncorhynchus mykiss</i>	February 6, 2006 (71 FR 834)	January 2, 2006 (70 FR 52629)	Threatened	NLAA
Steelhead - Southern California DPS	<i>Oncorhynchus mykiss</i>	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 of 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 dronship 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 μ Pa.

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 Guadalupe 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,

A handwritten signature in blue ink, appearing to read 'Cathryn E. Tortorici', with a stylized flourish at the end.

For Cathryn E. Tortorici
Chief, ESA Interagency Cooperation
Division Office of Protected Resources

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U.S. Department
of Transportation
**Federal Aviation
Administration**

Office of Commercial Space Transportation

800 Independence Ave., SW
Washington, DC 20591

OCT 15 2018

Jacqueline Pearson Meyer
ESA Interagency Cooperation Division
Office of Protected Resources
National Marine Fisheries Service
1315 East-West Highway
Silver Spring, MD 20910

RE: NMFS No: FPR-2017-9231

Dear Ms. Meyer,

On October 2, 2017, the Federal Aviation Administration (FAA) completed informal Endangered Species Act (ESA) consultation with your office regarding proposed commercial space launch operations conducted by SpaceX (FPR-2017-9231). Since completing that consultation, the National Marine Fisheries Service listed the giant manta ray (*Manta birostris*) as a threatened species under the ESA (83 FR 2916). Because this species could be located in the action area defined in our 2017 consultation, and because this species may be affected by the activities described in that consultation, we are reinitiating consultation with your office. We have determined the action described in the 2017 consultation **may affect, but is not likely to adversely affect**, the giant manta ray for the same reasons provided for the other marine species.

The FAA is requesting NMFS's written concurrence with our effect determination for the giant manta ray. Please contact Daniel Czelusniak, FAA Environmental Specialist, at Daniel.Czelusniak@faa.gov or (202) 267-5924 to discuss any questions or concerns.

Sincerely,

Howard Searight
Deputy Manager, Space Transportation Development Division



U.S. Department
of Transportation
**Federal Aviation
Administration**

Office of Commercial Space Transportation

800 Independence Ave., SW.
Washington, DC 20591

UCI 15 2018

Roy E. Crabtree, Ph.D
Regional Administrator
National Marine Fisheries Service
Southeast Regional Office
St. Petersburg, FL 33701

RE: SER-2016-17894

Dear Mr. Crabtree,

On August 8, 2016, the National Aeronautics and Space Administration (NASA), Federal Aviation Administration (FAA), and U.S. Air Force (USAF) completed informal Endangered Species Act (ESA) consultation with your office regarding proposed rocket launch operations at NASA Kennedy Space Center, Cape Canaveral Air Force Station, and SpaceX's launch site in southeastern Texas (under construction) (SER-2016-17894). Since completing that consultation, the National Marine Fisheries Service listed the giant manta ray (*Manta birostris*) and oceanic whitetip shark (*Carcharinus lonigmanus*) as threatened species under the ESA (83 FR 2916; 83 FR 4153). Because these species could be located in the action area defined in our 2016 consultation, and because these species may be affected by the activities described in that consultation, we are reinitiating consultation with your office. We have determined the action described in the 2016 consultation **may affect, but is not likely to adversely affect**, the giant manta ray and oceanic whitetip shark for the same reasons provided for the other marine species.

The FAA, NASA, and USAF are requesting NMFS's written concurrence with our effect determination for the giant manta ray and oceanic whitetip shark. Please contact Daniel Czelusniak, FAA Environmental Specialist, at Daniel.Czelusniak@faa.gov or (202) 267-5924 to discuss any questions or concerns.

Sincerely,

Howard Searight
Deputy Manager, Space Transportation Development Division

cc: Don Dankert, NASA
Eva Long, USAF



U.S. Department
of Transportation
**Federal Aviation
Administration**

800 Independence Ave., SW.
Washington, DC 20591

OCT 17 2018

Annie Dziergowski
Chief, Project Review and Consultation
U.S. Fish and Wildlife Service
North Florida Ecological Services Office
7915 Baymeadows Way, Suite 200
Jacksonville, FL 32256-7517
Submitted to: jaxregs@fws.gov

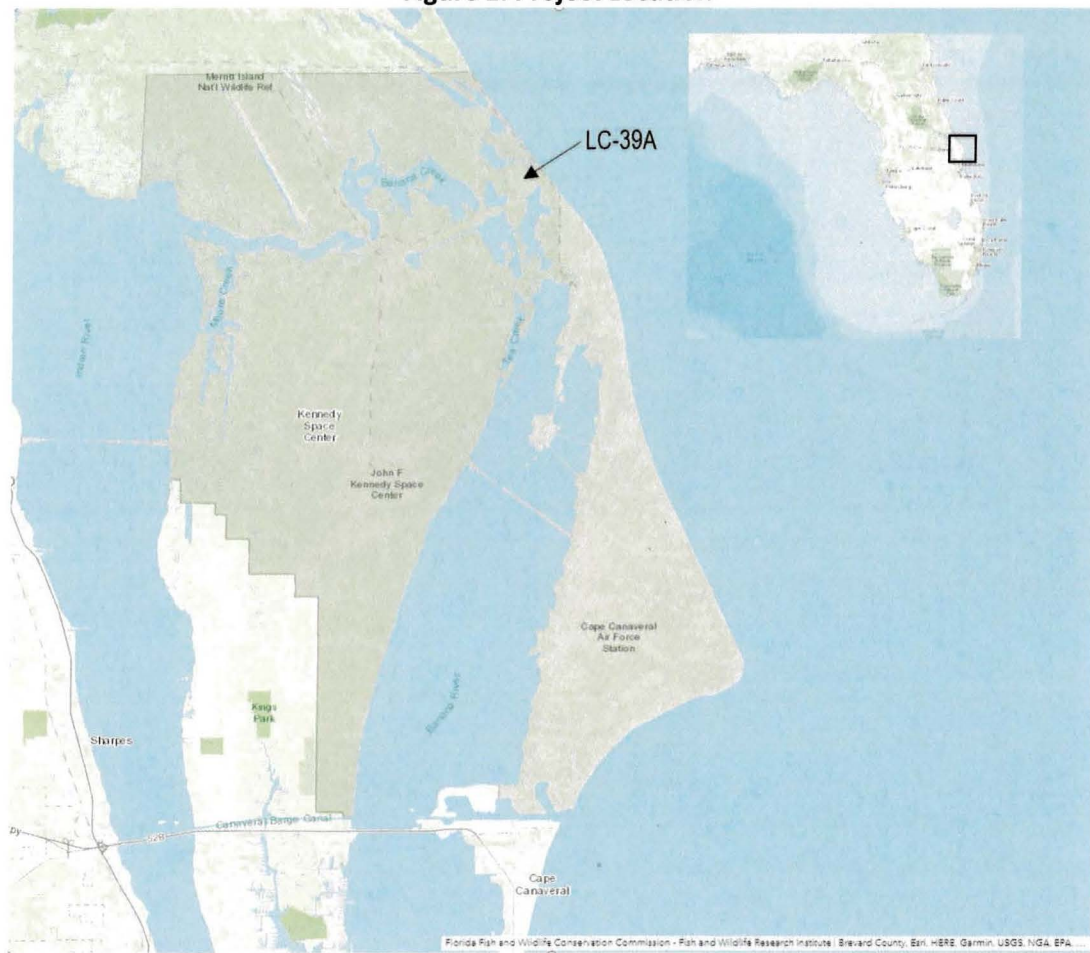
**SUBJECT: Endangered Species Act Consultation for SpaceX's Proposed In-flight Dragon Abort
Test, Kennedy Space Center, Brevard County, Florida**

Dear Ms. Dziergowski,

The Federal Aviation Administration (FAA) is evaluating SpaceX's proposal to conduct a one-time in-flight Dragon abort test (abort test) at the National Aeronautics and Space Administration (NASA) Kennedy Space Center (KSC) in Brevard County, Florida (see Figure 1 for project location). SpaceX must obtain a launch license from the FAA in order to conduct the test. We are currently preparing an environmental assessment (EA) in accordance with the National Environmental Policy Act (NEPA) and FAA's NEPA-implementing order. Our proposed action is to issue a launch license to SpaceX to conduct the one-time abort test at KSC's Launch Complex (LC) 39A.

Pursuant to section 7 of the Endangered Species Act (ESA), we are requesting U.S. Fish and Wildlife Service (USFWS) concurrence with our assessment and determination of potential effects of the proposed action on the following sea turtles: green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), Kemp's ridley (*Lepidochelys kempii*), leatherback (*Dermochelys coriacea*), and loggerhead (*Caretta caretta*). We have already completed ESA informal consultation with the National Marine Fisheries Service (NMFS). The following sections of this letter provide a description of the action, define the action area, provide ESA-listed species and critical habitat in the action area, discuss potential effects to the listed species and critical habitat, and provide the FAA's effect determination for each species and critical habitat.

Figure 1. Project Location

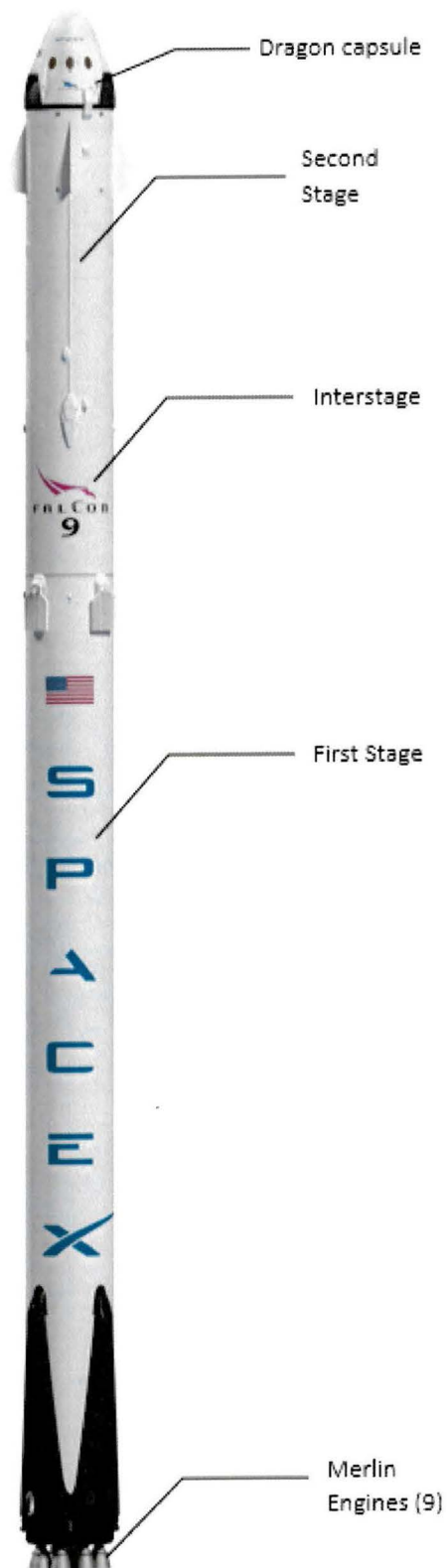


Project Description

The purpose of the one-time abort test is to demonstrate SpaceX's Dragon launch abort system and to facilitate meeting NASA's human certification requirements. The launch scenario where a Dragon abort is initiated during the ascent trajectory at the maximum dynamic pressure (known as max Q) is a design driver for the launch abort system. It dictates the highest thrust and minimum relative acceleration required between Falcon 9 and the aborting Dragon.

The abort test is currently scheduled to occur in 2019. It would be conducted from LC-39A at KSC. The integration of Dragon and Falcon 9 would be similar to that of a standard Dragon launch. Dragon would be mated to the second stage of Falcon 9 while in the transporter-erector. The launch vehicle would then be rolled out to the pad and moved to a vertical position (Figure 2).

Figure 2. Falcon 9 with Dragon



The abort test would start with a nominal launch countdown and release at T-0. The Falcon 9 with the Dragon attached would follow a standard International Space Station-bound trajectory with the exception of launch azimuth to approximately Mach 1. The Falcon 9 would be configured to shut down and terminate thrust, targeting the abort test shutdown condition (simulating a loss of thrust scenario). Dragon would then issue an abort command, which would initiate the startup of Dragon's engines. Concurrently, Falcon 9 would receive a command from Dragon to terminate Falcon 9's engine thrust. Dragon would then separate from Falcon 9. Under these conditions, the Falcon 9 vehicle would become uncontrollable and would break apart. SpaceX would not attempt first stage booster flyback to KSC, Cape Canaveral Air Force Station (CCAFS), or a droneship, nor would they attempt to fly the booster to orbit.

Dragon would fly until engine burnout and then coast until reaching apogee, at which point the trunk would be jettisoned. Thrusters would be used to reorient Dragon to entry attitude. Dragon would descend back toward Earth and deploy drogue parachutes at approximately 6 miles altitude and main parachutes at approximately 1 mile altitude. Dragon recovery operations would be very similar to actions for normal Dragon reentry and recovery, although Dragon recovery during the abort test would occur approximately 9–42 miles from shore, and normal Dragon recovery is approximately 200 miles offshore.

The Falcon 9 debris impact points from a Monte Carlo dispersion model and anticipated area of impact are shown in Figure 3. Debris propagation analysis was performed by the 45th Space Wing as part of the risk analysis process. These results are used to generate Notices to Airmen and Local Notices to Mariners, as well as to generate flight hazard areas taking into account the effects of debris dispersal and hypergol dispersion.. All of the debris is expected to land in the ocean, most of which is expected to sink relatively quickly. The debris that would have the potential to float include fragments from carbon fiber overwrapped pressure vessels (or COPVs) and transfer tubes.

SpaceX plans to recover all floating debris. SpaceX has performed successful recovery of floating rocket parts during previous Falcon 9 first stage booster landing attempts. SpaceX would mobilize a debris recovery operation to ensure necessary environmental protections are ready and available as soon as possible post-launch. Once the abort test commences, SpaceX would monitor the flight for nominal performance indicators including thrust, trajectory path, and propulsion systems. SpaceX would receive reports from existing assets to confirm debris status in flight and on the ocean surface. Assets would include mobile platforms used for launch surveillance and/or tracking cameras. Mobile assets would survey the applicable debris once the Eastern Range (Risk Assessment Center) confirms debris fall time and no longer poses a safety hazard.

Upon receiving survey debris observations, the debris recovery team would first recover any items deemed a public safety or maritime traffic hazard and then recover miscellaneous floating items, including items that are projected to float towards the shoreline based on observations and expected weather conditions. If it's necessary to access the beach to recover debris, SpaceX would coordinate with the applicable property owner (e.g., National Park Service, NASA).

SpaceX debris recovery would be a collaborative effort with the U.S. Coast Guard to ensure maritime safety based on the projected debris field of 2–20 miles offshore. Per customary practice, SpaceX would request the Emergency Operations Centers (EOCs) from Brevard County, KSC, and CCAFS to support SpaceX during the launch operation. The EOCs would also help facilitate any immediate land-based debris recovery efforts if needed.

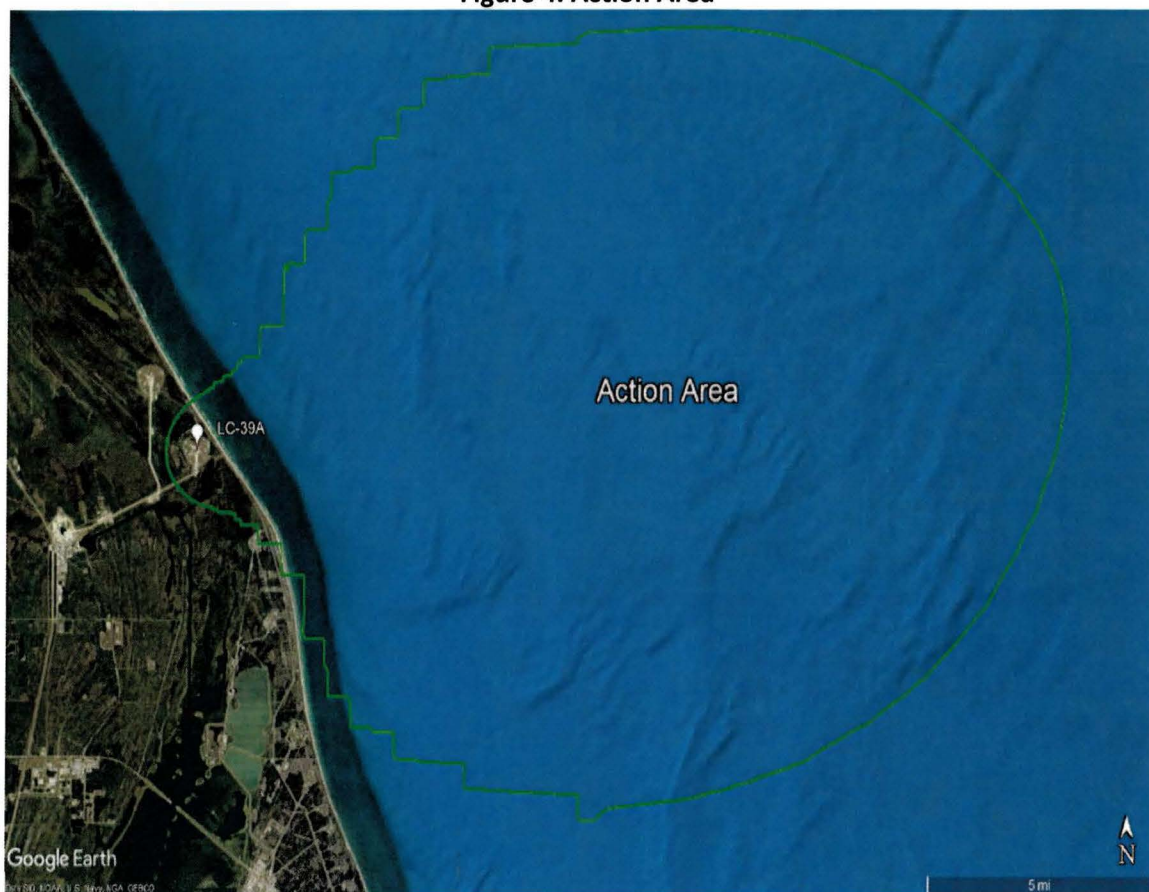
Figure 3. Monte Carlo Model of Debris



Action Area

The action area is defined as all areas directly or indirectly affected by the federal action. The action area encompasses those areas that would be affected by Falcon 9 takeoff (mainly from rocket engine noise) and nearshore and offshore areas affected by Falcon 9 debris and Dragon splashdown (Figure 4).

Figure 4. Action Area



ESA-Listed Species and Critical Habitat

The FAA used the USFWS's Information for Planning and Consultation (IPaC) online system and North Florida Ecological Services Office website to generate a species list for the project. Those ESA-listed species under USFWS jurisdiction potentially occurring in the action area are depicted in Table 2.

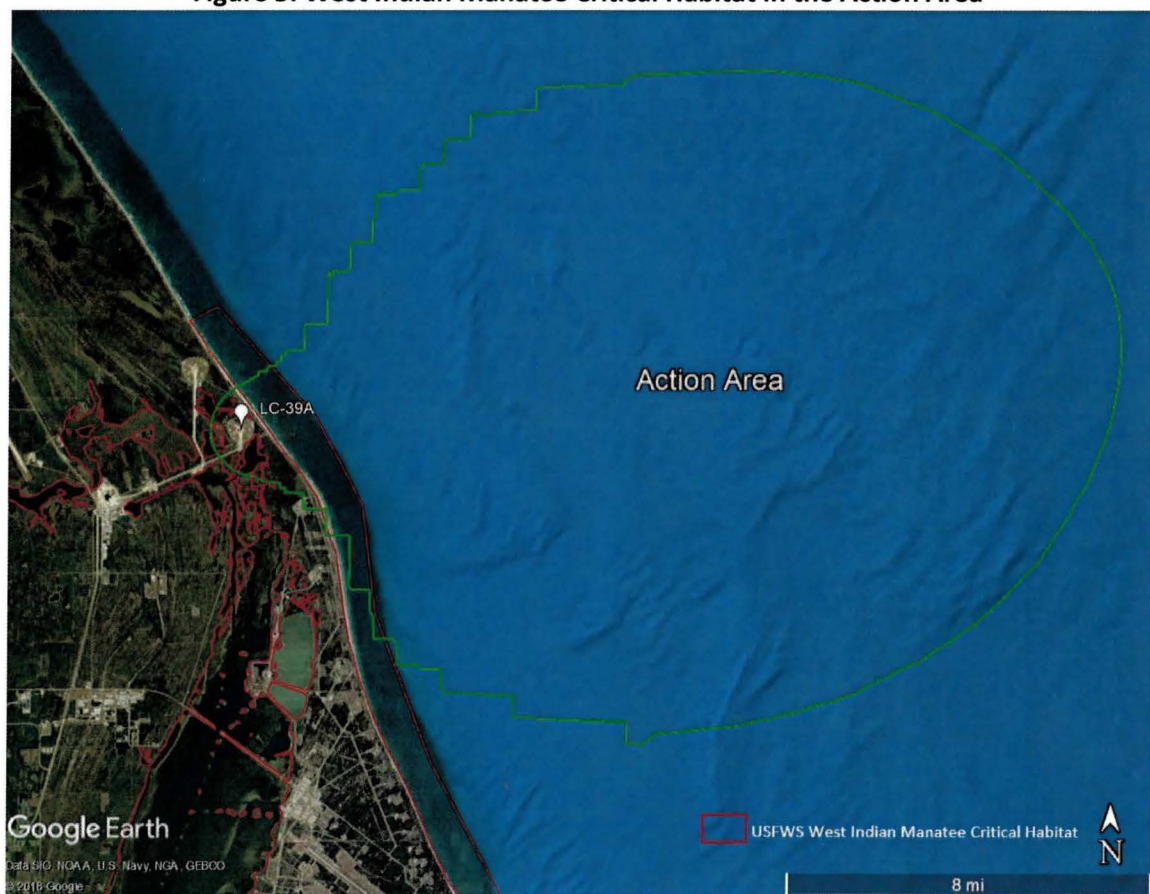
Table 2. ESA-Listed Species under USFWS Jurisdiction in the Action Area

Category	Species Common Name	Species Scientific Name	Status
Mammals	Southeastern beach mouse	<i>Peromyscus polionotus nineiventris</i>	Endangered
	West Indian manatee	<i>Trichechus manatus latirostris</i>	Threatened
Birds	Audubon's crested caracara	<i>Polyborus plancus audubinii</i>	Threatened
	Everglade snail kite	<i>Rostrhamus sociabilis plumbeus</i>	Endangered
	Florida scrub-jay	<i>Aphelocoma coerulescens</i>	Threatened
	Piping plover	<i>Charadrius melodus</i>	Threatened
	Red Knot	<i>Calidris canutus rufa</i>	Threatened
	Red-cockaded Woodpecker	<i>Picoides borealis</i>	Endangered
	Wood Stork	<i>Mycteria americana</i>	Endangered
Reptiles	Atlantic salt marsh snake	<i>Nerodia clarkii taeniata</i>	Threatened
	Eastern indigo snake	<i>Drymarchon corais couperi</i>	Threatened

Category	Species Common Name	Species Scientific Name	Status
	Green sea turtle	<i>Chelonia mydas</i>	Threatened
	Hawksbill sea turtle	<i>Eremochelys imbricata</i>	Endangered
	Kemp's ridley sea turtle	<i>Lepidochelys kempii</i>	Endangered
	Leatherback sea turtle	<i>Dermochelys coriacea</i>	Endangered
	Loggerhead sea turtle	<i>Caretta caretta</i>	Threatened
Plants	Carter's mustard	<i>Warea carteri</i>	Endangered
	Lewton's polygala	<i>Polygala lewtonii</i>	Endangered

Designated critical habitat for the West Indian manatee (Unit LOGG-N-17) is located within the action area (Figure 5). The estuarine waters surrounding KSC provide year-round safe harbor and foraging areas for West Indian manatees. Manatees can be found at KSC during all months of the year, except when winter cold fronts drop water temperatures below 66 degrees Fahrenheit. KSC generally experiences a spring peak in manatee numbers followed by a fairly consistent number of animals in summer, another increase each fall, and then a drop each winter.

Figure 5. West Indian Manatee Critical Habitat in the Action Area



Potential Effects to ESA-listed Species and Critical Habitat

Potential launch-related effects (i.e., effects caused by rocket takeoff from LC-39A) to the species in Table 2 have been previously addressed by NASA and USFWS. NASA is responsible for ensuring that KSC activities do not jeopardize the continued existence of listed species. Rocket launches have been occurring at KSC for many years and NASA consults USFWS and NMFS as needed. The use and management of KSC are described in Kennedy Contract Agreement KCA-1649 Rev B., the Interagency Agreement between NASA and USFWS. NASA works with the USFWS and NMFS to initiate consultation, as needed, when new species are listed or new activities are proposed that have not already been assessed for potential impacts. Therefore, this ESA consultation and effects analysis focuses on Dragon separation and Falcon 9 break-up during the abort test. This part of the abort test would have no effect on all of the species listed in Table 2, except for the five species of sea turtles, for the following reasons: the one-time abort test would occur at a high altitude and offshore, SpaceX would immediately recover floating debris (including any that washed ashore), and recovery boat operators would operate at slow speeds and avoid collisions with manatees if debris recovery operations close to shore were necessary. Similarly, given the one-time nature of the abort test and the debris recovery strategy that SpaceX would implement, no effects to West Indian manatee critical habitat are expected.

If SpaceX conducted the abort test during the sea turtle nesting season (May 1 – October 31), the action would have the potential to affect nesting sea turtles. Green, leatherback, and loggerhead sea turtles regularly nest on Florida beaches, including beaches in Brevard County.¹ While hawksbill and Kemp's ridley sea turtles are not regular nesters in Florida, they could nest on a beach within the action area. In the event SpaceX was not able to collect all floating debris at sea and a piece(s) of debris reached the shoreline, the debris could affect (disturb) individual adult turtles coming ashore to nest and lay eggs and during their crawl back into the ocean. Similarly, debris could impede hatchlings reaching ocean waters. Harm to an individual turtle is unlikely, as the turtle could swim or crawl around the debris. During sea turtle nesting season, regular beach patrols are conducted by a network of permit holders. As soon as a piece of debris is discovered approaching the beach or is discovered on the beach and SpaceX is notified, SpaceX would immediately retrieve the debris in coordination with the landowner. Therefore, the probability of an individual sea turtle encountering debris on its way to or from a nest is low and adverse effects are extremely unlikely to occur.

In summary, because the potential effects to nesting sea turtles would be discountable, the FAA determined the Proposed Action **may affect, but is not likely to adversely affect**, nesting green, hawksbill, leatherback, and loggerhead sea turtles.

¹ <http://myfwc.com/research/wildlife/sea-turtles/nesting/monitoring/>

Conclusion

We seek your concurrence on our effect determination for nesting sea turtles and welcome any additional comments. Thank you for your assistance in this matter. Please provide your response to Daniel Czelusniak via e-mail at Daniel.Czelusniak@faa.gov.

Sincerely,

A handwritten signature in black ink, reading "Howard Searight". The signature is written in a cursive style with a large, stylized "H" and "S".

Howard Searight
Deputy Manager, Space Transportation Development Division

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APPENDIX B: NOISE ASSESSMENT

LAUNCH NOISE ASSESSMENT OF FALCON 9 AND FALCON HEAVY AT CAPE CANAVERAL AIR FORCE STATION AND KENNEDY SPACE CENTER

TN 18-01

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Prepared for:

Space Exploration Technologies Corporation (SpaceX)
1 Rocket Road
Hawthorne, CA 90250



Prepared by:



Prepared by:

Kevin A. Bradley

Environment and Energy
200 12th Street S., Suite 300
Arlington, VA 22202
703.413.4700

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1 Introduction

Noise levels have been estimated for SpaceX Falcon 9 Block 5 and Falcon Heavy Block 5 launch operations at Cape Canaveral Air Force Station (CCAFS) and Kennedy Space Center (KSC). The Falcon 9 Block 5 succeeds the Falcon 9 Block 4 with changes that include 7-8% more thrust by uprating the engines, improvements on landing legs, and modifications to increase the efficiency of recovery and reusability of first-stage boosters. The Falcon 9 Block 5 will have uprated Merlin 1D (M1D) engines that each provide sea-level thrust of 190 KlbF. Falcon 9 Block 5 launches will occur at Cape Canaveral Air Force Station Space Launch Complex 40 (SLC-40) and Kennedy Space Center Launch Complex 39 (Launch Pad 39A or LC-39A). Falcon Heavy Block 5 launches will occur at LC-39A. This assessment was conducted to estimate the single event and cumulative noise levels in the vicinity of CCAFS and KSC due to both of these launch operations.

SpaceX provided the following data for noise modeling:

- Vehicle launch trajectories for the Falcon 9 Block 5 and the Falcon Heavy Block 5 from liftoff to main engine cutoff (MECO).
- Falcon 9 Block 5 engine operating data and nominal ascent thrust profile per engine (Figure 1).

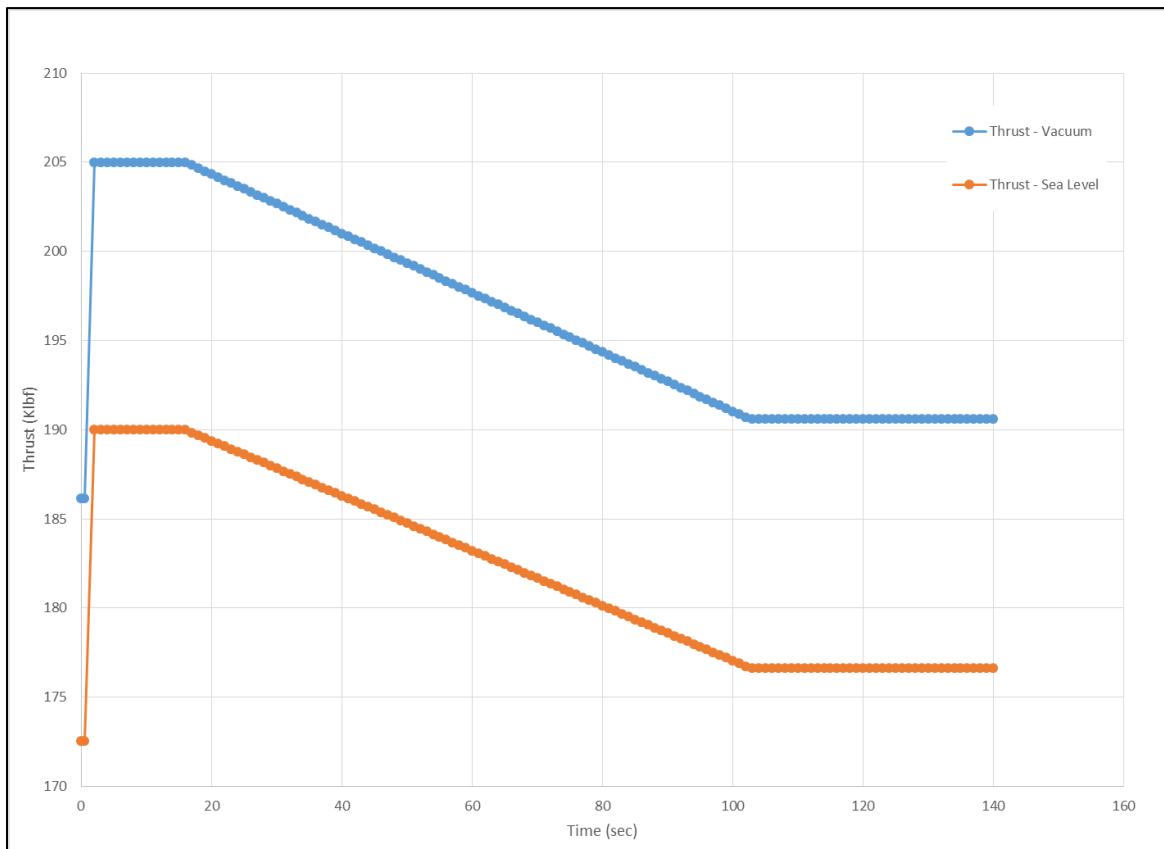


Figure 1. Falcon 9 Block 5 Nominal Ascent Thrust Profile (Per Engine)

To estimate the noise levels around SLC-40 and LC-39A, rocket noise from the Falcon 9 Block 5 and Falcon Heavy Block 5 was computed by Wyle's RNOISE model. RNOISE^{1,2} is a far-field (distances beyond several hundred feet) community noise model for launch noise assessment. A description of rocket noise fundamentals and noise metrics are provided in Section 2. Estimates of Falcon 9 Block 5 launch noise levels around SLC-40 and LC-39A are provided in Section 3. Estimates of Falcon Heavy Block 5 launch noise levels around LC-39A are provided in Section 4. Cumulative noise levels for existing launches and projected future launches of the Falcon 9 Block 5 and Falcon Heavy Block 5 are presented in Section 5.

2 Rocket Noise

2.1 Background

Rockets generate significant noise from the combustion process and turbulent mixing of the exhaust flow with the surrounding air. Figure 2 is a sketch of rocket noise. There is a supersonic potential core of exhaust flow, surrounded by mixing region. Noise is generated in this flow. It is directional, with the highest noise levels at an angle of 40 to 50 degrees from the direction of the exhaust flow. The fundamentals of predicting rocket noise were established by Wilhold et al.³ for moving rockets and by Eldred et al.⁴ for static firing. Sutherland⁵ has refined modeling of rocket source noise, improving its consistency relative to jet noise theory. Based on those fundamentals, Wyle has developed the PAD model for near field rocket noise⁶ and the RNOISE model for far field noise in the community. RNOISE was used for the current analysis.

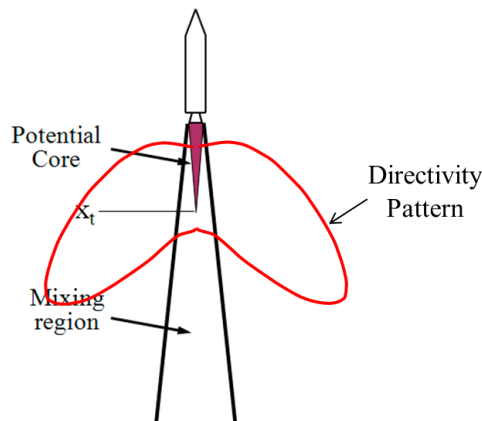


Figure 2. Rocket Noise Source

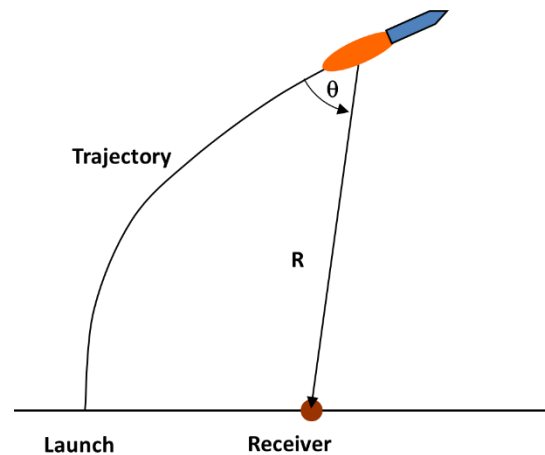


Figure 3. Modeling Rocket Noise at the Ground

Figure 3 is a sketch of far field rocket noise as treated by RNOISE. The vehicle position and attitude is known from the trajectory. Rocket noise source characteristics are known from the engine properties, with thrust and exhaust velocity being the most important parameters. The emission angle and distance to the receiver are known from the flight path and receiver position. Noise at the ground is computed accounting for distance, ground impedance,⁷ and atmospheric absorption of sound.⁸ RNOISE propagates

the full spectrum to the ground, accounting for Doppler shift from vehicle motion. It is a time simulation model, computing the noise at individual points or on a regular grid for every time point in the trajectory. Propagation time from the vehicle to the receiver is accounted for, yielding a spectral time history at the ground. A variety of noise metrics can be computed from the full calculated noise field and the metrics commonly used to assess rocket noise are described in the following section.

2.2 Noise Metrics

FAA Order 1050.1E specifies Day-Night Average Sound Level (DNL) as the standard metric for community noise impact analysis, but also specifies that other supplemental metrics may be used as appropriate for the circumstances. DNL is appropriate for continuous noise sources, such as airport noise and road traffic noise. It is not appropriate for irregularly occurring noise events such as rocket launches or static tests.

The noise metrics used for rocket noise analysis are:

- DNL, as defined by FAA Order 1050.1E;
- SEL, the Sound Exposure Level, for individual events;
- L_{Amax} , the maximum A-weighted level, for individual events;
- OASPL, the maximum overall sound pressure level, for individual events; and
- One third octave spectra at particular sensitive receptors.

As mentioned, DNL is necessary for policy. The next two metrics (L_{Amax} and SEL) are A-weighted and provide a measure of the impact of individual events. Loud individual events can pose a hearing damage hazard to people, and can also cause adverse reactions by animals. Adverse animal reactions can include flight, nest abandonment, and interference with reproductive activities. The last two metrics, OASPL and spectra, may be needed to assess potential damage to structures and adverse reaction of species whose hearing response is not similar to that of humans. The estimated noise results presented in section 3 will be L_{Amax} and SEL contours for single event noise assessment over the study area.

L_{Amax} is appropriate for community noise assessment of a single event, such as a rocket launch or static fire test. This metric represents the highest A-weighted integrated sound level for the event in which the sound level changes value with time. The L_{Amax} metric indicates the maximum sound level occurring for a fraction of a second. Slowly varying or steady sounds are generally integrated over a period of one second. The maximum sound level is important in judging the interference caused by a noise event with conversation, TV or radio listening, sleep, or other common activities. Although it provides some measure of the intrusiveness of the event, it does not completely describe the total event, because it does not include the period of time that the sound is heard.

SEL is a composite metric that represents both the intensity of a sound and its duration. Individual time-varying noise events (e.g., aircraft overflights) have two main characteristics: a sound level that changes throughout the event and a period of time during which the event is heard. SEL provides a measure of the net impact of the entire acoustic event, but it does not directly represent the sound level heard at any given time. For example, during an aircraft flyover, SEL would include both the maximum noise level and the lower noise levels produced during onset and recess periods of the overflight. SEL is a logarithmic

measure of the total acoustic energy transmitted to the listener during the event. Mathematically, it represents the sound level of a constant sound that would, in one second, generate the same acoustic energy as the actual time-varying noise event. For a rocket launch, the SEL is expected to be greater than the L_{Amax} because the launch noise event is up to several minutes in duration whereas the maximum sound level (L_{Amax}) occurs instantaneously.

3 Falcon 9 Block 5 Single Event Launch Noise Levels at SLC-40 and LC-39A

RNOISE was used to estimate the L_{Amax} , and SEL contours for Falcon 9 Block 5 Launches at SLC-40 and LC-39A using trajectory data, from liftoff to MECO, provided by SpaceX in file 'Falcon_9_Full_Thrust_Block5_Representative_Cape_Trajectory.asc'. The L_{Amax} contours indicate the maximum sound level at each location over the duration of the launch, from liftoff to MECO, where engine thrust varies according to the ascent thrust profile (Figure 1). Both launch events were modeled with a duration of 161 seconds, SEL values are higher than L_{Amax} values.

RNOISE computations were done using a radial grid consisting of 128 azimuths and 100 intervals out to 300,000 feet from the launch point. Ground areas were considered to be acoustically soft, and water acoustically hard. Ground effect was based on a weighted average over the propagation path. As will be shown in the resulting noise contour maps (Figures 4 through 11), the shape of the innermost contours is approximately circular. The shape of the outermost contours is due to rocket noise directivity and the difference between acoustically hard water and acoustically soft ground. The launch pad locations at SLC-40 and LC-39A are indicated in the map legends as are the Cape Canaveral Air Force Station and Kennedy Space Center (KSC) properties. SLC-40 is located about four miles southeast, along the coast, from LC-39A.

The L_{Amax} 70 dB through 110 dB contours shown in Figures 4 and 5 represent the maximum levels estimated for the Falcon 9 Block 5 launch at SLC-40; Figure 5 shows these contours using a zoomed in map scale to better show the extent of the noise exposure relative to cities located around SLC-40. The higher L_{Amax} contours (90, 100, and 110 dB) are located entirely within both the CCAFS and KSC properties. If a Falcon 9 Block 5 launch occurs during the day, when background levels are in the 50 dB to 60 dB range, residents of Titusville, Merritt Island, and Cape Canaveral may notice launch noise levels above 70 dB. If the same launch occurs during the night, when background levels are lower than during the day (e.g., below 40 dB to 50 dB range), these residents may notice launch noise levels that exceed 60 dB. A prevailing on-shore or off-shore breeze may also strongly influence noise levels in these communities.

SEL contour levels of 80, 90, 100, and 110 dB are shown in Figures 6 and 7 for the Falcon 9 Block 5 launch at SLC-40 with Figure 7 showing a zoomed in map scale. As mentioned previously, SEL is an integrated metric and is expected to be greater than the L_{Amax} because the launch event is up to several minutes in duration whereas the maximum sound level (L_{Amax}) occurs instantaneously. Figure 7 indicates that the 100 and 110 dB SEL contours are expected to remain almost entirely within the CCAFS and KSC properties.

The L_{Amax} , and SEL contours estimated for Falcon 9 Block 5 Launches at LC-39A are shown in Figures 8 through 11 in the same sequence as the figures presented for SLC-40. In general, the estimated noise exposure from Falcon 9 Block 5 launches at LC-39A is similar to the estimated noise exposure for launches at SLC-40, except the noise contours are shifted northeast, along the coast, by about four miles.

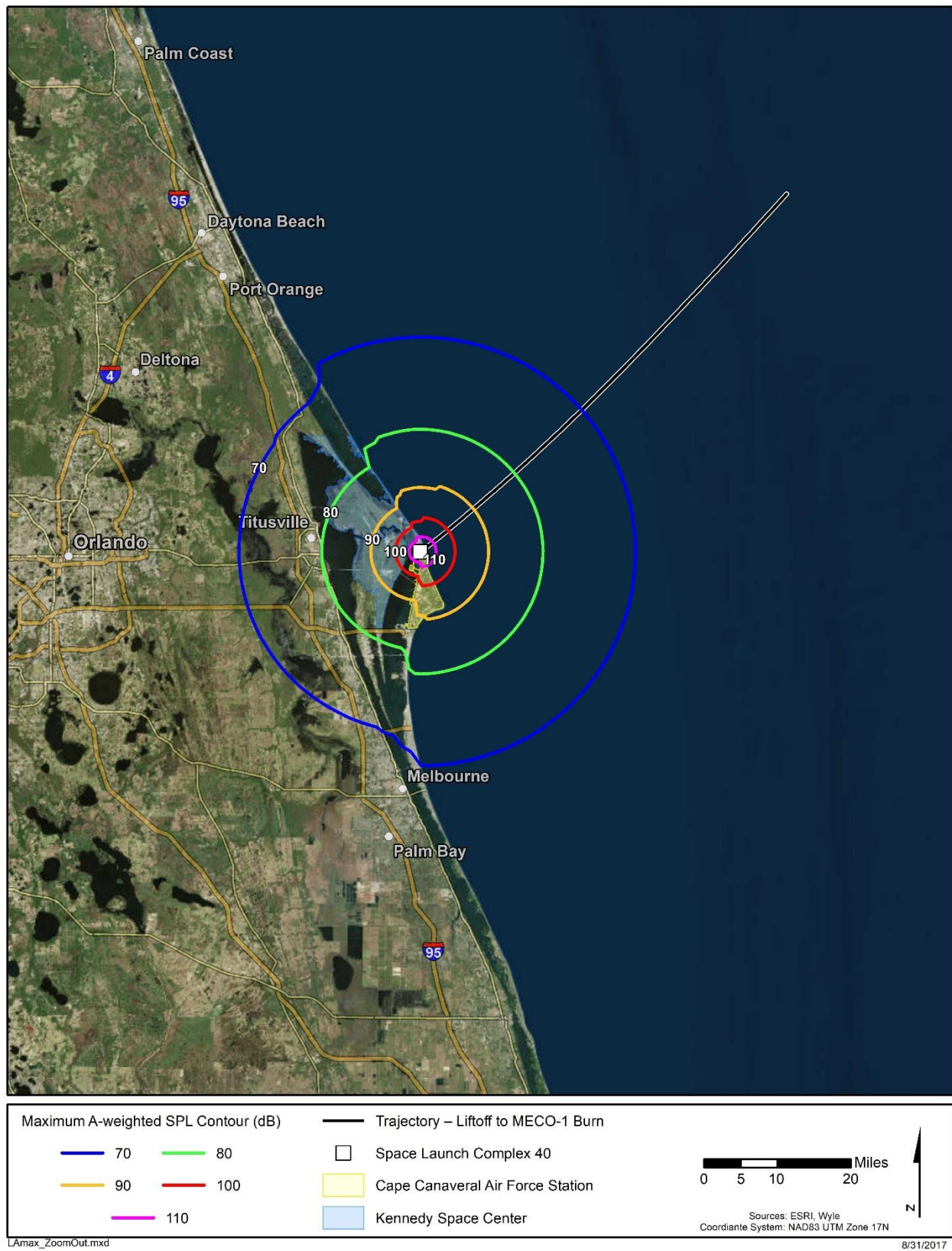


Figure 4. Maximum A-Weighted Sound Levels for Falcon 9 Block 5 Launch from SLC-40

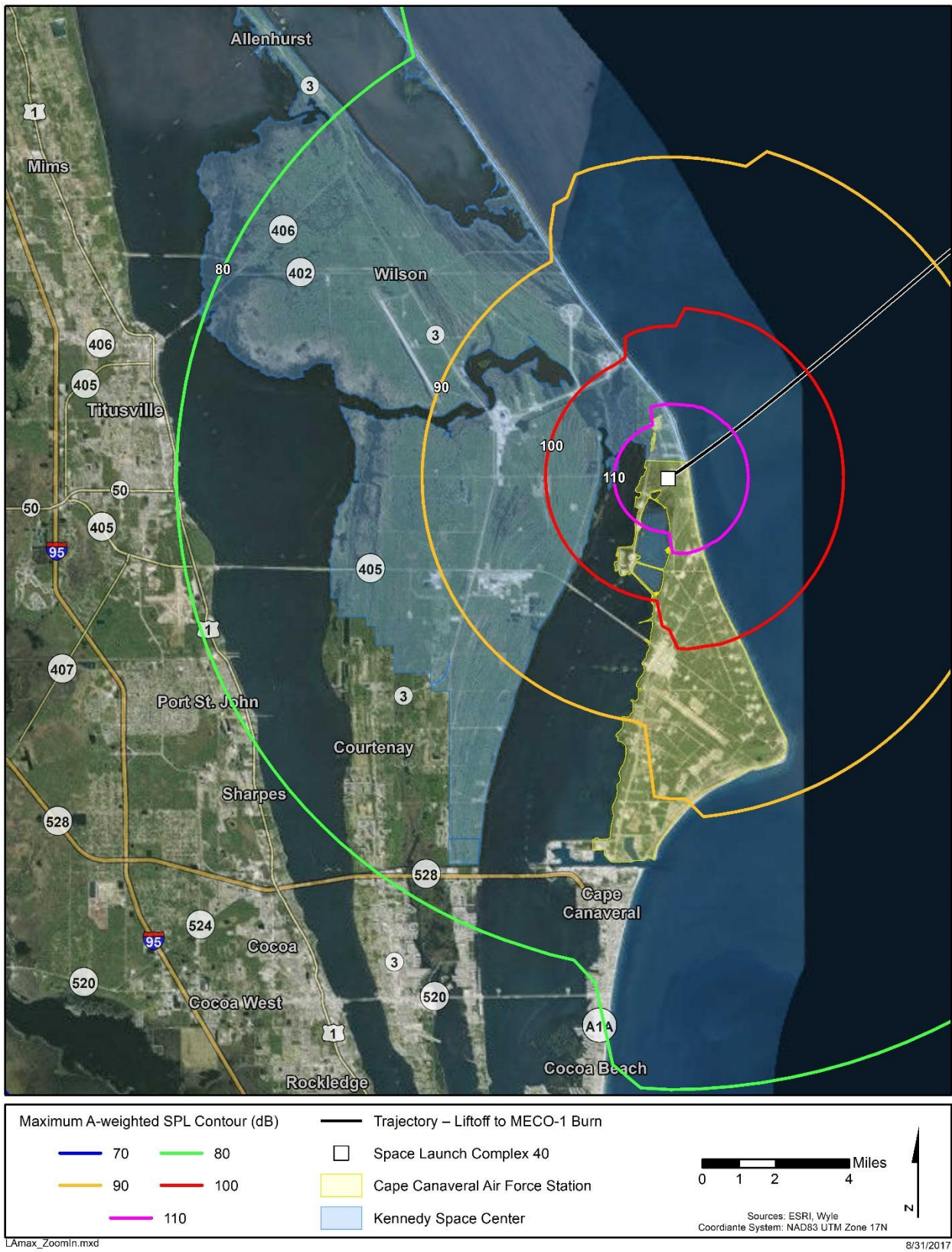


Figure 5. Maximum A-Weighted Sound Levels for Falcon 9 Block 5 Launch from SLC-40 (Zoomed in)

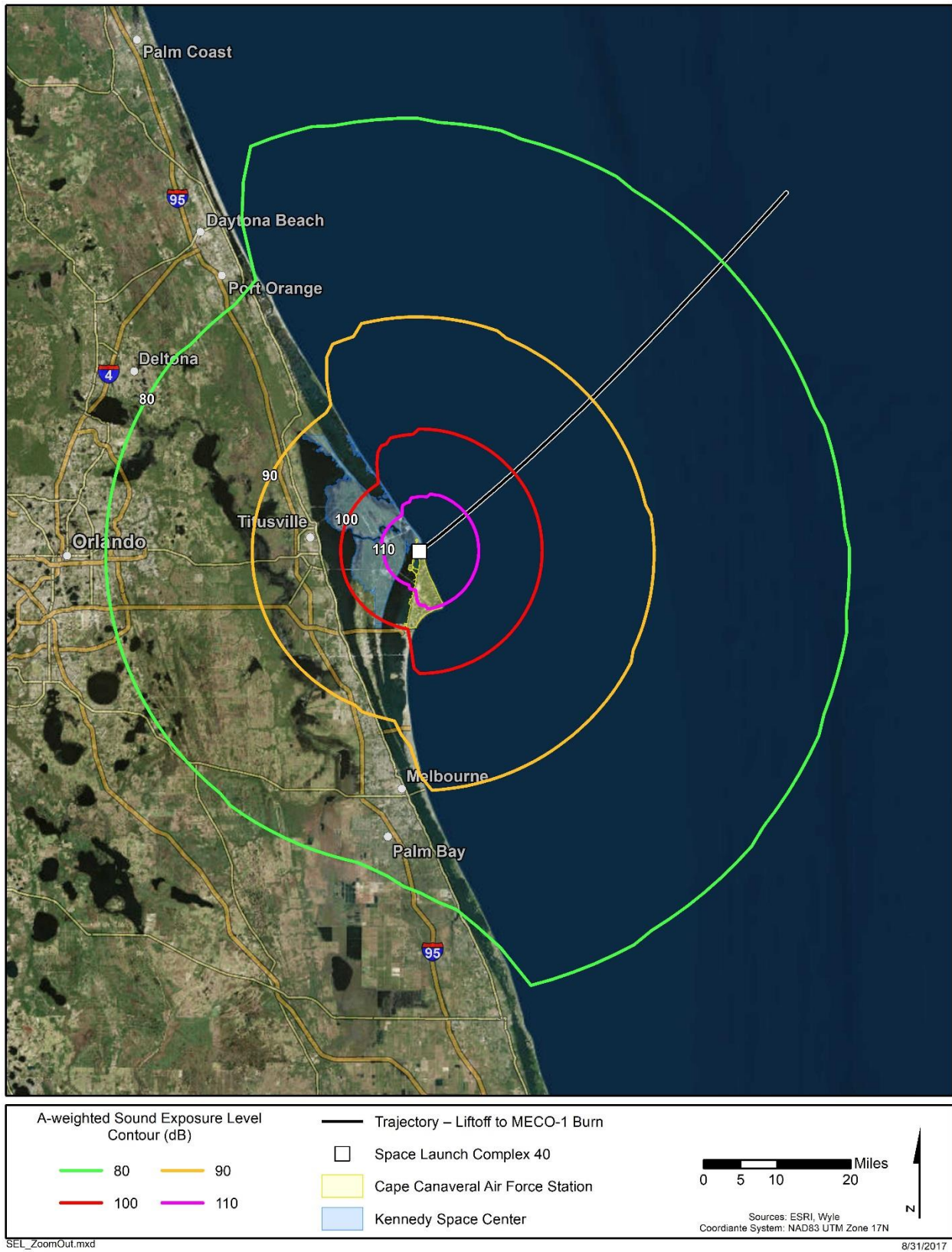


Figure 6. Sound Exposure Levels for Falcon 9 Block 5 Launch from SLC-40

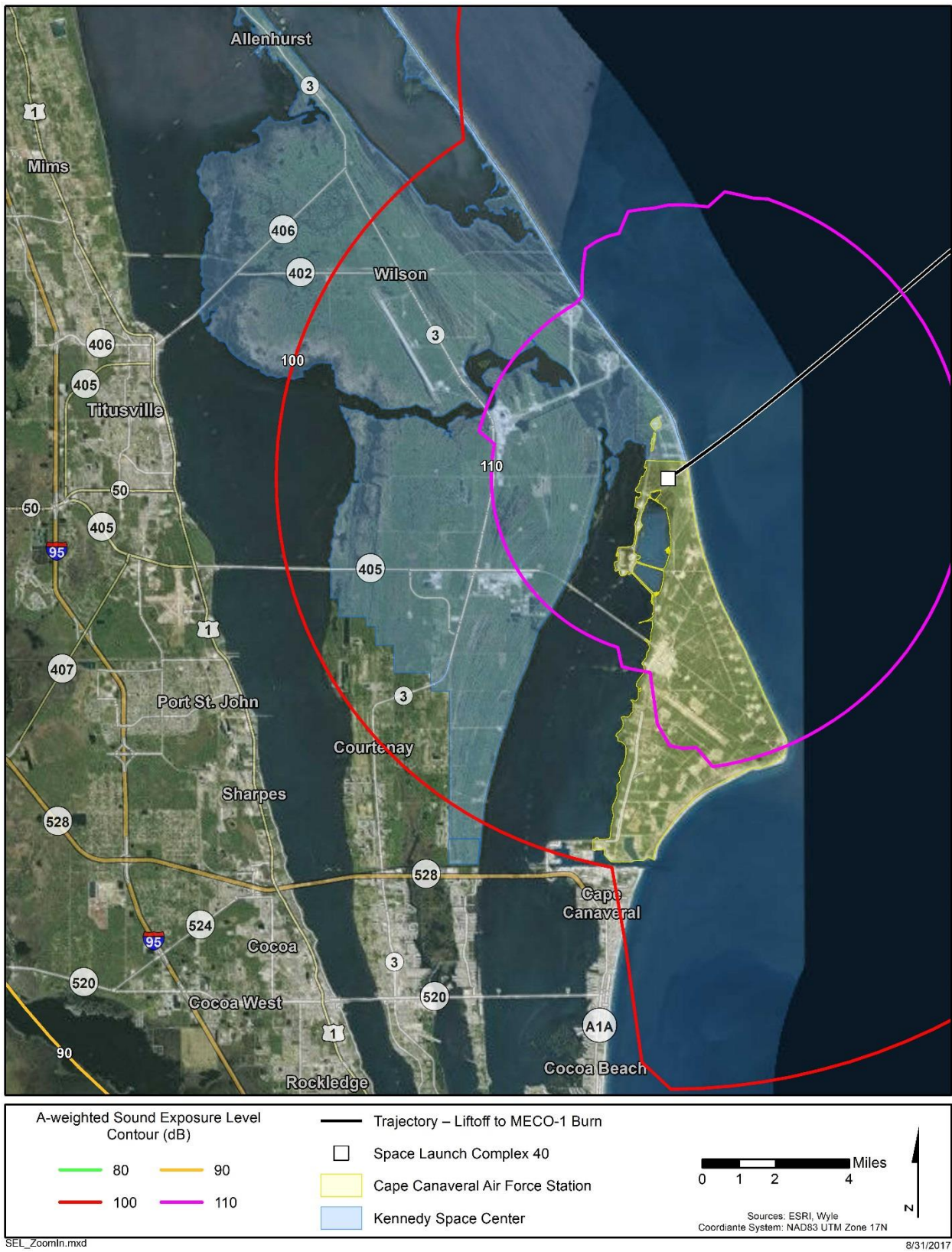


Figure 7. Sound Exposure Levels for Falcon 9 Block 5 Launch from SLC-40 (Zoomed In)

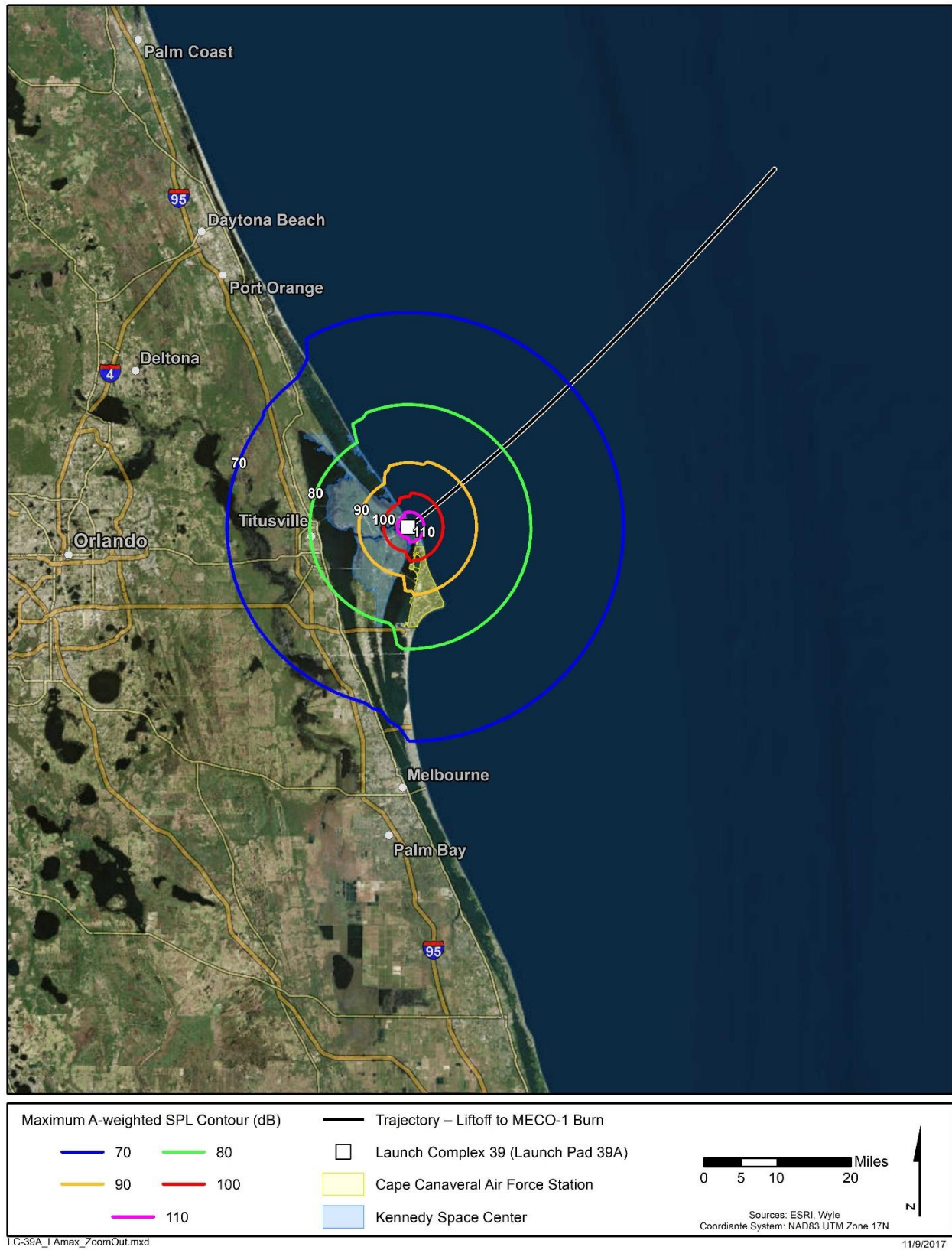


Figure 8. Maximum A-Weighted Sound Levels for Falcon 9 Block 5 Launch from LC-39A

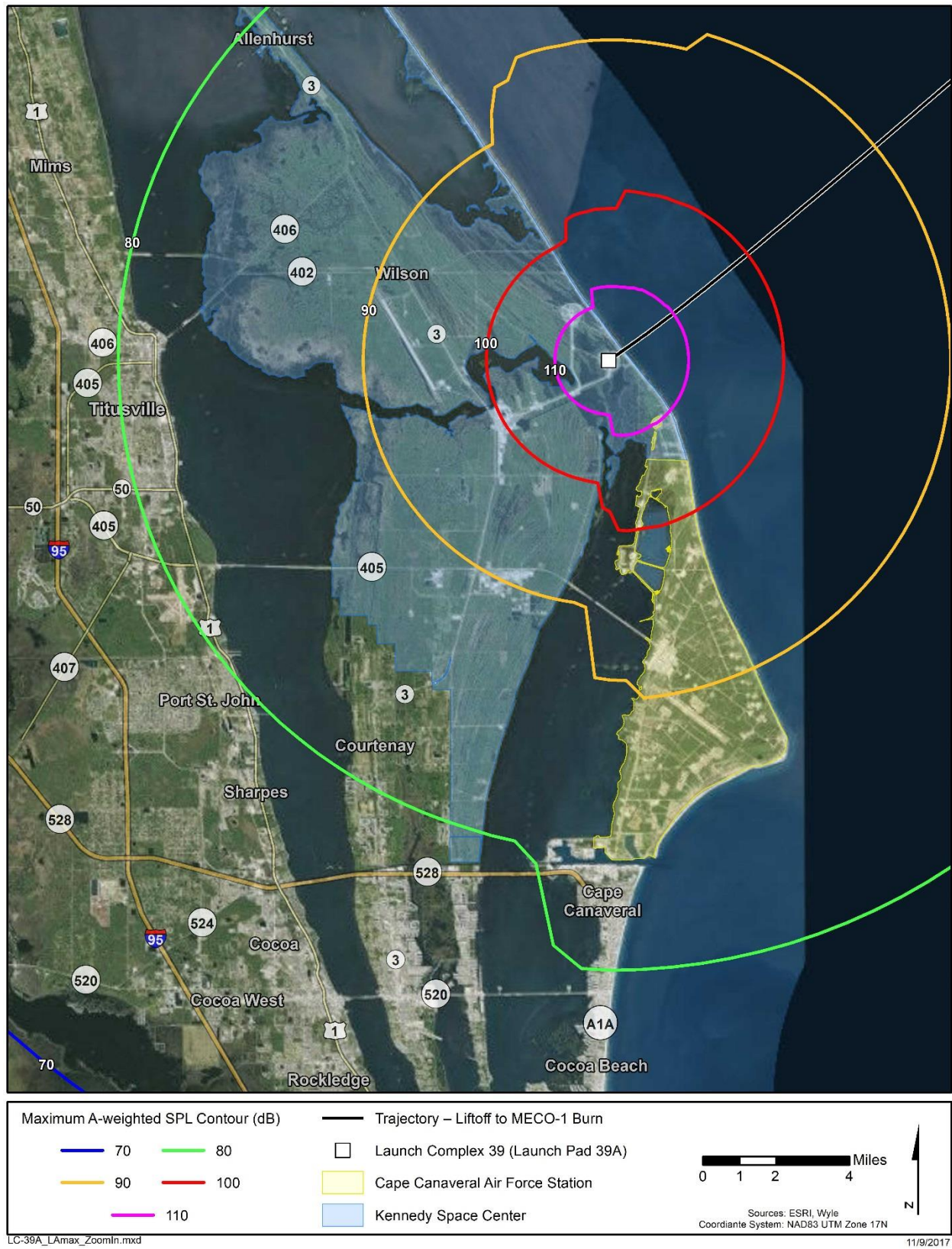


Figure 9. Maximum A-Weighted Sound Levels for Falcon 9 Block 5 Launch from LC-39A (Zoomed in)

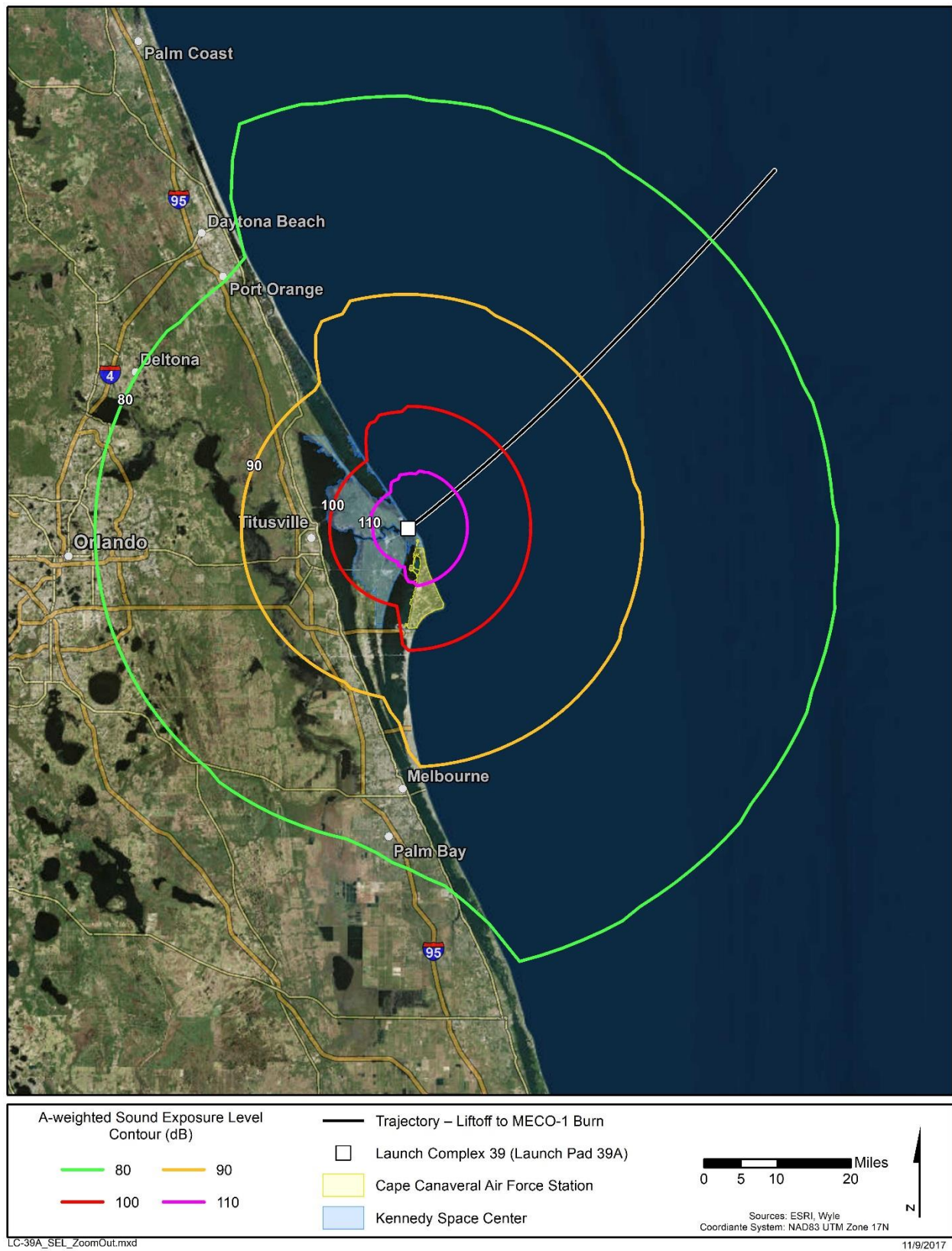


Figure 10. Sound Exposure Levels for Falcon 9 Block 5 Launch from LC-39A

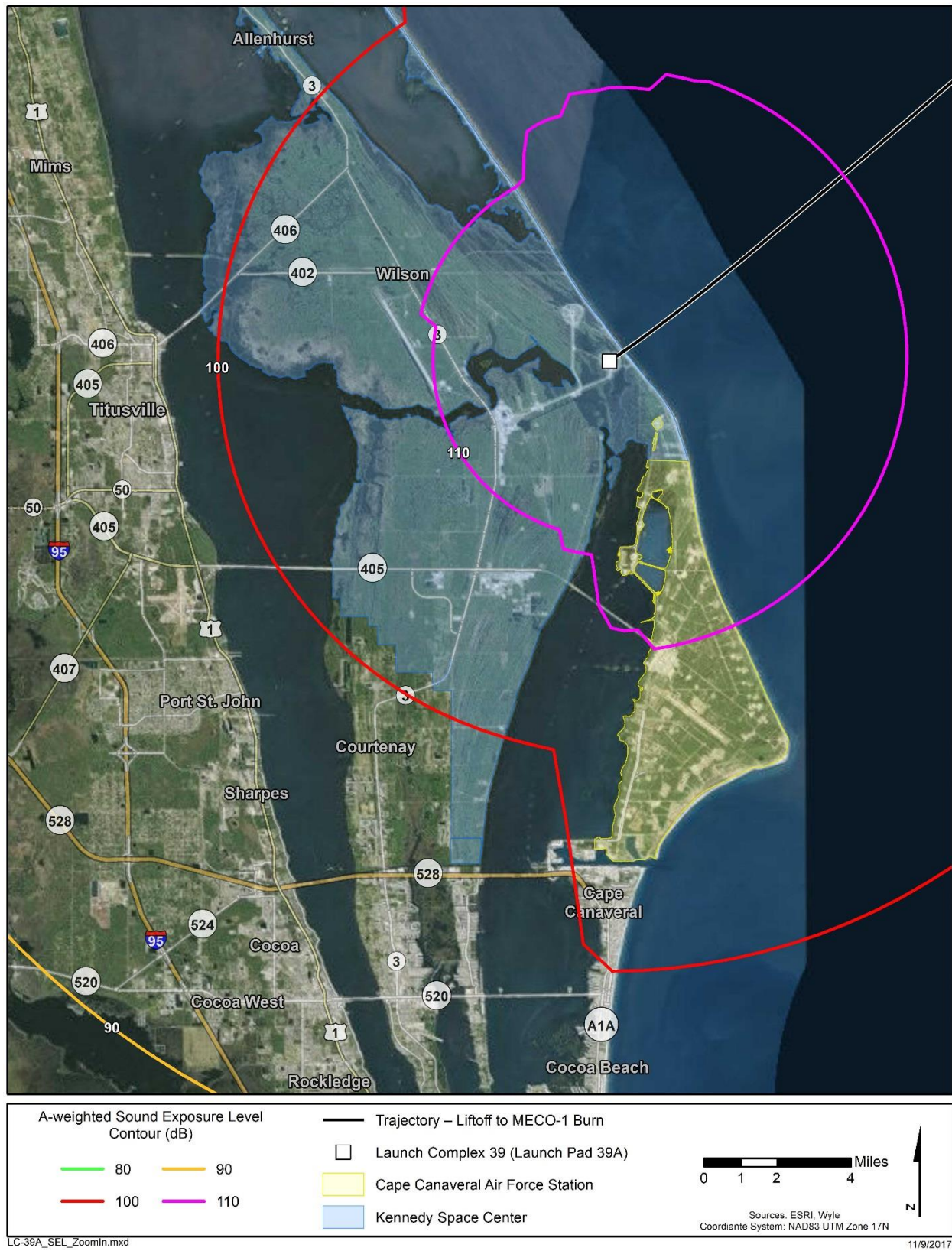


Figure 11. Sound Exposure Levels for Falcon 9 Block 5 Launch from LC-39A (Zoomed In)

4 Falcon Heavy Block 5 Single Event Launch Noise Levels at LC-39A

RNOISE was used to estimate the L_{Amax} and SEL contours for Falcon Heavy Block 5 Launches at LC-39A using trajectory data, from liftoff to MECO, provided by SpaceX in file 'FH_REPRESENTATIVE_ASCENT_80_12.asc'. The L_{Amax} contours indicate the maximum sound level at each location over the duration of the launch, from liftoff to MECO, where engine thrust varies according to the ascent thrust profile provided with the trajectory data.

RNOISE computations were done using a radial grid consisting of 128 azimuths and 100 intervals out to 300,000 feet from the launch point. Ground areas were considered to be acoustically soft, and water acoustically hard. Ground effect was based on a weighted average over the propagation path. As will be shown in the resulting noise contour maps (Figures 12 through 15), the shape of the innermost contours is approximately circular. The shape of the outermost contours is due to rocket noise directivity and the difference between acoustically hard water and acoustically soft ground. The launch pad location at LC-39A is indicated in the map legends as are the Cape Canaveral Air Force Station and Kennedy Space Center (KSC) properties.

The L_{Amax} 70 dB through 110 dB contours shown in Figures 12 and 13 represent the maximum levels estimated for the Falcon Heavy Block 5 launch at LC-39A; Figure 13 shows these contours using a zoomed in map scale to better show the extent of the noise exposure relative to cities located around LC-39A. The higher L_{Amax} contours (90, 100, and 110 dB) are located entirely within both the CCAFS and KSC properties. If a Falcon Heavy Block 5 launch occurs during the day, when background levels are in the 50 dB to 60 dB range, residents of Titusville, Merritt Island, and Cape Canaveral may notice launch noise levels above 70 dB. If the same launch occurs during the night, when background levels are lower than during the day (e.g., below 40 dB to 50 dB range), these residents may notice launch noise levels that exceed 60 dB. A prevailing on-shore or off-shore breeze may also strongly influence noise levels in these communities.

SEL contour levels of 90, 100, and 110 dB are shown in Figures 14 and 15 for the Falcon Heavy Block 5 launch at LC-39A with Figure 15 showing a zoomed in map scale. SEL is an integrated metric and is expected to be greater than the L_{Amax} for rocket launches. Figure 14 indicates that the 110 dB SEL contour is expected to remain within the CCAFS and KSC properties whereas Merritt Island and parts of Titusville are expected to be exposed to SELs higher than 100 dB.

The L_{Amax} and SEL contours estimated for Falcon Heavy Block 5 Launches at LC-39A are shown in Figures 12 through 15 in the same sequence as Figures 8 through 11 presented for Falcon 9 Block 5 launches at LC-39A. In general, the estimated noise exposure from Falcon Heavy Block 5 launches at LC-39A is 4 to 5 dB higher than the estimated noise exposure for Falcon 9 Block 5 launches at LC-39A. This difference reflects the higher power of the Falcon Heavy Block 5 which has three times the number of Merlin 1D engines as does the Falcon 9 Block 5. Two different trajectory data sets provided by SpaceX account for the differences in the Falcon Heavy Block 5 and Falcon 9 Block 5 noise contours which do not have the exact same delta (i.e. change in noise level) at all locations. The noise contours at LC-39A for the Falcon Heavy Block 5 and Falcon 9 Block 5 can be compared to see how the levels change at specific locations.

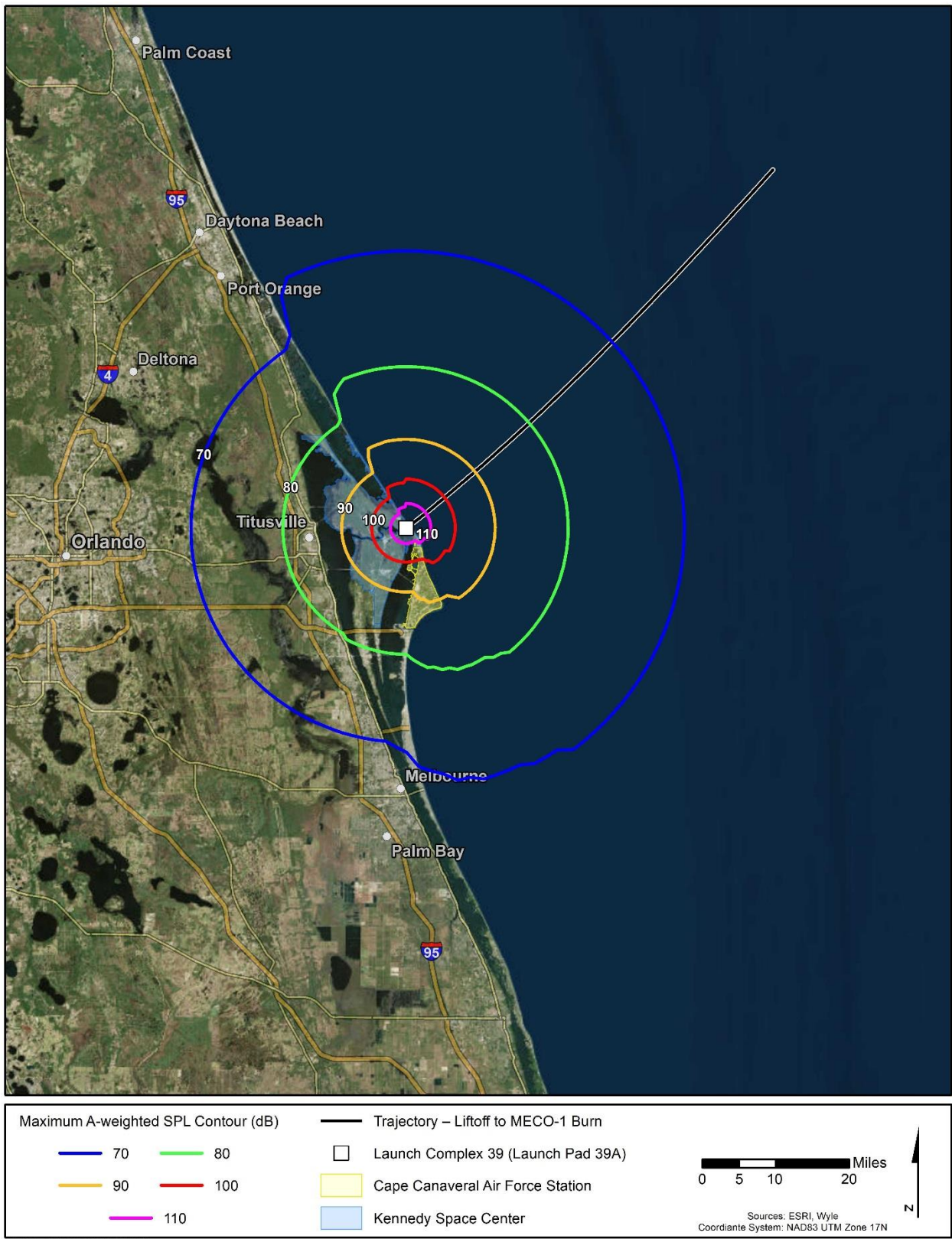


Figure 12. Maximum A-Weighted Sound Levels for Falcon Heavy Block 5 Launch from LC-39A

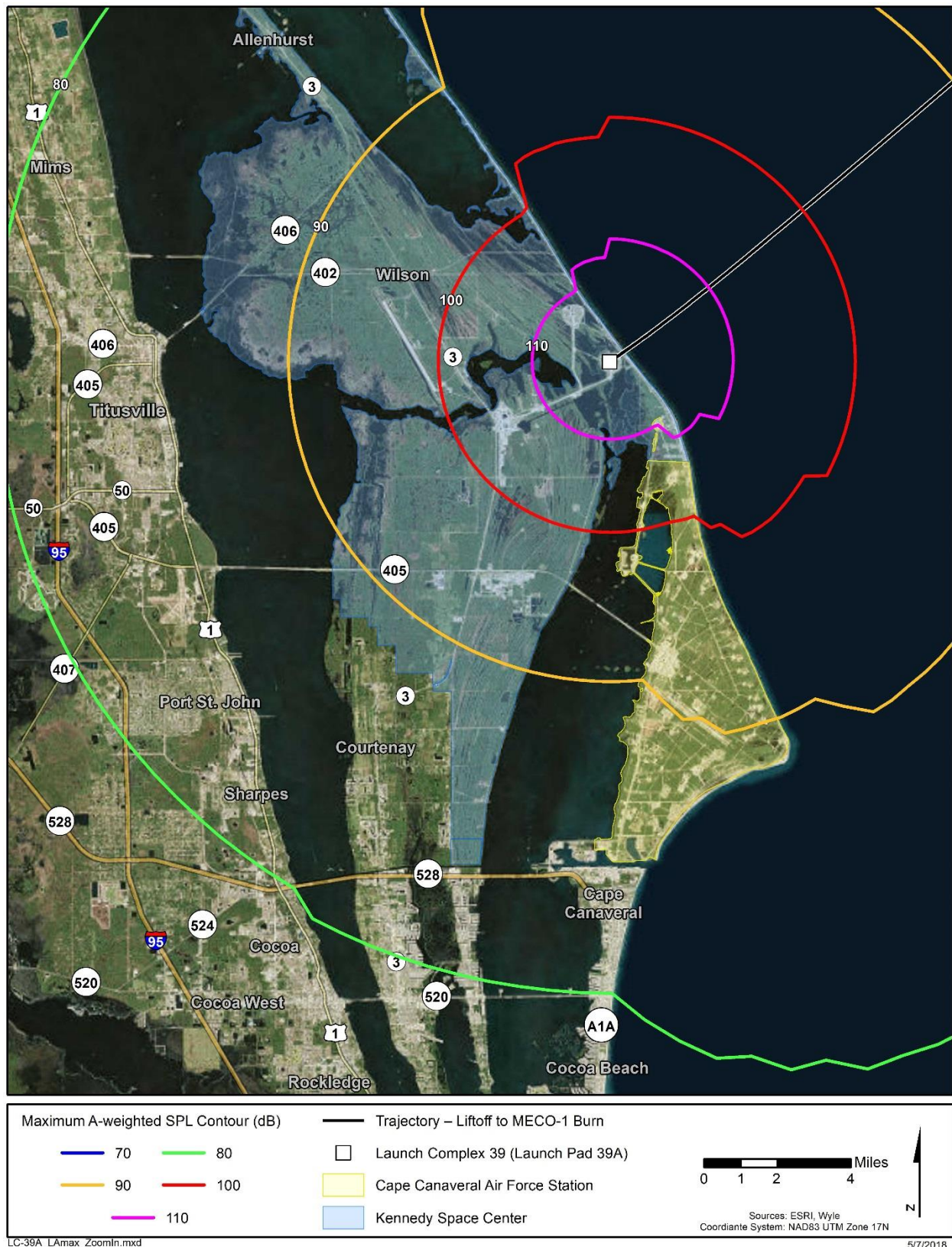


Figure 13. Maximum A-Weighted Sound Levels for Falcon Heavy Block 5 Launch from LC-39A (Zoomed in)

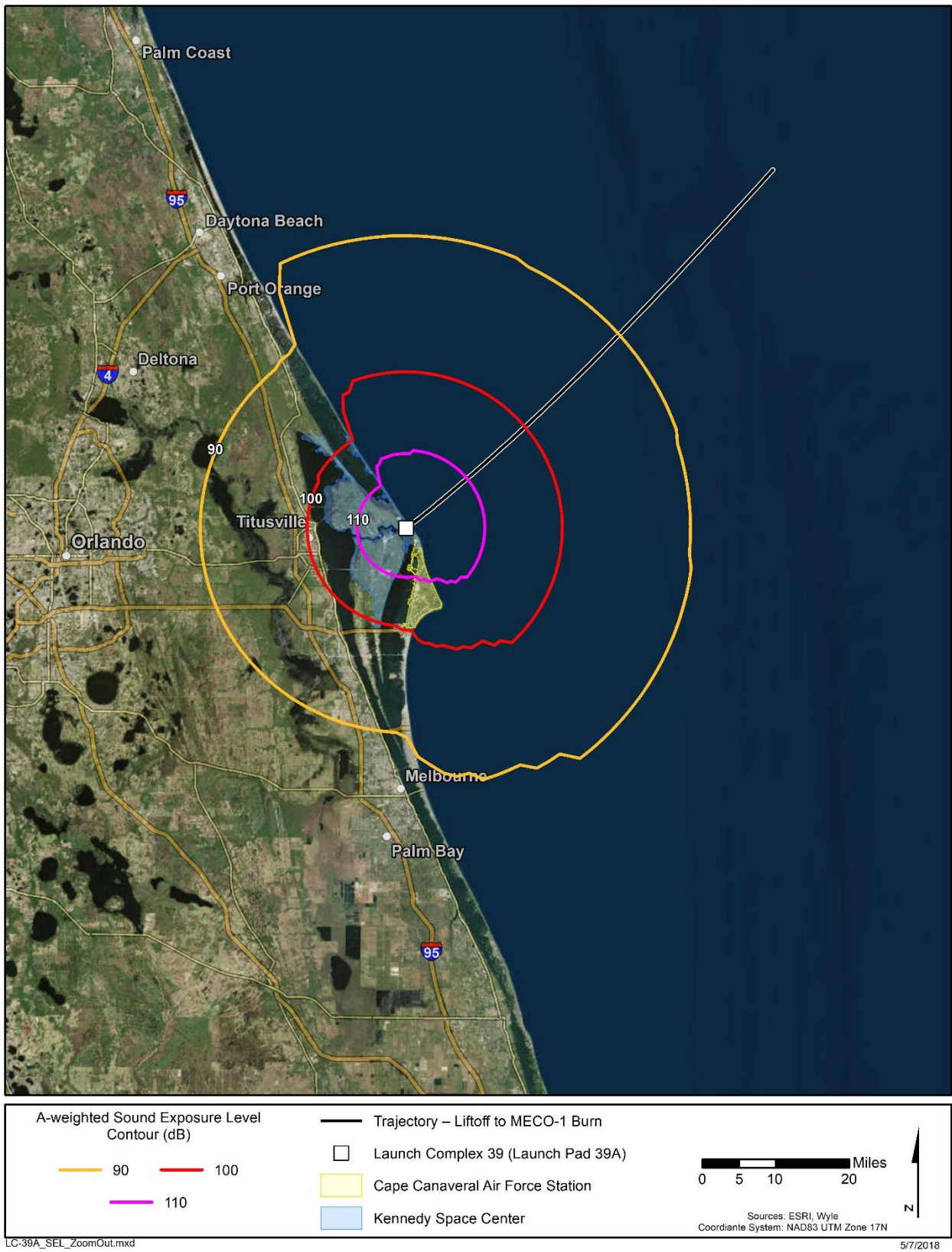


Figure 14. Sound Exposure Levels for Falcon Heavy Block 5 Launch from LC-39A

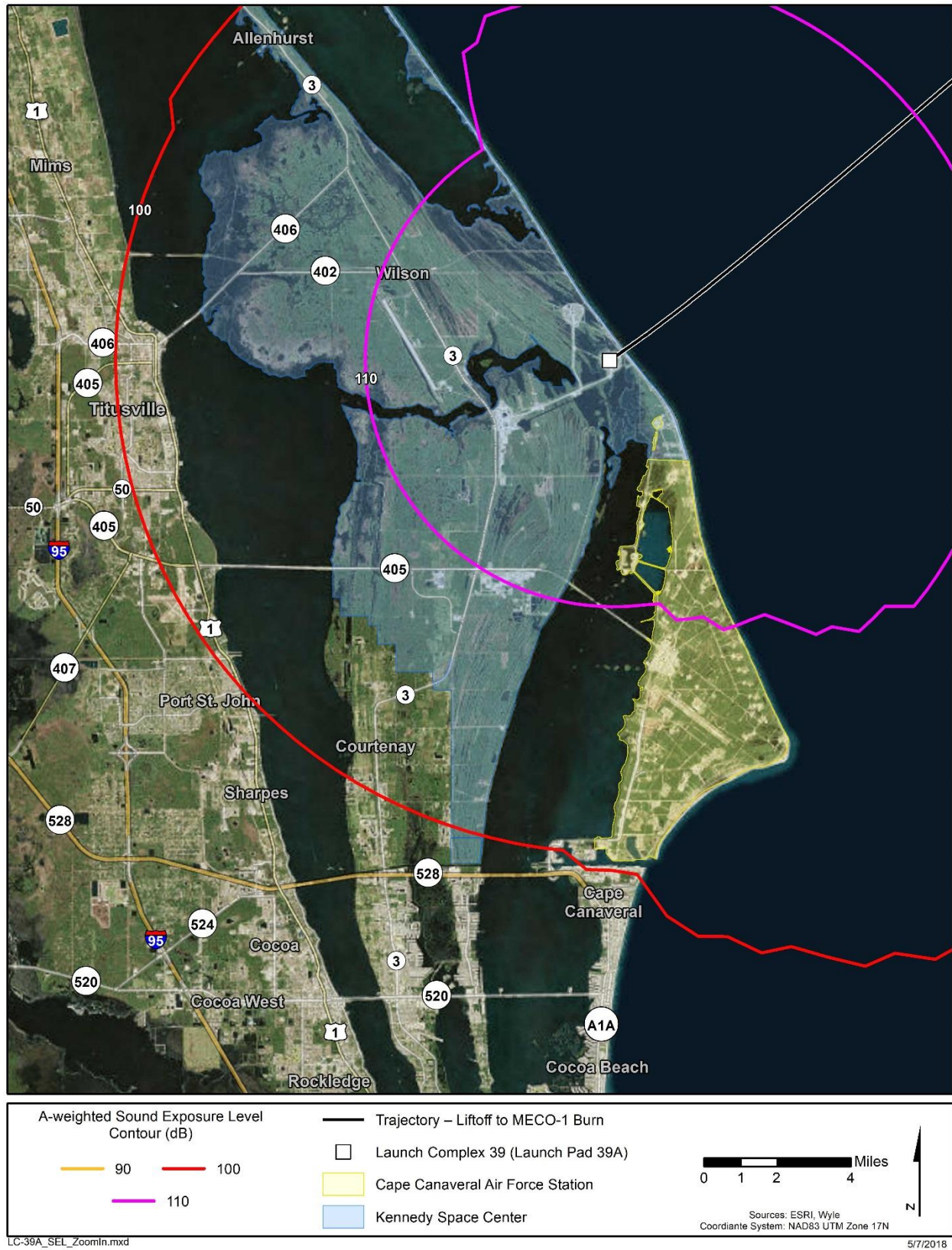


Figure 15. Sound Exposure Levels for Falcon Heavy Block 5 Launch from LC-39A (Zoomed In)

5 Day-Night Average Sound Level Estimates for Launch Operations at CCAFS and KSC

As noted in section 2, FAA Order 1050.1E specifies Day-Night Average Sound Level (DNL) as the standard metric for community noise impact analysis. DNL is appropriate for continuous noise sources, such as airport noise and road traffic noise. It is not appropriate for irregularly occurring noise events such as rocket launches or static tests, however these noise events may be evaluated using DNL for policy decisions.

This section presents an estimate of the DNL for 2017 launch operations and other typical noise events occurring at CCAFS and KSC and describes how projected future launch operations of the Falcon 9 Block 5 and Falcon Heavy Block 5 are expected to influence the DNL. To accurately describe the DNL at CCAFS and KSC, a detailed study would be required involving either the modeling of all major noise sources or conducting noise monitoring throughout these areas for a period of time that adequately represents the different types of launch vehicles and frequency of launches conducted. The estimates of DNL presented here are basic and serve to identify whether launch operations at CCAFS and KSC are expected to have a significant noise impact per the guidelines in FAA Order 1050.1E.

FAA Order 1050.1E specifies that a significant noise impact would occur if analysis shows that the proposed action will cause noise sensitive areas to experience an increase in noise of DNL 1.5 dB or more at or above DNL 65 dB noise exposure when compared to the no action alternative for the same timeframe.

Before estimating DNL for the CCAFS and KSC properties and surrounding cities it is important to note that these areas have a variety of land uses. CCAFS and KSC have areas that should be considered rural or remote, except where NASA or other launch facilities are located. KSC has a wildlife refuge. Populated areas of Merritt Island could be considered rural or quiet suburban residential areas whereas Titusville and the city of Cape Canaveral are more urban areas with mixed residential and industrial uses. It is therefore important to consider the land use category and associated background noise levels when determining if launch operations will have a significant noise impact.

The DNL estimates presented here are for the baseline year (2017) and for future years out to 2024 in which SpaceX proposes an increase in their Falcon 9 Block 5 and Falcon Heavy Block 5 launch operations. To estimate DNL for 2017, background noise levels were estimated as was the DNL from all 2017 launch operations at CCAFS and KSC. Background DNL was estimated using ANSI/ASA S12.9-2013/Part3⁹ which provides estimated background noise levels for different land use categories and population density. Table 1 shows the DNL estimated for rural or remote areas and several different categories of suburban and urban residential land use which can be used to represent DNL for the various land uses within CCAFS, KSC, and surrounding areas. According to these estimates, many of the remote areas within the CCAFS and KSC properties would be expected to have a DNL less than 49 dBA while parts of Titusville and the city of Cape Canaveral would be expected to have a DNL as high as 59 dBA. The DNL values in Table 1 provide an estimate of the background levels expected in typical noise environments and do not include noise from launch operations.

Table 1. Estimated Background Noise Levels

Example Land Use Category	Average Residential Intensity (people per acre)	DNL (dBA)	Leq (dBA)	
			Daytime	Nighttime
Rural or remote areas	<2	<49	<48	<42
Quiet suburban residential	2	49	48	42
	4	52	53	47
	4.5	52	53	47
Quiet urban residential	9	55	56	50
Quiet commercial, industrial, and normal urban residential	16	58	58	52
	20	59	60	54

ANSI/ASA S12.9-2013/Part3

To estimate the 2017 DNL for CCAFS, KSC, and the surrounding areas, the noise from all 2017 launches at CCAFS and KSC should be added to the background noise estimated for these areas. Table 2 shows all of the 2017 launches at CCAFS and KSC. There were nineteen total launches including thirteen Falcon 9 Full Thrust launches, twelve of these occurred at KSC LC-39A and one occurred at CCAFS SLC-40. The remaining six launches by the Atlas V (401 or 421), Delta IV M+(5,4), and Minotaur/Orion occurred at the three other CCAFS launch sites listed in Table 2. Of the nineteen launches in 2017, three (about 16%) were nighttime launches. The total first stage sea level (SL) thrust is provided for each vehicle in the table.

Table 2. Launches at CCAFS and KSC in 2017

Launch Vehicle	Launch Site	Thrust (1st stage) lbf (SL)	2017 Launches		
			Day	Night	Total
Falcon 9 Full Thrust	KSC LC-39A	1,710,000	11	1	12
Falcon 9 Full Thrust	CCAFS SLC-40	1,710,000	1	0	1
Atlas V 401 (3) or 421 (1)	CCAFS SLC-41	860,000	3	1	4
Delta IV M+(5,4)	CCAFS SLC-37B	705,000	1	0	1
Minotaur/Orion	CCAFS SLC-46	210,000	0	1	1

The DNL for all launches in Table 2 were estimated conservatively by making a few simplifying assumptions to the actual launch data. First, all of the launches were located at LC-39A (where the majority of launches occurred by the highest thrust vehicle, Falcon 9 Full Thrust). This is a conservative approximation which serves to concentrate the noise, rather than disperse it at the other launch sites. Second, noise received in the vicinity of the launch site is mostly due to the noise emissions of the first stage and can be scaled according to the total thrust of the first stage. Although there are several different types of vehicles in Table 2, with different first stage thrust levels, for the purposes of this estimate the equivalent number of Falcon 9 Full Thrust launches were determined. The scaling of operations is done using first stage thrust levels and accounting for nighttime launches which, because of the nighttime penalty inherent in DNL, are each equivalent to ten daytime launches. In this analysis, all nighttime launches were converted to

daytime launches for simplicity. Additionally, note that the first stage thrust of the Falcon 9 Full Thrust is the same as that of the Falcon 9 Block 5. And because Figures 10 and 11 show the SEL contours for the Falcon 9 Block 5 launch at LC-39A, these SEL contours were used as a basis for explaining the 2017 DNL results as described following.

By using the above simplifying assumptions and scaling methods, all of the 2017 launches listed in Table 2 are equivalent to approximately 30 annual Falcon 9 Full Thrust (or Falcon 9 Block 5) daytime launches at LC-39A, which equates to 0.082 daytime launches per average day. Given this low number of launches, it is not expected that the DNL estimated for the 2017 launches will be much higher than the DNL estimated for the background noise environments described in Table 1. Using the following relationship, the equivalent DNL can be determined from the SEL for any launch event and the scaling assumptions made for the number of daytime (N_d) and nighttime (N_n) launches.

$$\text{DNL} = \text{SEL} + 10 \cdot \log_{10}(N_d + 10 \cdot N_n) - 49.4 \quad (1)$$

This calculation was performed for all 2017 launches at CCAFS and KSC which is estimated to be equivalent to 30 annual daytime launches of the Falcon 9 Full Thrust or Falcon 9 Block 5 at LC-39A. Using Equation 1 with $\text{SEL} = 100$ dBA, $N_d = 30/365$, and $N_n = 0$, the equivalent DNL is 40 dBA. This means the SEL 100 dBA contour shown in Figures 10 and 11 can be used to represent the DNL for all 2017 launch operations and is equivalent to a DNL of 40 dBA and the SEL 110 dBA contour is equivalent to a DNL of 50 dBA.

In summary, all launches in 2017 (Table 2) are estimated to generate Day-Night Average Sound Levels such that the 40 DNL contour is co-located with the SEL 100 dBA contour shown in Figures 10 and 11. The estimated DNL exposure, from all 2017 launches at CCAFS and KSC, is in most areas less than any of the estimated background DNL values in Table 1. The 2017 launches at CCAFS and KSC are not expected to cause significant noise impact according to the guidelines for assessing DNL in FAA Order 1050.1E.

The same type of estimate can be made for SpaceX's projected future launch operations of the Falcon 9 Block 5 and Falcon Heavy Block 5 which are shown in Table 3.

Table 3. Falcon 9 Block 5 and Falcon Heavy Block 5 Launch Frequency

Year	Launch Complex 39A KSC		Launch Complex 40 CCAFS	Total Launches
	Falcon Heavy	Falcon 9	Falcon 9	
2018	3	4	17	24
2019	3	5	16	24
2020	10	10	44	64
2021	10	10	44	64
2022	10	10	50	70
2023	10	10	50	70
2024	10	10	50	70

The Falcon 9 Block 5 and Falcon Heavy Block 5 launches are expected to replace launches by the Falcon 9 Full Thrust vehicle starting in 2018. To estimate the cumulative noise levels for each future year launch scenario, DNL was estimated for the SpaceX launches projected for each year and the non-SpaceX launches that occurred in 2017. All of these launches were scaled to provide the equivalent number of daytime Falcon 9 Block 5 launches at LC-39A, as was done previously for the 2017 DNL estimate, which permits using the SEL contours in Figures 10 and 11 as a basis for estimating DNL exposure at CCAFS, KSC, and the surrounding areas. First stage total thrust for the Falcon 9 Block 5 is 1,710,000 lbf (SL). First stage total thrust for the Falcon Heavy Block 5 is 5,130,000 lbf (SL).

Three DNL estimates were made which reflects 24, 64, or 70 total launches depending on the year. Following the methodology above using Equation 1 and Figures 10 and 11, the SEL 100 dBA contour in these figures is equivalent to DNL=44.0 dBA for 24 launches in 2018 and 2019, DNL=48.1 dBA for 64 launches in 2020 and 2021, and DNL=48.4 dBA for 70 launches in 2022 through 2024. As with the DNL estimate for 2017 launches, in most areas none of these DNL estimates for 2018-2024 launches significantly exceeds the estimated background DNL values in Table 1. The SEL 110 dBA contour in Figures 10 and 11 represents either DNL=54.0 dBA (24 launches), DNL=58.1 dBA (64 launches), or DNL=58.4 dBA (70 launches) but this contour lies entirely within the CCAFS and KSC properties. In summary, the planned SpaceX launches of the Falcon 9 Block 5 and Falcon Heavy Block 5, projected to occur from 2018 through 2024, are not expected to cause significant noise impact according to the guidelines for assessing DNL in FAA Order 1050.1E.

The above DNL estimates are based on a number of simplifying assumptions to make this analysis practical. Equation 1 is best applied to a continuous noise environment, such as a busy airport. Note that ANSI S12.9-2005/Part4¹⁰ describes adjustments to sounds that have special characteristics so that the long-term community response to such sounds can be predicted by a method. But, this standard does not provide a method to predict the response of a community to short-term, infrequent, non-repetitive sources of sound, such as rocket launches. The method using Equation 1 may be improved if proper adjustments to SEL can be determined. Or, as mentioned previously, improved estimates of DNL in the CCAFS, KSC, and surrounding areas would require a detailed study involving either the modeling of all major noise sources or conducting noise monitoring throughout these areas for a period of time that adequately represents the different types of launch vehicles and frequency of launches conducted.

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