National Aeronautics and Space Administration
Low Density Supersonic Decelerator
Technology Demonstration Mission
Pacific Missile Range Facility

Supplemental Environmental Assessment

Final

April 2015

Space Technology Mission Directorate
National Aeronautics and Space Administration
Washington, DC 20546

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National Aeronautics and Space Administration
Headquarters
Washington, DC 20546-0001

Reply to Attn of: Space Technology Mission Directorate

National Environmental Policy Act;
Low Density Supersonic Decelerator Technology Demonstration Mission

AGENCY: National Aeronautics and Space Administration (NASA), Space Technology Mission Directorate

ACTION: Finding of No Significant Impact

SUMMARY: Pursuant to the National Environmental Policy Act of 1969 (NEPA), as amended (42 U.S.C. 4321 et seq.), the Council on Environmental Quality (CEQ) Regulations for Implementing the Procedural Provisions of NEPA (40 CFR Parts 1500-1508), and NASA policy and regulations (14 CFR Part 1216 Subpart 1216.3), NASA has made a Finding of No Significant Impact (FONSI) with respect to the proposed additional splashdown area which is needed in support of the Low Density Supersonic Decelerator (LDSD) Technology Demonstration Mission (TDM). Based on information gleaned from the first test conducted at the U.S. Navy Pacific Missile Range Facility (PMRF), Hawaii, NASA prepared a Supplemental Environmental Assessment (SEA) to evaluate the potential environmental consequences (environmental impacts) of changes planned for future tests campaigns to be conducted at PMRF. The SEA analyzes potential environmental consequences from three alternatives.

DATE: April 2015

AVAILABILITY: The SEA and FONSI prepared for the LDSD TDM mission are available at:

- Hawaii State Library
  Hawaii and Pacific Section Document Unit
  478 South King Street
  Honolulu, Oahu, HI 96813-2994
- Lihue Public Library
  4344 Hardy Street
  Lihue, Kauai, HI 96766
- Waimea Public Library
  9750 Kaumualii Highway
  Waimea, Kauai, HI 96796

Electronic copies of the SEA and FONSI are available at:

- http://sites.wff.nasa.gov/code250/NASA_LDSD_FSEA.html
- http://www.nasa.gov/mission_pages/tdm/ldsd/

COOPERATING AGENCIES:

The National Oceanic and Atmospheric Administration (NOAA) and the U.S. Fish and Wildlife Service (USFWS) served as Cooperating Agencies in preparing this SEA as each have regulatory authority regarding the Proposed Action.

FOR FURTHER INFORMATION CONTACT:

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SUPPLEMENTAL INFORMATION:

NASA has determined that the document entitled *National Aeronautics and Space Administration Low Density Supersonic Decelerator Technology Demonstration Mission Pacific Missile Range Facility Supplemental Environmental Assessment* (hereinafter the "LDSD SEA") adequately and accurately analyzes the potential environmental effects of the Proposed Action. The LDSD SEA and its underlying documents are hereby incorporated by reference in this FONSI.

BACKGROUND:

In May 2013, NASA completed the *Low Density Supersonic Decelerator Technology Demonstration Mission (TDM) Pacific Missile Range Facility (PMRF) Final Environmental Assessment* (LDSD Final EA) and issued its FONSI on 10 May 2013. The National Aeronautics and Space Act of 1958, as amended (42 U.S.C. 2451(d)(1)(5)) establishes a mandate to conduct activities in space that contribute substantially to "[t]he expansion of human knowledge of the Earth and of phenomena in the atmosphere and space," and "[t]he preservation of the role of the United States as a leader in aeronautical and space science and technology and in the application thereof to the conduct of peaceful activities within and outside the atmosphere." In response to this mandate, NASA, in coordination with the National Academy of Sciences (NAS), has developed a prioritized set of science objectives to be met through a long-range program of spacecraft missions. As part of the U.S. Space and Earth exploration effort, these missions are designed to be conducted in a specific sequence based on technological readiness, launch opportunities, timely data return, and a balanced representation of scientific disciplines. Section 1.1 of the 2013 LDSD Final EA provides a detailed background for NASA's LDSD mission directive, and Chapter 4 of the 2013 LDSD Final EA analyzes the environmental consequences to PMRF, Niihau, and the Open Ocean Area. The 2013 LDSD Final EA can be found at: http://www.sites.wff.nasa.gov/Code250/LDSD_Final_EA_May2013.pdf.

Subsequent to issuing the FONSI for the LDSD Final EA on 10 May 2013, NASA continued its mission planning and ultimately conducted the first LDSD flight in June 2014. Lessons learned from this initial LDSD flight indicated that changes to the Proposed Action as described in the 2013 LDSD Final EA could be warranted. Under NEPA, Federal agencies have a continuing duty to evaluate the environmental consequences of their actions. Under certain circumstances, agencies must supplement their existing environmental analyses should they

propose changes to those actions that could have a bearing on environmental consequences. Accordingly, NASA has prepared a Supplemental EA to the 2013 LDSD Final EA to evaluate the environmental consequences of operational changes it proposes for the future LDSD test flights scheduled to begin in the summer of 2015.

As discussed below, the SEA provides (1) a summary of the June 2014 LDSD test flight; (2) the lessons learned which prompted NASA to consider modifying its Proposed Action; and (3) the Federal authorization needed to undertake the proposed changes.

Lessons Learned from 2014 LDSD Supersonic Flight Dynamics Test (SFDT):

A significant accomplishment of the LDSD project's 2014 campaign was demonstrating the ability to accurately predict the balloon's climb out trajectory and to recover the balloon carcass and Test Vehicle. The hard lesson learned was that there is the possibility of going weeks without acceptable conditions for launch. Another lesson learned is that the northern trajectories represent significant risk of early termination unless mitigated.

Based on the results of the 28 June 2014 test flight, the LDSD project investigated the possibility of dropping and recovering expended flight hardware, with the exception of the balloon flight train, in the eastern part of Papahānaumokuākea Marine National Monument (PMNM) during future demonstration missions. This flight option would be conducted within the boundary of PMNM, but outside of the 5.6-km (3-nm) Special Management Area surrounding Nihoa Island. Section 1.1.3 of the LDSD SEA summarizes the request for authorization to splashdown within PMNM.

DESCRIPTION OF THE PROPOSED ACTION:

NO-ACTION ALTERNATIVE: Under the No-action Alternative, NASA would conduct the Proposed Action as detailed in the 2013 LDSD Final EA with the clarification that some recovery aids discussed in the EA may or may not be employed. This proposed test campaign would consist of launch, operation, and recovery of up to four missions from a designated location on PMRF. The SFDT campaign would consist of up to four flights from approximately June to July 2014 and June to August 2015. One flight was conducted in 2014, and up to three flights could be conducted in 2015. Under the No-action Alternative, Sections 2.2.2.1 (Operational Facilities) and 2.4.2 (Launch Operation) of the SEA would apply.

ALTERNATIVE 1—PROPOSED ACTION (PREFERRED ALTERNATIVE): The Proposed Action (Alternative 1–Preferred Alternative) incorporates all activities described in the No-action Alternative and provides for additional splashdown area and test opportunities for the SFDT. This would require approved entry into the easternmost part of the Open Ocean Area of PMNM; therefore, NASA has requested authorization for entry into PMNM through a Conservation and Management permit. This entry would consist of the splashdown and recovery of expended flight hardware, with the exception of the balloon flight train, and potential fly-over of Nihoa Island and its surrounding Special Management Area from scheduled SFDTs beginning in 2015. NASA could have up to two technology testing launches each year for the next 5 years (June through August, 2015 to 2019).

This additional splashdown area excludes the 70 hectares (170 acres) of Nihoa Island and the approximately 128.5 km^2 (37.5 nm^2) Special Management Area within 5.5 km (3 nm) surrounding Nihoa Island. To ensure the excluded area waters and/or island will not be entered, one of two scenarios would occur: (1) the LDSD Program would initiate the SFDT in

such a manner that expended flight hardware would be recovered before drifting into the excluded area; or (2) the flight system would overfly the excluded area, and the Test Vehicle would be dropped outside 5.5 km (3 nm) from Nihoa Island. Therefore, expended flight hardware would not be deposited on Nihoa Island or within the Special Management Area surrounding the island.

ALTERNATIVE 2—ADDITIONAL LAUNCH YEARS: Under Alternative 2, NASA would conduct the No-action Alternative as described in the SEA, which is the Proposed Action as detailed in the 2013 LDSD Final EA with clarification that some recovery aids discussed in the 2013 LDSD Final EA may or may not be employed. Under Alternative 2, NASA would conduct the launch, operation, and recovery of up to two missions per year over the next 5 years (June through August, 2015 to 2019) from a designated location on PMRF using the flight trajectory outlined in the 2013 LDSD Final EA. Under Alternative 2, Sections 2.1.1.1.2.1 (Operational Facilities) and 2.1.1.3 (Launch Operation) of the SEA would apply.

ENVIRONMENTAL EFFECTS:

Fourteen areas of environmental consideration were initially evaluated for the Open Ocean Area and Nihoa Island to provide a context for understanding the potential effects of the Proposed Action and to provide a basis for assessing the severity of potential environmental effects. These areas included air quality, airspace, biological resources, cultural resources, geology and soils, hazardous materials and waste, health and safety, land use, noise, socioeconomics, transportation, utilities, visual aesthetics, and water resources. Ultimately 3 of the 14 areas of environmental consideration were addressed (Air Quality; Biological; and Cultural), and 2 of the 14 areas were addressed for Nihoa Island (Biological and Cultural). The remaining resource areas did not warrant analysis in such a manner.

Air Quality: The ballast of the balloon system provides stability and control of the balloon during ascent. The LDSD balloon system carries approximately 110 kilograms (250 pounds) of ballast consisting of very fine steel shot (grain size 0.3 to 0.5 millimeter [mm] [0.01 to 0.02 inch]), which would be released to adjust the float altitude of the balloon system. Under National Ambient Air Quality Standards as promulgated in the Clean Air Act, the U.S. Environmental Protection Agency (EPA) regulates particulate matter of size 2.5 and 10 microns (1 micron is equal to 0.001 mm), as these sizes can be easily breathed into the lungs of humans or animals. However, as the particle size of the ballast exceeds 10 microns, the ballast material is not regulated by EPA. The released ballast would travel in the upper atmospheric winds and be dispersed over hundreds of kilometers. Therefore, under the Proposed Action, the emissions from SFDT would have no significant adverse effects on existing air quality within PMNM.

Biological Resources: In accordance with Section 7 of the Endangered Species Act, NASA initiated informal consultation with the National Marine Fisheries Service (NMFS) on 9 January 2015 and with USFWS on 6 March 2015. Based on the analysis in both Biological Evaluations, NASA and its Cooperating Agencies determined that the Proposed Action is likely to produce stressors to which listed individuals would respond if exposed. However, the likelihood of such exposure has been determined to be extremely remote. As such, NASA concluded that the proposed action "may affect, not likely to adversely affect," all listed species and designed critical habitat in the action area. In a letter dated 10 March 2015, NMFS concurred with this determination. In a letter dated 6 April 2015, USFWS also concurred with this determination.

In accordance with the Magnuson-Stevens Fishery Conservation and Management Act, NASA initiated Essential Fish Habitat (EFH) consultation with NMFS. On 27 March 2015, NMFS stated in an electronic communication that potential impacts to EFH would not change significantly enough from the 2013 LDSD Final EA determination of no impacts to EFH to warrant additional review.

Previously, on 7 January 2013, NASA in coordination with the Navy (PMRF) determined that the LDSD Test program at PMRF is covered by the Navy Coastal Zone Management Act (CZMA) De Minimis List, which was approved by the Hawaii CZM Program on 9 July 2009. On 10 March 2015, the Navy affirmed the continued applicability of their CZMA De Minimis List for the LDSD Test program.

Cultural Resources: NASA would conduct up to two SFDT test flights per year over the next 5 years (2015–2019). If expended flight hardware should splashdown or drift into PMNM, NASA would recover all floating hardware as quickly as possible, thereby avoiding adverse impacts to cultural resources. As PMNM is considered in Hawaiian traditions as a sacred place from which life springs and to which spirits return, unavoidable cultural impacts may occur, if either of the up to 10 balloon flight trains (up to two per year, over 5 years) should sink to the PMNM sea floor. However, given the unlikely probability of splashdown occurring in PMNM and that the balloon flight train is most likely to sink outside PMNM, the risk of impact is small. All identified cultural properties on Nihoa Island are situated some distance from the planned (nominal) trajectory of the Proposed Action. NASA estimates that the balloon has approximately a 0.4 percent chance of reaching float altitude within PMNM and a 20 percent chance of entering PMNM after reaching float altitude. These probabilities are further reduced when NASA and the U.S. Navy apply the project's established Go/No Go criteria.

Additionally, to further mitigate (reduce) the potential for environmental impact, Nihoa Island and the Special Management Area would be excluded and one of two scenarios would occur: (1) the LDSD Program would initiate the SFDT in such a manner that expended flight hardware would be recovered before drifting into the excluded area; or (2) the flight system would overfly the excluded area, and the Test Vehicle would be dropped outside 5.5 km (3 nm) from Nihoa Island. In letters to the State Historic Preservation Division (SHPD) and the Office of Hawaiian Affairs (OHA), NASA determined that there will be no archaeological/traditional Native Hawaiian sites or historic properties affected by the proposed activities. These letters stated, in accordance with the regulations that implement Section 106 of the National Historic Preservation Act, that if NASA had not received further comment from these offices within 30 days, the LDSD project would assume concurrence with the determination. No responses were received; therefore, NASA assumes that SHPD and OHA concur with this determination.

PUBLIC INVOLVEMENT:

NASA notified the public of the availability of the Draft SEA through a combination of mailed correspondence and published notices in local newspapers. The Draft SEA was also available for public review on the Internet and at local libraries. NASA provided a 30-day public comment period on the Draft SEA. Minor comments were received from NOAA's Office of National Marine Sanctuaries and have been incorporated into the Final LDSD SEA.

CONCLUSION:

On the basis of the LDSD SEA and underlying reference documents, NASA has determined that the environmental impacts associated with this Proposed Action will not individually or cumulatively have a significant impact on the quality of the human environment. Accordingly, the requirements of NEPA and CEQ and NASA implementing regulations are fulfilled, and an environmental impact statement is not required.

Stephen Jurczyk
Associated Administrator
Space Technology Mission Directorate

4/16/15
Date

Executive Summary

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EXECUTIVE SUMMARY

Introduction

The National Aeronautics and Space Administration (NASA) prepared a Final Environmental Assessment (EA) and issued a Finding of No Significant Impact (FONSI) in May 2013 which evaluated and addressed the potential environmental consequences of conducting the proposed launch, operation, and recovery of the Low Density Supersonic Decelerator (LDSD) Technology Demonstration Mission (TDM) test flights at the U.S. Navy's Pacific Missile Range Facility (PMRF) on Kauai, Hawaii. The 2013 LDSD Final EA addressed the first demonstration test which was successfully conducted in June 2014, as well as the campaigns planned in 2015 consisting of three additional demonstration tests. Based on information gleaned from the first test, the purpose of this Supplemental Environmental Assessment (SEA) is to evaluate the potential environmental consequences (environmental impacts) of changes planned for future campaigns. These changes consist of the No-action Alternative, Alternative 1, and Alternative 2:

- No-action Alternative: Under the No-action Alternative, NASA would conduct the Proposed Action as detailed in the 2013 LDSD Final EA and with the clarification that some recovery aids discussed in that EA may or may not be employed. This proposed test campaign would consist of launch, operation, and recovery of up to four missions from a designated location on PMRF. The Supersonic Flight Dynamics Test (SFDT) campaign would consist of up to four flights from approximately June to July 2014 and June to August 2015. One flight was conducted in 2014, and up to three could be conducted in 2015. Under the No-action Alternative, Sections 2.2.2.1 (Operational Facilities) and 2.4.2 (Launch Operation) of this SEA would apply.
- Alternative 1 (Preferred Alternative): Consists of using additional open ocean splashdown area within and outside of Papahānaumokuākea Marine National Monument (PMNM) and additional launch years. For Alternative 1 (Preferred Alternative), these changes consist of (1) permit authorization from the National Oceanic and Atmospheric Administration for flight hardware to potentially fly over, splashdown, and be recovered within the easternmost part of PMNM (except balloon flight train which would rapidly sink in the open ocean); and (2) perform up to two LDSD TDM test flights annually over the next 5 years, starting in June 2015 and ending in August 2019. Issuance of the permit is contingent upon final approval of this SEA and associated FONSI.
- Alternative 2: Consists of adding additional launch years to the 2013 LDSD Final EA with the clarification that some recovery aids discussed in that EA may or may not be employed. For Alternative 2, these changes consist of additional test flights of up to two missions per year over the next 5 years (June through August, 2015 to 2019) from a designated location on PMRF using the flight trajectory outlined in the 2013 LDSD Final EA. For future

testing, the full open ocean recovery of the expended flight hardware, including balloon carcass, Test Vehicle, and supersonic parachute, will take place within a pre-coordinated operational area located west by northwest of PMRF. Under Alternative 2, Sections 2.2.2.1 (Operational Facilities) and 2.4.2 (Launch Operation) of this SEA would apply.

This SEA is in compliance with the following statutes, regulations, and procedures:

- National Environmental Policy Act (NEPA) of 1969, as amended (42 United States Code [U.S.C.] 4321 et seq.)
- Council on Environmental Quality (CEQ) Regulations for Implementing the Procedural Provisions of NEPA (40 Code of Federal Regulations [CFR] Parts 1500-1508)
- NASA NEPA Implementing Regulation (Subpart 1216.3)
- NASA Procedural Requirement 8580.1, NASA National Environmental Policy Act Management Requirements
- Executive Order (EO) 12114, Environmental Effects Abroad of Major Federal Actions
- Presidential Proclamation, 8031 Establishment of the Northwestern Hawaiian Islands Marine National Monument
- 50 CFR Part 404, Northwestern Hawaiian Islands Marine National Monument

Background

In May 2013, NASA completed the *Low Density Supersonic Decelerator Technology Demonstration Mission (TDM) Pacific Missile Range Facility (PMRF) Final Environmental Assessment* (LDSD Final EA) and issued its FONSI on 10 May 2013. Subsequent to issuing the FONSI, NASA continued its mission planning and ultimately conducted the first LDSD flight in June 2014. Lessons learned from this initial LDSD flight indicated that changes to the Proposed Action as described in the 2013 LDSD Final EA could be warranted.

Accordingly, NASA has prepared this SEA as a supplement to the 2013 LDSD Final EA to evaluate the environmental consequences of operational changes it proposes for future LDSD test flights.

The following three sections of the Executive Summary provide (1) a summary of the June 2014 LDSD test flight; (2) a summary of the lessons learned that prompted NASA to consider modifying its Proposed Action; and (3) a summary of the Federal authorization needed to undertake the proposed changes.

1. 2014 LDSD SFDT Flight Summary

The LDSD Project's first Supersonic Flight Dynamics Test (SFDT) on 28 June 2014 from the U.S. Navy's PMRF represented the culmination of years of planning, development, and ingenuity by multiple NASA centers. The focus of this first SFDT was to determine if the devised test architecture and Concept of Operations (ConOps) achieved engineering and technology conditions to push the limits of the decelerators being developed. The SFDT had to be accomplished within established requirements outlined in the LDSD project's EA, NASA's Safety policies defined in the Wallops Flight Facility Range Safety Manual, and the U.S. Navy's Safety policies defined in the Range Safety Operational Plan.

Although the initial 2-week launch window opened on 2 June 2014, the LDSD project experienced daily upper wind conditions that preempted all launch attempts during that window. The LDSD project and the U.S. Navy's Management coordinated a second launch window at the end of June 2014 requiring redeployment of project personnel and support assets. The first day of the second launch window opened on 28 June 2014 and provided a valid opportunity for launch. The predicted balloon trajectory was along a path north of Niihau. This particular balloon trajectory only afforded an approximate 30-minute decision window whether to drop the Test Vehicle based on any inflight anomalies (i.e., unplanned scenarios) that might occur. The LDSD project accepted the risks associated with this northern trajectory and moved forward with a launch attempt. After numerous decision meetings, all Go/No Go criteria were green and the balloon was released from the launch site at PMRF.

The balloon ascent progressed in accordance to plan except for slightly higher upper air wind speeds than predicted and the balloon's ascent being slightly slower than predicted. Each of these slight changes to the timeline narrowed the overall margin in the decision window for Test Vehicle drop before initiation of the SFDT. Had there been any significant delay in the mission (e.g., non-participating vessels in the range, hardware issue, etc.), then the U.S. Navy Range Safety Organization would have issued a mission termination order, resulting in an immediate drop of the balloon and Test Vehicle into the ocean to prevent potential PMNM infringement, resulting in the likely full loss of the vehicle due to impact damage.

2. 2014 Lessons Learned That Prompted This SEA

A significant accomplishment of the LDSD project's 2014 campaign was demonstrating the ability to accurately predict the balloon's climb-out trajectory and to recover the balloon carcass and Test Vehicle. Figure 1-3 of the SEA captures recovery operations of the balloon, and Figure 1-4 shows recovery operations at the Test Vehicle recovery site. The hard lesson learned was that there is the possibility of going weeks without acceptable conditions for launch. Another lesson learned is that the northern trajectories represent significant risk of early termination unless mitigated. Based on the results of the 28 June 2014 test flight, the LDSD project decided to investigate the possibility of potentially dropping and recovering expended flight hardware, with the exception of the balloon flight train, in the eastern part of PMNM during future

demonstration missions, as part of any additional flight option. This would be conducted within the boundary of PMNM as measured from PMRF, but outside of the 5.6-kilometer (km) (3-nautical-mile [nm]) Special Management Area surrounding Nihoa Island. Section 1.1.3 of the SEA summarizes the request for authorization to operate within PMNM.

3. Papahānaumokuākea Marine National Monument Permit and Authorization Request Process

In January 2015, NASA submitted to the permit coordinator an application seeking authorization to include the eastern part of PMNM surrounding Nihoa Island as part of its splashdown area for the SFDTs. NASA requests authorization under Permit Category—Conservation and Management per recommendation of the PMNM Permit Coordinator. The activity for potential entry into the monument would occur on the day of the launches beginning with the 2015 test flights scheduled for 1 June through 31 August 2015. Test flights are anticipated to occur annually during the June–August time frame beginning in 2015 and ending in 2019. A launch window would be based on wind studies conducted at PMRF.

The LDSD project requested authorization to potentially drop and recover expended flight hardware, with the exception of the balloon flight train which would sink to the seafloor, from up to two scheduled SFDTs in 2015 (with the potential for up to two additional flights per year through 31 August 2019) in the Open Ocean Area within the boundary of PMNM, but outside of the 5.6-km (3-nm) boundary surrounding Nihoa Island. This operations area excludes the 70 hectares (170 acres) of Nihoa Island and the Special Management Area within the 5.6 km (3 nm) surrounding Nihoa Island. This permit would also allow NASA to enter PMNM for recovery purposes if the flight hardware is dropped outside PMNM and carried into PMNM by ocean currents.

There are two factors that determine whether entering into PMNM would be required. The presence of these factors cannot be definitively determined until after the balloon has been launched. The first factor is the progress of the balloon's ascent on its predicted trajectory. If the balloon is ascending along its predicted trajectory, then it would most likely reach float altitude well to the east of PMNM. The balloon in some cases is allowed to float westerly, providing it does not overfly Niihau. The Test Vehicle is eventually dropped, initiating the SFDT along a northeasterly trajectory and avoiding PMNM altogether. Once the Test Vehicle has been released, the balloon flight is terminated and the balloon carcass falls to the ocean for recovery.

The second factor in determining PMNM entry is the latitude at which the balloon is moving westerly. Under the planned (nominal) scenario, the upper level winds carry the balloon nearly due west. The possibility of the balloon entering into PMNM decreases as the point where the float altitude is reached.

Under unplanned (i.e., anomalous) scenarios, the winds at a given altitude may or may not be as predictable. If it is predicted that the balloon will not reach its planned

(nominal) float altitude, then a decision would be made whether to continue with an SFDT attempt or terminate the flight depending on altitude reached and the predicted path the balloon is traveling. Depending on the nature and timing of the anomaly (unplanned scenario), the flight system could float westerly long enough for PMNM entry.

In either unplanned scenario (i.e., anomalous), NASA would enter PMNM and recover all floating expended flight hardware as demonstrated in the 2014 SFDT mission. NASA would deploy three recovery vessels to Test Support Positions within the operational area outside PMNM. Immediately upon splashdown of the expended flight hardware, the vessels would be directed to the different floating hardware locations to begin recovery. During the 2014 mission, it took the respective vessels approximately 5 hours to reach and recover the ring-sail parachute, 6.5 hours to reach and recover the balloon carcass, and 4 hours to reach and recover the Test Vehicle. All items designated for recovery were recovered.

Issuance of a PMNM permit is contingent upon final approval of this SEA and its associated signed FONSI. Access into PMNM would not occur prior to issuance of a PMNM permit. NASA anticipates receiving the PMNM Research Permit prior to the opening of the launch window on 1 June 2015. The Permit Application is attached as Appendix C of this SEA. If the permit is not received prior to 2015 launch attempts, NASA would accept the mission risks of operating as in the 2014 LDSD campaign without the possibility of entering into PMNM as described in the No-action Alternative (the Proposed Action of the 2013 LDSD Final EA).

Purpose and Need

The Proposed Action is needed to increase the number of testing opportunities and the probability of successful test flights while decreasing the risk of a scenario for an unplanned (i.e., anomalous) termination of the test flight. To execute the Proposed Action, NASA has requested authorization for entry into PMNM through a Research permit.

NASA could have up to two technology testing launches each year for the next 5 years (June through August, 2015 to 2019). The SEA is needed to present the potential environmental impacts to PMNM. The overall goals of NASA's LDSD TDM as detailed in the 2013 LDSD Final EA continue to apply to the future test flights.

No-action Alternative

Under the No-action Alternative, NASA would conduct the Proposed Action as detailed in the 2013 LDSD Final EA and with the clarification that some recovery aids discussed in that EA may or may not be employed. This proposed test campaign would consist of launch, operation, and recovery of up to four missions from a designated location on PMRF. The SFDT campaign would consist of up to four flights from approximately June to July 2014 and June to August 2015. One flight was conducted in 2014, and up to

three could be conducted in 2015. Under the No-action Alternative, Sections 2.2.2.1 (Operational Facilities) and 2.4.2 (Launch Operation) of this SEA would apply.

Alternative 1—Proposed Action (Preferred Alternative)

The Proposed Action is for NASA to be allowed access to an additional 37,600 square kilometers (km^2) (10,950 square nautical miles [nm^2]) of splashdown area for future SFDT test flights. Of the approximately 37,600 km^2 (10,950 nm^2), approximately 28,730 km^2 (8,370 nm^2) is Open Ocean Area within PMNM and the other approximately 8,875 km^2 (2,600 nm^2) of Open Ocean Area is north of PMNM (Figure 2-2). The Proposed Action would require authorized entry into the easternmost part of the PMNM Open Ocean Area, which would consist of the splashdown, and recovery of expended flight hardware, with the exception of the balloon flight train which would sink quickly to the seafloor, from scheduled SFDTs beginning in 2015. The Proposed Action excludes the 70 hectares (170 acres) of Nihoa Island and the approximately 128.5 km^2 (37.5 nm^2) Special Management Area within 5.5 km (3 nm) surrounding Nihoa Island. NASA could have up to two technology testing launches each year for the next 5 years (June through August, 2015 to 2019).

Alternative 2—Additional Launch Years

Under Alternative 2, NASA would conduct the Proposed Action as detailed in the 2013 LDSD Final EA with the clarification that some recovery aids discussed in that EA may or may not be employed. Under Alternative 2, NASA would conduct the launch, operation, and recovery of up to two missions per year over the next 5 years (June through August, 2015 to 2019) from a designated location on PMRF using the flight trajectory outlined in the 2013 LDSD Final EA. Under Alternative 2, Sections 2.1.1.1.2.1 (Operational Facilities) and 2.1.1.3 (Launch Operation) of this SEA would apply.

Environmental Impact Assessment Methodology

Resources Carried Forward for Detailed Analysis

Table ES-1 presents the results of the process of identifying resources to be analyzed in this SEA for Alternative 1, which are air quality, biological resources and cultural resources for Open Ocean; and biological resources, cultural resources, and health and safety for Nihoa Island. The general organization of resource areas is consistent with the 2013 LDSD Final EA; however, some have been incorporated by reference in the SEA and are detailed in Table ES-1.

Resources Considered but Eliminated from Detailed Analysis

Fourteen areas of environmental consideration were initially evaluated to provide a context for understanding the potential effects of the Alternative 1—Proposed Action (Preferred Alternative) and to provide a basis for assessing the severity of potential environmental impacts. These areas included air quality, airspace, biological resources, cultural resource, geology and soils, hazardous materials and waste, health and safety, land use, noise, socioeconomics, transportation, utilities, visual aesthetics, and water resources. Ultimately, 3 of the 14 areas of environmental consideration were addressed

for the Open Ocean Area (air quality, biological resources and cultural resources) and 2 of the 14 areas of environmental consideration were addressed for Nihoa Island biological and cultural resources), and the results are listed in Table ES-1. The remaining resource areas were not analyzed in such a manner. Those resources not warranting further discussion are also presented in Table ES-1. The No-action Alternative headings of Table ES-1 refer to the analysis in the 2013 LDSD Final EA applicable to the Proposed Action in that document. For Alternative 2, analyses for the affected environment were detailed in the 2013 LDSD Final EA, and results are incorporated by reference. Table ES-2 is a summary of the cumulative effects associated with an additional 4 years of SFDT launches from PMRF.

Table ES-1. Summary of Environmental Impacts for Alternative 1—Proposed Action

Resource Category	Open Ocean Area (PMNM and Outside Area)	Nihoa Island (Including Special Management Area)	No-action Alternative
Air Quality	The ballast of the balloon system provides stability and control of the balloon during ascent. The Low Density Supersonic Decelerator (LDSD) balloon system carries approximately 110 kilograms (250 pounds) of ballast consisting of very fine steel shot (grain size 0.3 to 0.5 millimeters [mm] [0.01 to 0.02 inch]), which would be released to adjust the float altitude of the balloon system. In the United States, the U.S. Environmental Protection Agency (EPA) regulates particulate matter of size 2.5 and 10 microns (1 micron is equal to 0.001 mm), as these sizes can be easily breathed into the lungs of humans or animals. However, as the particle size of the ballast exceeds 10 microns, the ballast material is not regulated by EPA. The released ballast would travel in the upper atmospheric winds and be dispersed over hundreds of kilometers. Therefore, under the Proposed Action, the emissions from Supersonic Flight Dynamics Test (SFDT) would have no significant adverse effect on existing air quality within Papahānaumokuākea Marine National Monument (PMNM).	Hawaii's air quality standards (Hawaii Revised Statutes [HRS], Chapter 342B, Air Pollution Control and Hawaii Administrative Rules [HAR] Chapters 11-59 and 11-60.1) are broadly based and adhere to all federal emission standards for hazardous air pollutants. Due to the remote location and low level of human activities, the air of PMNM (Northwestern Hawaiian Islands) is relatively pristine.	Based on the Proposed Action from the 2013 LDSD Final Environmental Assessment (EA) (those results are incorporated by reference) and with the clarification that some recovery aids discussed in that EA may or may not be employed. One flight was conducted in 2014, and up to three could be conducted in 2015. Under the No-action Alternative, Sections 2.1.1.1.2.1 (Operational Facilities) and 2.1.1.3 (Launch Operation) of this Supplemental Environmental Assessment (SEA) would apply.
Airspace	No incremental, additive adverse cumulative impacts to airspace were identified for the Broad Ocean Area within PMNM. The detailed analysis presented in the 2013 LDSD Final EA applies to the airspace over PMNM which includes Nihoa Island, and is therefore added by reference. The National Aeronautics and Space Administration (NASA) will comply with all applicable Federal Aviation Administration (FAA) requirements.	No incremental, additive adverse cumulative impacts to airspace were identified for Nihoa Island within PMNM. The detailed analysis presented in the 2013 LDSD Final EA applies to the airspace over PMNM which includes Nihoa Island, and is therefore added by reference. NASA will comply with all applicable FAA requirements.	Based on the Proposed Action from the 2013 LDSD Final EA (those results are incorporated by reference) and with the clarification that some recovery aids discussed in that EA may or may not be employed. One flight was conducted in 2014, and up to three could be conducted in 2015. Under the No-action Alternative, Sections 2.1.1.1.2.1 (Operational Facilities) and 2.1.1.3 (Launch Operation) of this SEA would apply.

Table ES-1. Summary of Environmental Impacts for Alternative 1—Proposed Action (Continued)

Resource Category	Open Ocean Area (PMNM and Outside Area)	Nihoa Island (Including Special Management Area)	No-action
Biological Resources	The proposed activities of concern for analysis are (1) expended flight hardware, (2) unrecovered sinkable hardware, and (3) sea vessels and airplanes. **Expended Flight Hardware:** The threatened and endangered species (cetaceans, pinnipeds, and sea turtles) and critical habitat (Hawaiian monk seal) listed in Table 3-2 of the SEA have been observed and designated in the region of influence. Based on the Biological Evaluation, the Proposed Action is likely to produce stressors (i.e., 1. supersonic flight, 2. direct or proximate strike, 3. entanglement, 4. ingestion, 5. aircraft overflight, and 6. recovery vessel operations) to which listed individuals would respond if exposed. However, the likelihood of such exposures has been determined to be highly unlikely/extremely remote/very low. Based on the low density of whales during the summer, the distance from shorelines where sea turtles and Hawaiian monk seals are more likely to be encountered, the prompt recovery of all floating expended flight hardware, and the small number of overall launch attempts (up to 10 over the next 5 years), the draft determination is that the Proposed Action may affect but is not likely to adversely affect Endangered Species Act (ESA) listed Hawaiian monk seals, sea turtles, whales, and Hawaiian monk seal critical habitat. There are no known endangered corals or bottomfish in the action area, and therefore no environmental impact is anticipated.	**Expended Flight Hardware (Including Balloon Flight Train):** **Terrestrial—**The primary concern regarding terrestrial resources would be the potential for SFDT hardware to crash, burn, and/or bury an individual endangered plant and/or animal (Nihoa fan palm, `Ohai, Amaranthus brownii, Nihoa millerbird, Nihoa finch—see Table 3-1 in the SEA). To mitigate (reduce) the potential for environmental impact to Nihoa Island and the Special Management Area, one of two scenarios would occur: (1) the LDSD Program would initiate the SFDT in such a manner that expended flight hardware would be recovered before drifting into the excluded area; or (2) the flight system would overfly the excluded area, and the Test Vehicle would be dropped outside 5.5 kilometers (km) (3 nautical miles [nm]) from Nihoa Island. **Marine—**The endangered Hawaiian monk seal has been observed at Nihoa Island. Potential adverse environmental effects would be associated with an unplanned scenario (anomalies) which would allow SFDT hardware to encounter a Hawaiian monk seal. However, one of two scenarios listed above would occur, and the same probability assumption applied to terrestrial resources is applicable to the unexpected adverse environmental impacts to the Hawaiian monk seal. There are no endangered corals, fish, or other invertebrates found within the region of influence.	Based on the Proposed Action from the 2013 LDSD Final EA (those results are incorporated by reference) and with the clarification that some recovery aids discussed in that EA may or may not be employed. One flight was conducted in 2014, and up to three could be conducted in 2015. Under the No-action Alternative, Sections 2.1.1.1.2.1 (Operational Facilities) and 2.1.1.3 (Launch Operation) of this SEA would apply.

Table ES-1. Summary of Environmental Impacts for Alternative 1—Proposed Action (Continued)

Resource Category	Open Ocean Area (PMNM and Outside Area)	Nihoa Island (Including Special Management Area)	No-action
Biological Resources (Continued)	For federally listed seabirds, it would be expected that the splashdown of the expended flight hardware would be likely to produce short-term stressors (i.e., 1. supersonic flight, 2. direct or proximate strike, 3. entanglement, 4. ingestion, 5. aircraft overflight, and 6. recovery vessel operations). These short-term stressors would have the potential to cause seabirds to leave the immediate area for a short time or permanently. **Unrecovered Sinkable Hardware:** The balloon flight train would rapidly sink in the Open Ocean Area and/or PMNM and would be almost impossible to locate, which may cause environmental impacts to biological/marine wildlife in the form of stressors (i.e., 1. supersonic flight, 2. direct or proximate strike, 3. entanglement, 4. ingestion, 5. aircraft overflight, and 6. recovery vessel operations) to which listed individuals would respond if exposed. However, based on the occurrence of the species in the splashdown area being directly under the flight train as it sinks (i.e., descends to the ocean floor) during the SFDT launch season (June–August), the likelihood of such exposure has been determined to be highly unlikely/extremely remote. It is conceivable that the balloon train could settle on deep-sea coral as it reaches the ocean floor. However, review of National Oceanic and Atmospheric Administration and United Nations Environment Programme surveys of coral reefs in the Main Hawaiian Islands and Northwestern Hawaiian Islands indicate that coral reefs are not expected in the splashdown area and, therefore, significant impacts to corals from the balloon flight train are not anticipated.	**Seaborne Vessel and Aircraft:** Based on the planned (nominal) trajectory, the test flights would not overfly Nihoa Island, which would mitigate the need for the seaborne vessel are aircraft to sail near or fly over Nihoa Island. However, if overflight of Nihoa Island is needed, one of two scenarios would occur: (1) the LDSD Program would initiate the SFDT in such a manner that expended flight hardware would be recovered before drifting into the excluded area; or (2) the flight system would overfly the excluded area, and the Test Vehicle would be dropped outside 5.5 km (3 nm) from Nihoa Island. **ESA Section 7 Consultation:** In accordance with Section 7 of the ESA, NASA initiated informal consultation for the SEA with the U.S. Fish and Wildlife Service (USFWS) on 15 January 2015.	

Table ES-1. Summary of Environmental Impacts for Alternative 1—Proposed Action (Continued)

Resource Category	Open Ocean Area (PMNM and Outside Area)	Nihoa Island (Including Special Management Area)	No-action
Biological Resources (Continued)	It is conceivable that the balloon train could come in contact with bottomfish and marine mammals as it reaches the ocean floor. Based on natural behavior (e.g., startled by noise, vibrations), it is anticipated that bottomfish and marine mammals would leave the immediate area as the balloon flight train is descending to the ocean floor. **Seaborne Vessels and Aircraft:** Endangered species including whales, monk seals, and sea turtles may be seen during vessel operation activities within PMNM. However, due to the rare to unlikely occurrence of these species within the operating area during the SFDT test flight season (June–August) the seaborne vessels may strike, but the seaborne vessels are not likely to encounter an ESA species. The vessels are not anticipated to come in contact with deep-sea coral, bottomfish, or seabirds. The deep-sea coral and bottomfish are located at depths beyond the natural hull reach of the vessels. It is anticipated that seabirds would depart the immediate area. The three seaborne vessels would not anchor during the recovery process. Aircraft currently operate on an FAA approved flight plan throughout PMNM. It is not anticipated that the aircraft would have an adverse environmental impact on marine mammals, turtles, deep-sea corals, bottomfish, marine mammals, and seabirds. **ESA Section 7 Consultation:** In accordance with Section 7 of the ESA, NASA initiated informal consultation for the SEA with NMFS on 9 January 2015.		

Table ES-1. Summary of Environmental Impacts for Alternative 1—Proposed Action (Continued)

Resource Category	Open Ocean Area (PMNM and Outside Area)	Nihoa Island (Including Special Management Area)	No-action
Cultural Resources	As PMNM is considered in Hawaiian traditions as a sacred place from which life springs and to which spirits return, unavoidable cultural impacts may occur if either of the up to 10 balloon flight trains (up to two per year over 5 years) should sink to the PMNM sea floor. However, given the unlikely probability of splashdown occurring in PMNM and that the balloon flight train is most likely to sink outside PMNM, the risk of impact is small. No Section 106 Consultation was required for this Proposed Action.	All identified cultural properties on Nihoa Island are situated some distance from the planned (nominal) trajectory of the Proposed Action. In the highly unlikely probability that an unplanned scenario occurs (e.g., crash, fire) and indication of a culturally or historically significant site is adversely impacted, NASA would contact the Monument Permit Coordinator as soon as reasonably possible. NASA understands that if an archaeological activity needs to occur in PMNM, the activity must be permitted and undergo a National Historic Preservation Act consultation prior to issuance of a PMNM permit. No Section 106 Consultation was required for this Proposed Action.	Based on the Proposed Action from the 2013 LDSD Final EA (those results are incorporated by reference) and with the clarification that some recovery aids discussed in that EA may or may not be employed. One flight was conducted in 2014, and up to three could be conducted in 2015. Under the No-action Alternative, Sections 2.1.1.1.2.1 (Operational Facilities) and 2.1.1.3 (Launch Operation) of this SEA would apply.
Geology and Soil	N/A*	The LDSD Program proposes no ground activities on Nihoa Island.	Based on the Proposed Action from the 2013 LDSD Final EA (those results are incorporated by reference) and with the clarification that some recovery aids discussed in that EA may or may not be employed. One flight was conducted in 2014, and up to three could be conducted in 2015. Under the No-action Alternative, Sections 2.1.1.1.2.1 (Operational Facilities) and 2.1.1.3 (Launch Operation) of this SEA would apply.

*N/A—Resource not applicable and not analyzed for this location.

Table ES-1. Summary of Environmental Impacts for Alternative 1—Proposed Action (Continued)

Resource Category	Open Ocean Area (PMNM and Outside Area)	Nihoa Island (Including Special Management Area)	No-action
Hazardous Materials and Waste	The detailed analysis presented in the 2013 LDSD Final EA applies to hazardous materials and waste for the Open Ocean Area within and north of PMNM and is therefore incorporated by reference. All hazardous materials are fully integrated into either the balloon system or the Test Vehicle. Immediately post-landing, vessels would transit from the test support locations beyond the launch hazard arc to intercept and salvage the floating systems-balloon and Test Vehicle. Whether or not either of these systems enters PMNM, they would be recovered as quickly as possible. Under nominal conditions, all pyrotechnic systems are fired during flight and land spent (as part of the balloon system or Test Vehicle) in the ocean.	The detailed analysis presented in the 2013 LDSD Final EA applies to hazardous materials and waste for the On-shore Area and is therefore added by reference. NASA would exclude a splashdown near the 70 hectares (170 acres) of Nihoa Island and the approximately 128.5 km^2 (37.5 nm^2) Special Management Area surrounding Nihoa Island. In the highly unlikely probability that an unplanned scenario occurs (e.g., crash, fire), NASA would contact the PMNM Permit Coordinator immediately.	Based on the Proposed Action from the 2013 LDSD Final EA (those results are incorporated by reference) and with the clarification that some recovery aids discussed in that EA may or may not be employed. One flight was conducted in 2014, and up to three could be conducted in 2015. Under the No-action Alternative, Sections 2.1.1.1.2.1 (Operational Facilities) and 2.1.1.3 (Launch Operation) of this SEA would apply.
Health and Safety	The detailed analysis presented in the 2013 LDSD Final EA applies to the health and safety for the Open Ocean Area within and north of PMNM and is therefore added by reference.	Undeveloped and unpopulated island.	Based on the Proposed Action from the 2013 LDSD Final EA (those results are incorporated by reference) and with the clarification that some recovery aids discussed in that EA may or may not be employed. One flight was conducted in 2014, and up to three could be conducted in 2015. Under the No-action Alternative, Sections 2.1.1.1.2.1 (Operational Facilities) and 2.1.1.3 (Launch Operation) of this SEA would apply.

Table ES-1. Summary of Environmental Impacts for Alternative 1—Proposed Action (Continued)

Resource Category	Open Ocean Area (PMNM and Outside Area)	Nihoa Island (Including Special Management Area)	No-action
Land Use	N/A*	Undeveloped and unpopulated island.	Based on the Proposed Action from the 2013 LDSD Final EA (those results are incorporated by reference) and with the clarification that some recovery aids discussed in that EA may or may not be employed. One flight was conducted in 2014, and up to three could be conducted in 2015. Under the No-action Alternative, Sections 2.1.1.1.2.1 (Operational Facilities) and 2.1.1.3 (Launch Operation) of this SEA would apply.
Noise	Any change in noise levels is expected to be short-term and temporary and would not adversely affect marine animals.	Any change in noise levels is expected to be short-term and temporary and would not adversely affect terrestrial or marine animals.	Based on the Proposed Action from the 2013 LDSD Final EA (those results are incorporated by reference) and with the clarification that some recovery aids discussed in that EA may or may not be employed. One flight was conducted in 2014, and up to three could be conducted in 2015. Under the No-action Alternative, Sections 2.1.1.1.2.1 (Operational Facilities) and 2.1.1.3 (Launch Operation) of this SEA would apply.
Socioeconomics	Post launch activities are not anticipated to affect any commercial or private commerce on the open seas. Commercial and private sea vessels and aircraft would be notified in advance of launch activities by PMRF as part of their routine operations through Notices to Airmen (NOTAMs) and Notices to Mariners (NOTMARs).	Undeveloped and unpopulated island.	Based on the Proposed Action from the 2013 LDSD Final EA (those results are incorporated by reference) with the clarification that some recovery aids discussed in that EA may or may not be employed. One flight was conducted in 2014, and up to three could be conducted in 2015. Under the No-action Alternative, Sections 2.1.1.1.2.1 (Operational Facilities) and 2.1.1.3 (Launch Operation) of this SEA would apply.

*N/A — Resource not applicable and not analyzed for this location.

Table ES-1. Summary of Environmental Impacts for Alternative 1—Proposed Action (Continued)

Resource Category	Open Ocean Area (PMNM and Outside Area)	Nihoa Island (Including Special Management Area)	No-action
Transportation	Post launch activities are not anticipated to adversely affect any commercial or private sea vessels or aircraft that could be present in the area. Commercial and private sea vessels and aircraft would be notified in advance of launch activities by PMRF as part of their routine operations through NOTAMs and NOTMARs. Federal regulations (50 CFR Part 404) define specific vessel traffic reporting rules for areas within PMNM, a designated Particularly Sensitive Sea Area (PSSA). All domestic vessels, foreign vessels greater than 300 gross tons that are either going to or coming from a U.S. port or place, and foreign vessels of any size that are heading to or coming from a U.S. port or place must provide entry notification within 72 hours of entering the PSSA and provide exit notification within 12 hours of exiting the PSSA. Notification is to PMNM via telephone, fax, or email (http://www.papahana umokuakea.gov/ resource/ship_reporting.html). All other vessels are encouraged to participate, but are not required. Passage without interruption is highest during the winter months (October–February) due to bad weather north of PMNM. In general, due to the area's remote location, vessel traffic is minimal throughout the year.	Undeveloped and unpopulated island.	Based on the Proposed Action from the 2013 LDSD Final EA (those results are incorporated by reference) and with the clarification that some recovery aids discussed in that EA may or may not be employed. One flight was conducted in 2014, and up to three could be conducted in 2015. Under the No-action Alternative, Sections 2.1.1.1.2.1 (Operational Facilities) and 2.1.1.3 (Launch Operation) of this SEA would apply.

Table ES-1. Summary of Environmental Impacts for Alternative 1—Proposed Action (Continued)

Resource Category	Open Ocean Area (PMNM and Outside Area)	Nihoa Island (Including Special Management Area)	No-action
Utilities	N/A*	Undeveloped and unpopulated island.	Based on the Proposed Action from the 2013 LDSD Final EA (those results are incorporated by reference) and with the clarification that some recovery aids discussed in that EA may or may not be employed. One flight was conducted in 2014, and up to three could be conducted in 2015. Under the No-action Alternative, Sections 2.1.1.1.2.1 (Operational Facilities) and 2.1.1.3 (Launch Operation) of this SEA would apply.
Visual Aesthetics	Although the balloon and parachute may be visible for a brief time, there are no known receptors that would suffer adverse environmental impacts to "scenic views" in the Open Ocean Area.	Undeveloped and unpopulated island.	Based on the Proposed Action from the 2013 LDSD Final EA (those results are incorporated by reference) and with the clarification that some recovery aids discussed in that EA may or may not be employed. One flight was conducted in 2014, and up to three could be conducted in 2015. Under the No-action Alternative, Sections 2.1.1.1.2.1 (Operational Facilities) and 2.1.1.3 (Launch Operation) of this SEA would apply.
Water	The detailed analysis presented in the 2013 LDSD Final EA applies to water resources for the Open Ocean Area within and north of PMNM and is therefore added by reference.	The detailed analysis presented in the 2013 LDSD Final EA applies to water resources for the Open Ocean Area within and north of PMNM and is therefore added by reference.	Based on the Proposed Action from the 2013 LDSD Final EA (those results are incorporated by reference) and with the clarification that some recovery aids discussed in that EA may or may not be employed. One flight was conducted in 2014, and up to three could be conducted in 2015. Under the No-action Alternative, Sections 2.1.1.1.2.1 (Operational Facilities) and 2.1.1.3 (Launch Operation) of this SEA would apply.

*N/A—Resource not applicable and not analyzed for this location.

Under Alternative 2, NASA would conduct the Proposed Action as detailed in the 2013 LDSD Final EA and with clarification of recovery aids that may or may not be employed. The proposed test campaign for Alternative 2 would consist of launch, operation, and recovery of up to two missions per year over the next 5 years (June through August, 2015 to 2019) from a designated location on PMRF using the flight trajectory outlined in the 2013 LDSD Final EA. Under Alternative 2, Sections 2.2.2.1 (Operational Facilities) and 2.4.2 (Launch Operation) of this SEA would apply. Analyses for the affected environments were detailed in the 2013 LDSD Final EA, and results are incorporated by reference. The corresponding 2013 LDSD Final EA section numbers are denoted in parentheses after each heading. Table ES-2 is a summary of the cumulative effects associated with 5 additional years of SFDT launches from PMRF.

Table ES-2. Summary of Environmental Impacts for Alternative 2—Additional Launch Years

Affected Environment	Cumulative Effects
Pacific Missile Range Facility	**No-action:** Based on the Proposed Action from the 2013 Low Density Supersonic Decelerator Final Environmental Assessment (LDSD Final EA); those results are incorporated by reference. **Proposed Action:** Based on the analysis of resources analyzed and presented in the 2013 LDSD Final EA for the Pacific Missile Range Facility (PMRF) (air quality [4.1.1], airspace [4.1.2], biological resources [4.1.3], hazardous materials and waste [4.1.4], health and safety [4.1.5], socioeconomics [4.1.6], and water resources [4.1.7]), the following conclusions can be made. Negligible temporary increases would occur in emissions, and activities would be minor and transitory. Airspace would continue to be coordinated through the Federal Aviation Administration (FAA). The addition of eight flights over 4 years and other activities combined would be performed at varying times and locations on PMRF and should have negligible adverse cumulative environmental impacts on biological resources. Pre-launch and launch activities represent routine types of hazardous material and waste as well as health and safety activities at PMRF; as a result, no substantial adverse environmental impacts from the management of Supersonic Flight Dynamics Test (SFDT) project related hazardous materials and waste and routinely provided safety support are anticipated. There would continue to be no negative environmental impacts on the permanent population size, employment characteristics, schools, and type of housing available on-island. The amount of exhaust products from the SFDT that could potentially be deposited due to the launch activity would be small, and no cumulative impacts are expected. The Test Vehicle hardware, debris, and propellants that could fall into the ocean are expected to have only a localized, short-term effect on water quality.

Table ES-2. Summary of Environmental Impacts for Alternative 2—Additional Launch Years (Continued)

Affected Environment	Cumulative Effects
Niihau	**No-action:** Based on the Proposed Action from the 2013 LDSD Final EA; those results are incorporated by reference. **Proposed Action:** Based on the analysis of resources analyzed and presented in the 2013 LDSD Final EA for Niihau (airspace [4.2.1], biological resources [4.2.2], cultural resources [4.2.3], and health and safety [4.2.4]), the additional LDSD launches may still require overflight of Niihau. The overflight is not anticipated to result in adverse environmental impacts to the airspace over Niihau; is not anticipated to environmentally impact biological and cultural resources on the island; and all missions or projects are closely reviewed and analyzed to ensure that there are no unacceptable risks to the public, Government and military personnel, and contractors.
Open Ocean Area	**No-action Alternative:** Based on the Proposed Action from the 2013 LDSD Final EA; those results are incorporated by reference. **Proposed Action:** Based on the analysis of resources analyzed and presented in the 2013 LDSD Final EA for the Open Ocean Area (airspace [4.3.1], biological [4.3.2], cultural [4.3.3], hazardous materials and waste [4.3.4], health and safety [4.3.5], and water resources [4.3.6]), the launch activity will continue the use of the required scheduling and coordination process for area airspace, and adherence to applicable Department of Defense directives and FAA regulations. The activities proposed may affect but are not likely to adversely affect federally-listed marine mammals and sea turtles in the operational area. The proposed activities would not result in any direct environmental impacts on corals or degradation of water/sediment quality in the vicinity of corals. Any submerged features that might be within this area are at considerable depth, and the potential for disturbance is extremely remote. The implementation of Alternative 2 would not introduce new types of hazardous materials and waste into the Open Ocean Area, and only small increases in quantities of previously introduced types of hazardous wastes are expected. For health and safety, rocket launches are short-term, discrete events that are actively managed by PMRF range safety. The launch activities would not be scheduled to occur at the same time as other launch programs. The effect of any rocket motor emission products deposited in the open ocean would be very transient due to the buffering capacity of sea water and dilution by current ocean mixing and would not be expected to result in any cumulative adverse effects.
Global Environment	**No-action Alternative:** Based on the Proposed Action from the 2013 LDSD Final EA; those results are incorporated by reference. **Proposed Action:** Because the LDSD launches would release little or no ozone depleting substance, there would be no adverse cumulative environmental impacts on the stratospheric ozone layer.

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Acronyms and Abbreviations

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ACRONYMS AND ABBREVIATIONS

AGL	Above Ground Level
ATK	Alliant Techsystems Incorporated
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
ConOps	Concept of Operations
DoD	Department of Defense
DPS	Distinct Population Segment
EA	Environmental Assessment
EFH	Essential Fish Habitat
EGSE	Electronic Ground Support Equipment
EO	Executive Order
EPA	United States Environmental Protection Agency
ESA	Endangered Species Act
FAA	Federal Aviation Administration
FONSI	Finding of No Significant Impact
ft	Feet
kg	Kilogram(s)
km	Kilometer(s)
km^2	Square Kilometer(s)
km/hr	Kilometers per Hour
lb	Pound(s)
LDSD	Low Density Supersonic Decelerators
LEO	Low Earth Orbit
m	Meter(s)
mcf	Million Cubic Feet
MET	Meteorological
MHI	Main Hawaiian Islands
mi	Mile(s)
mi^2	Square Mile(s)
N/A	Not Applicable
NASA	National Aeronautics and Space Administration
NEPA	National Environmental Policy Act

NHPA	National Historic Preservation Act
nm	Nautical Mile(s)
nm^2	Square Nautical Mile
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOTAM	Notice to Airmen
NOTMAR	Notice to Mariners
NWHI	Northwestern Hawaiian Islands
PMNM	Papahānaumokuākea Marine National Monument
PMRF	Pacific Missile Range Facility
PSSA	Particularly Sensitive Sea Area
ROBIN	Rocket Balloon Instruments
RSOP	Range Safety Operational Plan
SEA	Supplemental Environmental Assessment
SFDT	Supersonic Flight Dynamics Test
SIAD	Supersonic Inflatable Aerodynamic Decelerator
SSRS	Supersonic Ring-Sail
STMD	Space Technology Mission Directorate
TDM	Technology Demonstration Mission
TSP	Test Support Positions
U.S.C.	United States Code
USFWS	United States Fish and Wildlife Service
WPRFMC	Western Pacific Regional Fishery Management Council

UNIT CONVERSION TABLE

Metric Unit		Conversion Factor		Imperial (English) Unit
meter	Multiply by:	3.28084	To convert to:	foot
kilometer		0.539957		nautical mile*
kilometer		0.621371		mile
square kilometer		0.291181		square nautical mile
hectare		2.47105		acre
kilogram		2.20462		pound

*Note: To convert miles into nautical miles multiply by 0.86897.

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1.0 Purpose and Need for Proposed Action

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1.0 PURPOSE AND NEED FOR PROPOSED ACTION

The National Aeronautics and Space Administration (NASA) prepared a Final Environmental Assessment (EA) and issued a Finding of No Significant Impact (FONSI) in May 2013 which evaluated and addressed the potential environmental consequences of conducting the proposed launch, operation, and recovery of the Low Density Supersonic Decelerator (LDSD) Technology Demonstration Mission (TDM) test flights at the U.S. Navy's Pacific Missile Range Facility (PMRF) on Kauai, Hawaii (Figure 1-1). The 2013 Final EA addressed the first demonstration test which was successfully conducted in June 2014, as well as the campaigns planned in 2015 consisting of three additional demonstration tests. Based on information gleaned from the first test, the purpose of this Supplemental Environmental Assessment (SEA) is to evaluate the potential environmental consequences (environmental impacts) of changes planned for future campaigns. These changes consist of the No-action Alternative, Alternative 1, and Alternative 2:

- No-action Alternative: Under the No-action Alternative, NASA would conduct the Proposed Action as detailed in the 2013 LDSD Final EA and with the clarification that some recovery aids discussed in that EA may or may not be employed. This proposed test campaign would consist of launch, operation, and recovery of up to four missions from a designated location on PMRF. The Supersonic Flight Dynamics Test (SFDT) campaign would consist of up to four flights from approximately June to July 2014 and June to August 2015. One flight was conducted in 2014, and up to three could be conducted in 2015. Under the No-action Alternative, Sections 2.1.1.1.2.1 (Operational Facilities) and 2.1.1.3 (Launch Operation) of this SEA would apply.
- Alternative 1 (Preferred Alternative): Consists of using additional open ocean splashdown area within and outside of Papahānaumokuākea Marine National Monument (PMNM) and additional launch years. For Alternative 1 (Preferred Alternative), these changes consist of (1) permit authorization from the National Oceanic and Atmospheric Administration (NOAA) (issuance of which is contingent upon final approval of this SEA and associated FONSI) for flight hardware to potentially fly over, splashdown, and be recovered (except the balloon flight train, which would rapidly sink in the open ocean) within the easternmost part of PMNM; and (2) perform up to two LDSD TDM test flights annually over the next 5 years, starting in June 2015 and ending in August 2019.
- Alternative 2: Consists of adding additional launch years to the 2013 Final EA and with the clarification that some recovery aids discussed in that EA may or may not be employed. For Alternative 2, these changes consist of additional test flights of up to two missions per year over the next 5 years (June through August, 2015 to 2019) from a designated location on

EXPLANATION

Proposed Launch Area (not to scale)

Red Label Area (not to scale)

NORTH

Overview of PMRF and the Western Shore of Kauai

Kauai, Hawaii

Figure 1-1

11_overview, 4/1/2015

PMRF using the flight trajectory outlined in the 2013 LDSD Final EA. For future testing, the full open ocean recovery of the expended flight hardware, including balloon carcass, Test Vehicle, and supersonic parachute, will take place within a pre-coordinated operational area located west by northwest of PMRF (Figure 1-2). Under Alternative 2, Sections 2.1.1.1.2.1 (Operational Facilities) and 2.1.1.3 (Launch Operation) of this SEA would apply.

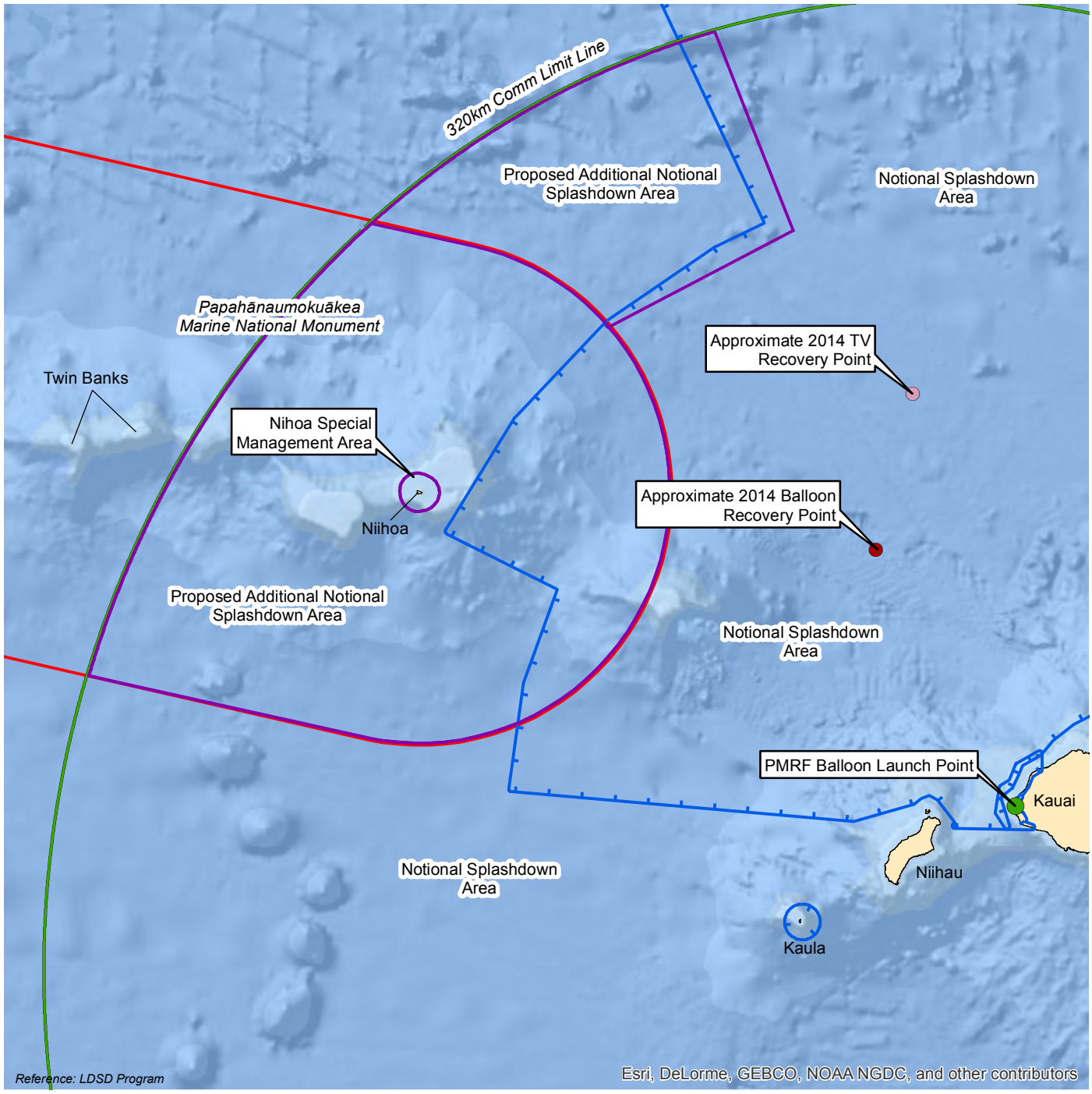
This SEA is in compliance with the following statutes, regulations, and procedures:

- National Environmental Policy Act (NEPA) of 1969, as amended (42 United States Code [U.S.C.] 4321 et seq.)
- Council on Environmental Quality (CEQ) Regulations for Implementing the Procedural Provisions of NEPA (40 Code of Federal Regulations [CFR] Parts 1500-1508)
- NASA NEPA Implementing Regulation (Subpart 1216.3)
- NASA Procedural Requirement 8580.1, NASA National Environmental Policy Act Management Requirements
- Executive Order (EO) 12114, Environmental Effects Abroad of Major Federal Actions
- Presidential Proclamation, 8031 Establishment of the Northwestern Hawaiian Islands Marine National Monument
- 50 CFR Part 404, Northwestern Hawaiian Islands Marine National Monument

1.1 BACKGROUND

Section 1.1 of the 2013 LDSD Final EA provides a detailed background for NASA's LDSD mission directive, and Chapter 4 of the 2013 LDSD Final EA analyzes the environmental consequences of conducting the series of LDSD tests from PMRF, and also potential impacts on Niihau and the Open Ocean Area. The 2013 LDSD Final EA can be found at http://www.sites.wff.nasa.gov/Code250/LDSD_Final_EA_May2013.pdf.

Subsequent to issuing a FONSI for the LDSD Final EA on 10 May 2013, NASA continued its mission planning and ultimately conducted the first LDSD flight in June 2014. Lessons learned from this initial LDSD flight indicated that changes to the Proposed Action as described in the LDSD Final EA could be warranted.



EXPLANATION

- PMRF Balloon Launch Point
- Approximate 2014 Balloon Recovery Point
- Approximate 2014 TV Recovery Point
- Proposed Additional Notional Splashdown Area
- 320-km Communications Limit Line
- Special Use Airspace
- Papahānaumokuākea Marine National Monument

NORTH 0 12.5 25 50 Nautical Miles

2014 SFDT Test Flight Recovery Points for Flight Hardware

PMRF, Niihau, and Open Ocean

Figure 1-2

12_hardware_recovery, 4/1/2015

Under NEPA, Federal agencies have a continuing duty to evaluate the environmental consequences of their actions. Under certain circumstances, agencies must supplement their existing environmental analyses should they propose changes to those actions that could have a bearing on environmental consequences.

Accordingly, NASA has prepared this SEA as a supplement to the 2013 LDSD Final EA to evaluate the environmental consequences of operational changes it proposes for the additional LDSD test flights scheduled to be conducted in the summers of 2015 through 2019.

The following three sections of the SEA provide (1) a summary of the June 2014 LDSD test flight; (2) the lessons learned which prompted NASA to consider modifying its Proposed Action; and (3) the Federal authorization needed to undertake the proposed changes.

1.1.1 2014 LDSD SFDT FLIGHT SUMMARY

The LDSD project's first Supersonic Flight Dynamics Test (SFDT), executed on 28 June 2014 from the U.S. Navy's PMRF, represented the culmination of years of planning, development, and ingenuity by multiple NASA centers. The focus of this first SFDT was to determine if the devised test architecture and Concept of Operations (ConOps) achieved engineering and technology conditions to push the limits of the decelerators being developed. The SFDT had to be accomplished within established requirements outlined in the LDSD project's EA, NASA's policies defined in the Wallops Flight Facility Range Safety Manual, and the U.S. Navy's Safety policies defined in the Range Safety Operational Plan (RSOP).

Although the initial 2-week launch window opened on 2 June 2014, the LDSD project experienced daily upper wind conditions that preempted all launch attempts during that window. The LDSD project and the U.S. Navy's Management coordinated a second launch window at the end of June 2014 requiring redeployment of project personnel and support assets. The first day of the second launch window opened on 28 June 2014 and provided a valid opportunity for launch. The predicted balloon trajectory was along a path north of Niihau. This particular balloon trajectory only afforded an approximate 30-minute decision window for Test Vehicle drop to reaction to any inflight anomalies (i.e., unplanned scenarios) that might occur. The LDSD project accepted the risks associated with this northern trajectory and moved forward with a launch attempt. After numerous decision meetings, all Go/No Go criteria were green and the balloon was released from the launch site at PMRF.

The SFDT consisted of releasing a 1 million cubic meter (34 million cubic foot [mcf]) scientific balloon that carried the Test Vehicle to the minimum desired float altitude of 37,000 meters (m) (120,000 feet [ft]). The Test Vehicle was then released, initiating the mission sequence. After the Test Vehicle dropped, small solid-fueled rocket motors ignited and stabilized the Test Vehicle prior to the main motor ignition. The main motor ignited propelling the Test Vehicle upwards to an altitude of approximately 55,000 m

(180,000 ft) at a speed of approximately Mach 4. The Test Vehicle then deployed a torus (doughnut-shaped) tube called the Supersonic Inflatable Aerodynamic Decelerator (SIAD) to slow its velocity to approximately Mach 2. The Test Vehicle then deployed the 30.5-m (100-ft) diameter supersonic parachute, designed to carry the Test Vehicle safely to a controlled oceanic impact in a pre-coordinated operational area off the west coast of the island of Kauai, Hawaii.

The combined flight system (balloon and Test Vehicle) was continually tracked by PMRF ground instrumentation providing positional data to the U.S. Navy Range Safety Organization. The position of the flight system along with individual splashdown dispersions (variable, maximum 26 kilometers [km] [14 nautical miles [nm]) for the balloon, detached balloon flight train on recovery parachute, and Test Vehicle were overlaid onto a display system. The splashdown dispersions (for each item) were compared to restrictions imposed on the LDSD project due to Niihau and Kauai islands (public safety criteria), Federal Aviation Administration (FAA) boundaries (public safety criteria), and PMNM (environmental safety criteria).

The balloon ascent progressed in accordance to plan except for slightly higher upper air wind speeds than predicted and the balloon's ascent being slightly slower than predicted. Each of these slight changes to the timeline narrowed the overall margin in the decision window for Test Vehicle drop for initiation of the SFDT. The LDSD project estimates that the 26-km (14-nm) splashdown dispersion circle was between 8 to 15 minutes from violating the outer boundary of PMNM. Had there been any significant delay in the mission (e.g., non-participating vessels in the range, hardware issue, etc.), then the U.S. Navy Range Safety Organization would have issued a mission termination order, resulting in an immediate drop of the balloon and Test Vehicle into the ocean to prevent potential PMNM infringement, resulting in the likely full loss of the vehicle due to impact damage.

Almost all expended flight hardware was then recovered from the open ocean, with the exception of the balloon flight train. This flight train connects the Test Vehicle to the balloon. Once the Test Vehicle dropped, a signal was sent that separated the flight train from the balloon. The flight train consisted of a burst parachute (a safety instrument), sensors, connections, and Kevlar® cabling. As anticipated and discussed in the 2013 LDSD Final EA, this system sank rapidly in the ocean and was impossible to locate.

1.1.2 2014 LESSONS LEARNED THAT PROMPTED THIS SEA

A significant accomplishment of the LDSD project's 2014 campaign was demonstrating the ability to accurately predict the balloon's climb-out trajectory and to recover the balloon carcass and Test Vehicle. Figure 1-3 captures recovery operations of the balloon, and Figure 1-4 shows recovery operations at the Test Vehicle recovery site. The hard lesson learned was that there is the possibility of going weeks without acceptable conditions for launch. Another lesson learned is that the northern trajectories represent significant risk of early termination unless mitigated.

2014 SFDT Test Flight Recovery Operations of the Scientific Balloon

Figure 1-3

13_balloon_recovery, 4/1/2015

2014 SFDT Test Flight Operations at the Test Vehicle Recovery Site

Figure 1-4

14_TV_recovery, 4/1/2015

Based on the results of the 28 June 2014 test flight, the LDSD project decided to investigate the possibility of potentially dropping and recovering expended flight hardware, with the exception of the balloon flight train, in the eastern part of PMNM during future demonstration missions, as part of any additional flight option. This flight option would be conducted within the boundary of PMNM, but outside of the 5.6-km (3-nm) Special Management Area surrounding Nihoa Island. Section 1.1.3 summarizes the request for authorization to splashdown within PMNM (Figure 1-5).

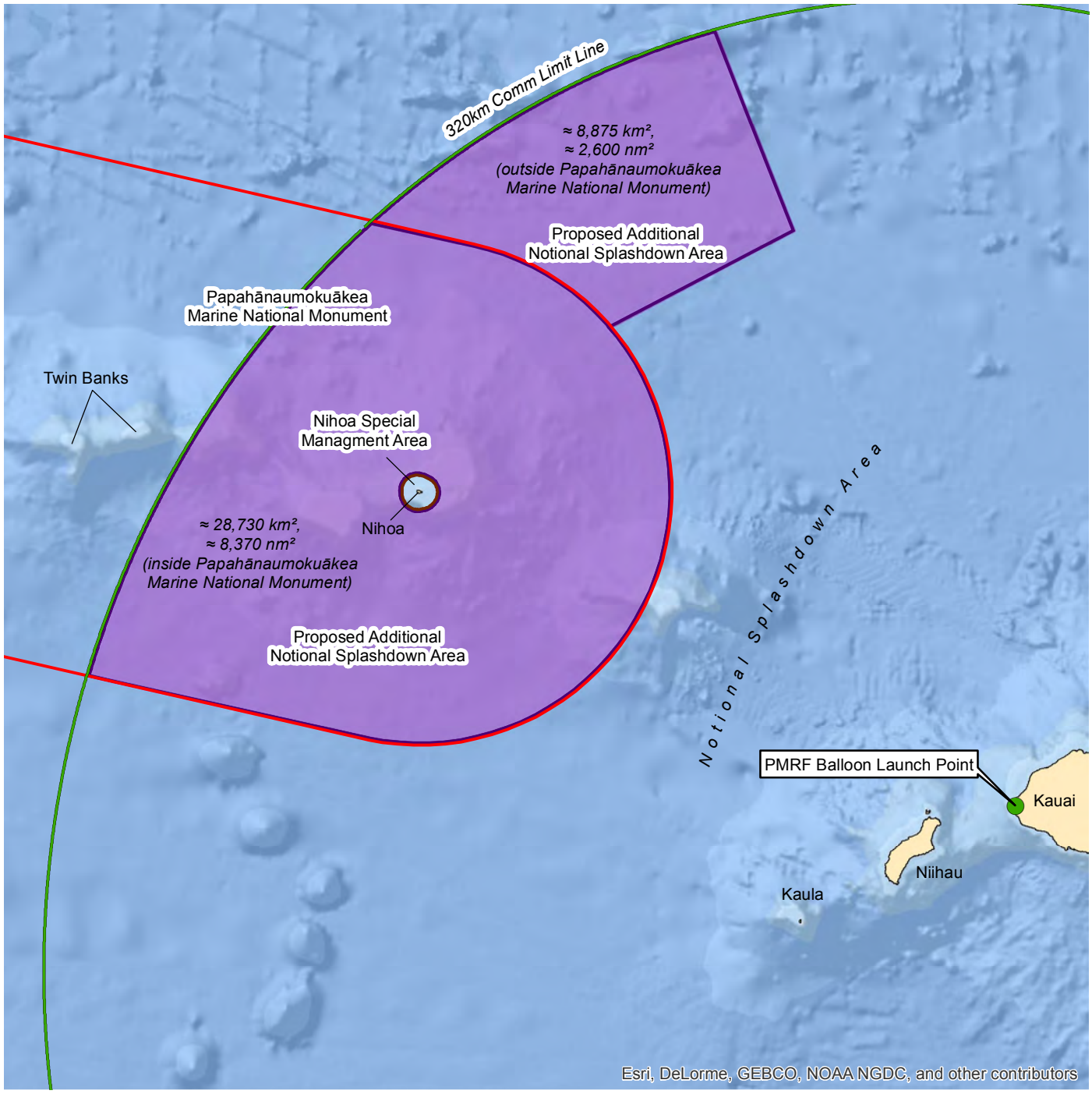
1.1.3 PAPAHĀNAUMOKUĀKEA MARINE NATIONAL MONUMENT PERMIT AND APPLICATION PROCESS

In January 2015, NASA submitted to the PMNM permit coordinator an application seeking authorization to include the eastern part of PMNM surrounding Nihoa Island as part of its splashdown and recovery area for the SFDTs. NASA is seeking authorization to conduct activities within PMNM via the established permitting process defined in Presidential Proclamation 8031 and codifying regulations in 50 CFR Part 404. PMNM issues permits in six categories (Research, Education, Conservation and Management, Native Hawaiian Practices, Special Ocean Use, and Recreation). Issuance of a PMNM permit is contingent upon final approval of this SEA and its associated signed FONSI. Access into PMNM would not occur prior to issuance of a PMNM permit. NASA requests authorization under Permit Category-–Conservation and Management per recommendation of the PMNM permit coordinator. The activity for potential entry into PMNM would occur on the day of the launches beginning with the 2015 test flights scheduled for 1 June through 31 August 2015. Test flights are anticipated to occur during the June–August time frame beginning in 2015 and ending in 2019. A launch window would be based on wind studies conducted at PMRF.

The LDSD project requested authorization to potentially drop and recover expended flight hardware, with the exception of the balloon flight train which would sink to the seafloor, from up to two scheduled SFDTs in 2015 (with the potential for up to two additional flights per year through 31 August 2019) in the Open Ocean area within the boundary of PMNM. This operations area excludes the 70 hectares (170 acres) of Nihoa Island and the Special Management Area within the 5.6 km (3 nm) surrounding Nihoa Island. This permit would also allow NASA to enter PMNM if the flight hardware is dropped outside PMNM and carried into PMNM by ocean currents.

This overlay of the hardware splashdown area was derived from negotiations among the LDSD project, U.S. Navy Range Management, and the FAA and also considered the 320-km (170-nm) telecommunications limitation arc from the Test Vehicle to PMRF.

Two factors determine whether entering into PMNM would be required. The presence of these factors cannot be definitively determined until after the balloon has been launched. The first factor is the progress of the balloon’s ascent on its predicted



EXPLANATION

- PMRF Balloon Launch Point
- 320-km Communications Limit Line
- Proposed Additional Notional Splashdown Area
- Nihoa 3-nautical mile Special Management Area
- Papahānaumokuākea Marine National Monument

NORTH 0 12.5 25 50 Nautical Miles

Proposed Additional Splashdown Area

PMRF, Niihau, and Open Ocean

Figure 1-5

15_proposed_splashdown, 4/1/2015

trajectory. If the balloon is ascending along its predicted trajectory, then it would most likely reach float altitude well to the east of PMNM. The balloon in some cases is allowed to float westerly, providing it does not overfly Niihau. The Test Vehicle is eventually dropped, initiating the SFDT along a northeasterly trajectory and avoiding PMNM altogether. Once the Test Vehicle has been released, the balloon flight is terminated and the balloon carcass falls to the ocean for recovery.

During the ascent and float stage of the balloon, unplanned scenarios (i.e., anomalies) in the following elements could result in actions being taken leading to the flight system moving into PMNM:

- Determination that the sun will interfere with on-board camera systems
- System failure involving one or more of the recovery assets (sea vessels and aircraft)
- System failure involving the balloon and/or Test Vehicle
- Non-participating sea vessel and/or aircraft in the mission related hazard areas
- System failure involving one or more of the ground telecommunications systems

Once aloft (in flight/airborne), NASA has no control over the balloon's direction of travel. All the anomalies (unplanned scenarios) listed above could result in one of two possible outcomes:

- A delay until the flight system is deemed flight ready and the SFDT is initiated
- A delay until the flight system is deemed unsafe and terminated

The second factor in determining PMNM entry is the latitude at which the balloon is moving westerly. Under the planned (i.e., nominal) scenario, the upper level winds carry the balloon nearly due west. The southeasterly point of PMNM is at roughly 22 degrees 13 minutes north latitude. The possibility of the balloon entering into PMNM decreases as the point where the float altitude is reached moves southward of 22 degrees 13 minutes north latitude.

Under unplanned (anomalous) scenarios, the winds at a given altitude may or may not be as predictable as those at approximately 37,000 meters (m) (120,000-feet [ft]). If it is predicted that the balloon will not reach its planned (i.e., nominal) float altitude, then a decision is made whether to continue with an SFDT attempt or terminate the flight depending on altitude reached and where it predicted the balloon is traveling. Depending on the nature and timing of the anomaly (i.e., unplanned scenario), the flight system could float westerly long enough for PMNM entry.

In either unplanned (i.e., anomalous) scenario, NASA would enter PMNM and recover all floating expended flight hardware as demonstrated in the 2014 SFDT mission (Figures 1-3 and 1-4). NASA would deploy up to two aircraft to fly surveillance tracks

between approximately 460 and 7,300 m (1,500 and 24,000 ft) above ground level (AGL) and to aid in recovery and up to three recovery vessels to Test Support Positions (TSPs) within the operational area outside PMNM. Immediately upon splashdown of the expended flight hardware, the spotter aircraft would be directed to the different floating hardware locations to begin recovery. During the 2014 mission, it took the respective vessels approximately 5 hours to reach and recover the ring-sail parachute, 6.5 hours to reach and recover the balloon carcass, and 4 hours to reach and recover the Test Vehicle.

Almost all expended flight hardware is then recovered from the ocean, with the exception of the balloon flight train. This flight train connects the Test Vehicle to the balloon. Once the Test Vehicle is dropped, a signal is sent that separates the flight train from the balloon and in the process, rips the balloon to allow descent. The flight train weighs approximately 375 kilograms [kg] (830 pounds [lb]); is approximately 300 m (990 ft) long; and consists of a burst parachute (a safety instrument), sensors, connections, and Kevlar® cabling. This system would sink rapidly in the ocean and would be almost impossible to locate.

NASA anticipates receiving the PMNM Research Permit prior to the opening of the launch window on 1 June 2015. The Permit Application is attached as Appendix C of this SEA. If the Permit is not received prior to 2015 launch attempts, NASA would accept the mission risks of operating as in the 2014 LDSD campaign without entering into PMNM, as described in the No-action Alternative.

1.2 SCOPE OF SUPPLEMENTAL ENVIRONMENTAL ASSESSMENT

This SEA is prepared in compliance with the statutes and regulations previously listed that direct NASA officials to consider potential environmental consequences when authorizing or approving Federal actions. This SEA evaluates the potential environmental impacts over 5 years of up to two per year of the potential fly-over, splashdown, and recovery of the LDSD balloon and Test Vehicle in the eastern part of PMNM, which includes the 28,723 square kilometers [km^2] (8,364 square nautical miles [nm^2]) of Open Ocean Area in the easternmost part of PMNM and the approximately 8,874 km^2 (2,600 nm^2) of Open Ocean Area north of PMNM and recovery of the balloon carcass, Test Vehicle, and supersonic parachute. This SEA also evaluates the potential environmental impacts of the balloon flight train remaining on the open ocean seafloor. Alternative 2 of this SEA assesses expanding the No-action Alternative for 4 additional years with up to two SFDTs per year. The No-action Alternative of this SEA is the Proposed Action in the 2013 LDSD Final EA, and with the clarification that some recovery aids discussed in that EA may or may not be employed, is not reassessed as there is no change in the Proposed Action. For the No-action Alternative, one flight was conducted in 2014, and up to three could be conducted in 2015 (National Aeronautics and Space Administration, 2013).

This SEA addresses all of the reasonably foreseeable activities in the particular geographical areas of the eastern part of PMNM (Open Ocean) potentially affected by

the Proposed Action and focuses on those activities ready for Federal and resource agency decisions. The majority of activities would use existing facilities and/or be on previously disturbed land (located on PMRF).

Consistent with the CEQ regulations, the scope of the analysis presented in this SEA was defined by the range of potential environmental impacts that would result from implementation of the Proposed Action. Resources that may be impacted are considered in the SEA analysis to provide the decision makers with sufficient evidence and analysis for evaluation of the potential effects of the action. For this SEA, the environment is discussed in terms of two resource areas (biological resources and cultural resources) associated with Open Ocean Area within and outside PMNM.

1.3 PURPOSE AND NEED OF THE PROPOSED ACTION

The Proposed Action (Alternative 1–Preferred Alternative) is to provide for additional splashdown area and test opportunities for the SFDT. This would require approved entry into the easternmost part of the Open Ocean Area of PMNM; therefore, NASA has requested authorization for entry into PMNM through a Conservation and Management permit. This entry would consist of the splashdown and recovery of expended flight hardware and potential fly-over of Nihoa Island and its surrounding Special Management Area from scheduled SFDTs beginning in 2015. NASA could have up to two technology testing launches each year for the next 5 years (June to August, 2015 through 2019). These additional test opportunities would increase the probability of successful test flights and lower the risk of a scenario for an unplanned (i.e., anomalous) termination of the test flight.

1.4 COOPERATING AND COORDINATING AGENCY

In accordance with 40 CFR 1508.5, a *Cooperating Agency* means any Federal agency other than a Lead Agency that has jurisdiction by law or special expertise with respect to any environmental impact involved in a proposal (or a reasonable alternative) for major Federal action significantly affecting the quality of the human environment. The selection and responsibilities of a Cooperating Agency are described in 40 CFR 1501.6. NASA is the Lead Agency for preparation of this SEA. NASA considers the Co-trustees of PMNM as Cooperating Agencies, as any approved permit would be a joint permit signed by all the agencies (NOAA, U.S. Fish and Wildlife Service [USFWS], and State of Hawaii as noted in 40 CFR 1508.5 and 40 CFR 1508.6). This permit would grant authorization for the splashdown and recovery activities of future SDFT flight tests to take place in the easternmost part of PMNM. The SEA must be finalized before the permit is approved. As the Cooperating Agencies have a joint action in issuing the Conservation and Management Permit to NASA, this SEA also serves to fulfill the NEPA obligations for the PMNM Co-Trustees. NASA, as the project proponent, is the Lead Agency and is responsible for ensuring overall compliance with applicable environmental statutes, including NEPA.

A Coordinating Agency refers to an agency that was instrumental in the preparation of this SEA. NASA considers the U.S. Navy to be a Coordinating Agency since the PMRF facilities and range have been selected as the baselined location for the LDSD SFDT campaigns.

The LDSD is being developed under the NASA Space Technology Mission Directorate (STMD) and is neither associated with any Department of Defense (DoD) program nor using any repurposed weapons technology. The LDSD project is not regulated by any of the following treaties: Strategic Arms Reduction Treaty, Intermediate-Range Nuclear Forces Treaty, Open Skies Treaty, Anti-ballistic Missile Treaty, or Chemical Weapons Convention.

1.5 PUBLIC NOTIFICATION AND REVIEW

In accordance with the CEQ, and NASA regulations for implementing NEPA, NASA is soliciting comments on this Draft SEA from interested and affected parties. A Notice of Availability for the Draft SEA has been published in the newspapers identified in Table 1-1.

Table 1-1. Local Newspapers

Country or State	City/Town	Newspaper
Hawaii	Kauai	*The Garden Island*
	Honolulu	*Star Advertiser*
	Honolulu	*Environmental Notice, Office of Environmental Quality Control*

Copies of the Draft SEA have been placed in local libraries and are available over the Internet at http://sites.wff.nasa.gov/code250/docs/NASA_LDSD_DSEA.pdf. Appendix A lists agencies, organizations, and libraries that have been sent a copy of the Draft SEA.

1.6 DECISION(S) TO BE MADE

The decision(s) to be made are based in part on the analysis presented in the SEA. Following the public review period (as specified in the newspaper notices), NASA will consider public and agency comments received to decide whether to (1) issue a Final SEA and a Finding of No Significant Impact, which would allow the Proposed Action to proceed; or (2) conduct additional environmental analysis (if needed); or (3) select the Alternative 2 or the No-action Alternative; or (4) prepare a Notice of Intent to prepare an Environmental Impact Statement. The PMNM Co-Trustees will make the decision whether to issue the NASA LDSD project a Conservation and Management Permit authorizing entrance into PMNM.

1.7 RELATED ENVIRONMENTAL DOCUMENTATION

Environmental documents for some of the programs, projects, and installations within the geographical scope of this SEA that have undergone environmental review to ensure compliance with the NEPA and EO 12114, Environmental Effects Abroad of Major Federal Actions, include the following:

- Hawaii–Southern California Training and Testing EIS/OEIS, August 2013, and Record of Decision, December 2013
- *National Aeronautics and Space Administration Low Density Supersonic Decelerator Technology Demonstration Mission Pacific Missile Range Facility*, Environmental Assessment, May 2013
- *Hawaii Range Complex Environmental Impact Statement/Overseas Environmental Impact Statement*, May 2008, and Record of Decision, June 2008

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2.0 Description of Proposed Action and Alternatives

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2.0 DESCRIPTION OF PROPOSED ACTION AND ALTERNATIVES

This chapter describes the modifications made to the 2013 LDSD Final EA Proposed Action (Section 2.1), Test Description and Procedures (Section 2.2), Launch Trajectory (Section 2.3), Launch Operation (Section 2.4), and the No-action Alternative (Section 2.5). These changes describe the No-action Alternative for this SEA and are incorporated into Alternatives 1 and 2. The topics in Sections 2.1.2 (Proposed Additional Splashdown Area) and Section 2.5 (Alternative 2) in this SEA are new and were not in the 2013 LDSD Final EA.

2.1 NO-ACTION ALTERNATIVE

Under the No-action Alternative, NASA would conduct the Proposed Action as detailed in the 2013 LDSD Final EA with the clarification that some recovery aids discussed in the EA may or may not be employed. This proposed test campaign would consist of launch, operation, and recovery of up to four missions from a designated location on PMRF. The SFDT campaign would consist of up to four flights from approximately June to July 2014 and June to August 2015. One flight was conducted in 2014, and up to three flights could be conducted in in 2015. Under the No-action Alternative, Sections 2.2.2.1 (Operational Facilities) and 2.4.2 (Launch Operation) of this SEA would apply.

2.1.1 TECHNOLOGY DEVELOPMENT

NASA's STMD established the LDSD project as a test architecture for the development and full-scale testing of decelerator technologies at representative conditions to those found on the planet Mars. The current decelerator technologies were developed in the 1970s as part of NASA's Viking Program, which sent two probes to the Martian surface. Since these early Mars landers, the main focus on technology development has been on the landing phase of orbital insertion.

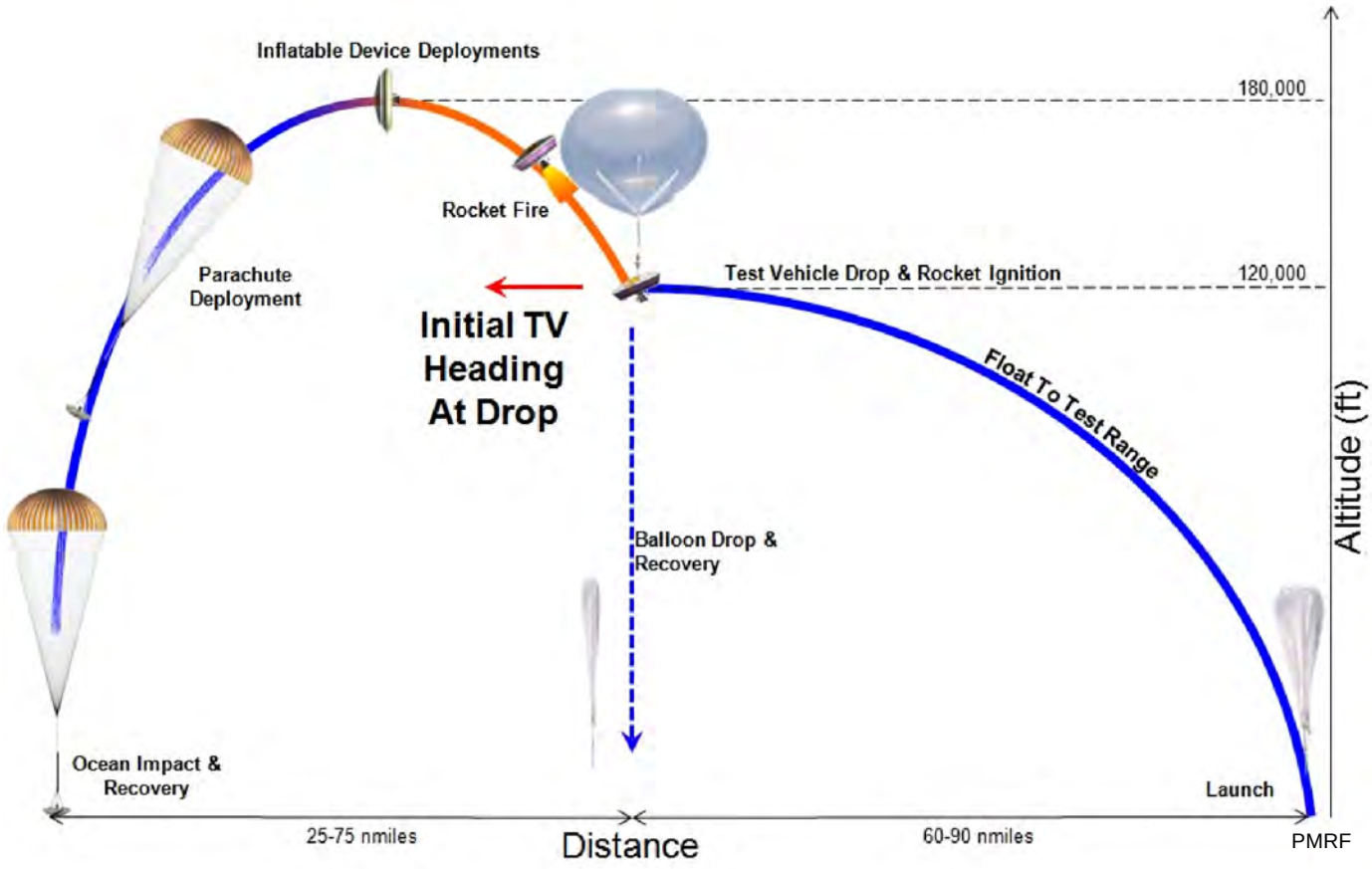
The decelerator technologies that could be developed through the LDSD project enable the following:

- Put more mass on the Martian surface in a single landing
  - Increase cost effectiveness of missions
  - Open up possibilities for future human exploration of Mars
  - Enable NASA to take advances of new rocket systems being developed
    - Current (United Launch Alliance): Delta IV-H, approximate capacity 27,569-kilograms (kg) (60,779-pounds [lb]) to Low Earth Orbit (LEO)
    - Future (Space Exploration Technologies Corporation): Falcon 9 Heavy, approximate capacity 53,000 kg (116,845 lb) to LEO

- Open up more of the Martian surface for landing
  - Current decelerators require a lot of atmosphere to slow descent, restricting landings to only the lowest points on Martian surface
  - New decelerators open up Martian plateau and mountains for direct landings
- Increase the probability of landing at a desired location on the Martian surface
  - Parachute drift is a significant contributor to inaccuracy
  - Less atmosphere on descent potentially opens up delaying parachute deployment until closer to the surface

Under this broad project scope, the LDSD project could execute up to two SFDTs per year for the next 5 years (June through August, 2015 to 2019) at the U.S. Navy's PMRF on Kauai, Hawaii. The focus of the LDSD project's 2014 campaign was to validate the test architecture itself, build confidence in the test ConOps, and closeout many lingering unknowns related to first use hardware and techniques. An added benefit was the certification of the Supersonic Inflatable Aerodynamic Decelerator (SIAD), specifically the Robotic class design (denoted SIAD-R). NASA has scheduled two SFDTs to validate the design of a supersonic parachute design to be flown in conjunction with the validated SIAD-R decelerator.

With each SFDT, the NASA Jet Propulsion Laboratory (JPL) designed Test Vehicle is dropped from the 1 million cubic meter (34 mcf) scientific balloon at approximately 37,000 m (120,000 ft). After the Test Vehicle drop, small solid-fuel rocket motors ignite to spin-stabilize the Test Vehicle ahead of the main motor ignition. The main motor for all SFDTs is an Orbital Alliant Techsystems (ATK), Incorporated manufactured Star 48B long nozzle solid-fueled rocket engine. The Star 48 is ignited, propelling the Test Vehicle upwards to a maximum altitude of approximately 54,000 m (180,000 ft) and at a speed of approximately Mach 3.8. The Test Vehicle then deploys its SIAD to slow its velocity to approximately Mach 2. The Test Vehicle's main supersonic parachute then deploys, carrying the Test Vehicle safely for a controlled splashdown within a pre-coordinated operational area located west by northwest of PMRF. Starting with the 2015 campaign, NASA is seeking authorization from the PMNM Co-Trustees to potentially fly over, splashdown, and recover floating expended flight hardware within the boundary of PMNM, but outside of the 5.6-km (3-nm) Special Management Area surrounding Nihoa Island. Figure 2-1 illustrates the LDSD test operational sequence at PMRF, which would include the planned (nominal) landing operations of the balloon and Test Vehicle within the operational area. The environmental impacts for this operational area were assessed in the 2013 LDSD Final EA (results are hereby included by reference).



LDSD Supersonic Flight Dynamics Test Operational Sequence

Kauai, Hawaii

Figure 2-1

21_sfdt, 4/1/2015

2.1.1.1 Test Description and Procedures

2.1.1.1.1 Unmodified Sections of Test Description and Procedures

The following Test Description and Procedures sections will remain as outlined and detailed in the 2013 LDSD Final EA. These sections describe the No-action Alternative for this SEA and are incorporated into Alternatives 1 and 2. The 2013 EA section numbers are denoted in parenthesis after each section heading bullet.

- Supersonic Flight Dynamic Test (2.2.1.1)
- Test Vehicle System Information (2.2.1.2)
- Balloon Launch Platform (2.2.2)
- SFDT Test Vehicle (2.2.3)
- Test Vehicle System Ordnance Items and Storage (2.2.5)
- Test Vehicle Instrumentation System (2.2.6)
- Test Vehicle Global Positioning System (2.2.7)
- Test Vehicle Command Systems (2.2.8)
- Test Vehicle Flight Termination System (2.2.9)

2.1.1.1.2 Modified Sections of Test Description and Procedures

The following sections have been modified from what is stated in the 2013 LDSD Final EA. These sections describe the No-action Alternative for this SEA and are incorporated into Alternatives 1 and 2. The 2013 EA section numbers are denoted in parentheses after each heading.

2.1.1.1.2.1 Operational Facilities (2.2.4)

Any appropriate and available operational facility at PMRF could be used for the proposed SFDT. These modifications would also apply to Alternative 2 and the No-action Alternative. In addition to the facilities identified in the 2013 LDSD Final EA, the following facilities have been added:

Building 360—Administrative Offices

NASA would use Building 360 to provide office space and a dedicated conference room for project use during deployment to PMRF. The building would be equipped with printers, copiers, projections screens, and white boards. Communication interfaces are needed throughout the facility.

Building 384—Aircraft Hangar

NASA requires the use of Building 384 as a “Day of Launch Media Center.” A Transportable Satellite Ground Station would be located outside on the north side of Building 384.

Building 560—Balloon/Test Vehicle Operations Center

NASA would use Building 560 as the operations center for both NASA Balloon and Test Vehicle teams during launch operations. This facility is the location of the Balloon and Test Vehicle Electronic Ground Support Equipment (EGSE). The majority of the commands during the mission would be initiated from this location; the only exception would be the UHF commands associated with the Test Vehicle drop circuit. The drop circuit commands would be initiated from Building 105 by the U.S. Navy's Range Safety Organization.

2.1.1.2 Launch Trajectory

2.1.1.2.1 Unmodified Sections of Launch Trajectory

The following Launch Trajectory sections will remain as outlined and detailed in the 2013 LDSD Final EA. These sections describe the No-action Alternative for this SEA and are incorporated into Alternatives 1 and 2. The 2013 EA section numbers are denoted in parenthesis after each section heading bullet.

- SFDT Test Vehicle Nominal Trajectory Information (2.3.2)

2.1.1.2.2 Modified Sections of Launch Trajectory

The following sections have been modified from what is stated in the 2013 LDSD Final EA. These sections describe the No-action Alternative for this SEA and are incorporated into Alternatives 1 and 2. The 2013 EA section numbers are denoted in parenthesis after each heading.

2.1.1.2.2.1 Balloon Launch Platform Notional Trajectory (2.3.1)

The notional predicted trajectories of the balloon from PMRF include possible over-flight of Nihoa Island, the Special Management Area around Nihoa Island, and the easternmost part of PMNM.

Launch decisions for the SFDT are tied directly to suitability of winds from ground level to a height of approximately 55,000 m (180,000 ft). Meteorological (MET) soundings are used to gauge mid- and upper level wind conditions. Two sizes of latex MET balloons (2,000 grams [g] [70.5 ounces] and 30 g [1 ounce]), would be released to measure lower- and mid-level wind conditions from ground up to a height of approximately 33,500 m (110,000 ft) while Super Loki sounding rocket-deployed Rocket Balloon Instruments (ROBINs) are used to calculate upper level wind conditions to a height of approximately 90,000 m (295,000 ft). Two 2,000-g (70.5-ounce) MET balloons would be released the day of launch (one 1.5 hours prior to launch and the other 1.5 hours after launch). Each 2,000-g (70.5-ounce) MET balloon would be equipped with a radiosonde that contains instruments capable of making direct in-situ measurements of air temperature, humidity, and pressure. These observed data are transmitted immediately to the ground station by a radio transmitter located within the instrument package. The Super Loki is a two-stage rocket system used to obtain density,

temperature, ozone, and wind data at altitudes ranging from 85,000 to 110,000 m (279,000 to 361,000 ft) to ground level. The first stage is a solid propellant rocket, 0.1 m (0.3 ft) in diameter and 2.0 m (6.6 ft) long. The second stage is an inert instrumented Dart, 0.054 m (0.177 ft) in diameter and 1.26 m (4.13 ft) long. Both stages consist of an aluminum case with an internally burning cast-in-the-case solid propellant. The propellant fuel is a polysulfide polymer, and the oxidizer is ammonium perchlorate. Each Super Loki rocket would deploy a ROBIN, (a metalized 0.5-mil thick Mylar sphere, 1.0 m [3.3 ft] in diameter, inflated to 12 hectopascal pressure), to a height of approximately 89,900 m (295,000 ft. Since the ROBIN sphere's mass and spherical diameter is known, as the sphere falls from this initial deployment height to a minimum height of approximately 30,500 m (100,000 ft), where the higher external pressure causes the sphere to collapse, radar tracking information can be used to calculate wind direction, wind velocity, temperature, density, and pressure.

The balloon's pressure and altitude would remain at a fairly constant float level (constant pressure altitude), oscillating ±200 m (650 ft) with ballast commands. The balloon's internal pressure and altitude could be controlled via radio commands sent from the command station. If the balloon pressure needs to be lowered, a command is sent to vent helium until the correct pressure is achieved. Should the internal pressure need to be raised, flight controllers can send a command to slowly release a portion of the ballast material until the correct pressure and a slightly higher float altitude is again achieved. The LDSD balloon system carries approximately 113 kg (250 lb) of 0.3 to 0.5 mm (0.01 to 0.02 inches) steel shot ballast that has been designed to be slowly and completely released during the ascent phase. It should be noted that while such fine-tune control of the balloon flight is possible by releasing ballast material, gross trajectory control (i.e., steering) cannot be achieved with the balloon system; the balloon system would follow the prevailing wind patterns encountered during its flight. These wind patterns were part of the computational algorithms used during the Monte Carlo simulations utilized to project flight trajectories.

The Monte Carlo method is a problem solving technique which approximates the probability of certain outcomes by running multiple trial runs, called simulations, using random variables. Monte Carlo simulations were employed to take an identified set of variables (e.g., wind patterns) representing real world conditions that could affect the LDSD flight and used computational algorithms to find potential outcomes (flight trajectories) of "what-if" scenarios. These scenarios were not screened against the safety and mission success criteria, so several of these trajectories would not be executed under the project's established Go/No Go criteria.

Under the assumption that all possible trajectories were allowed to fly, NASA estimates the balloon has approximately a 0.4% chance of reaching float altitude within PMNM and a 20% chance of entering PMNM after reaching float altitude. These probabilities are reduced when NASA and the U.S. Navy apply the project's established Go/No Go criteria (e.g., safety restrictions, proper weather conditions, operational status of all LDSD subsystems, telemetry checks, and readiness of recovery systems). These test rules eliminate trajectories that are predicted to fly out directly over large populated

areas or follow a trajectory outside boundaries set by NASA, the U.S. Navy, and the FAA. (Combs, 2014) Figure 2-2 depicts notional test footprints for a balloon supersonic flight test launch trajectory.

2.1.1.3 Launch Operation

2.1.1.3.1 Unmodified Sections of Launch Operation

The following Launch Operation sections will remain as outlined and detailed in the 2013 LDSD Final EA. These sections describe the No-action Alternative for this SEA and are incorporated into Alternatives 1 and 2. The 2013 EA section numbers are denoted in parenthesis after each section heading bullet.

- Pre-Launch Activities (2.4.1)
  - Launch Preparation Activities (2.4.1.2)
  - Transportation and Storage (2.4.1.1)
  - Personnel, Utility and Equipment Requirement (2.4.1.3)
  - Safety Hazard Issues (2.4.1.4)
- Launch Activities (2.4.2)
  - Launch Control (2.4.2.2)
  - Telemetry Data (2.4.2.4)

2.1.1.3.2 Modified Sections of Launch Operation

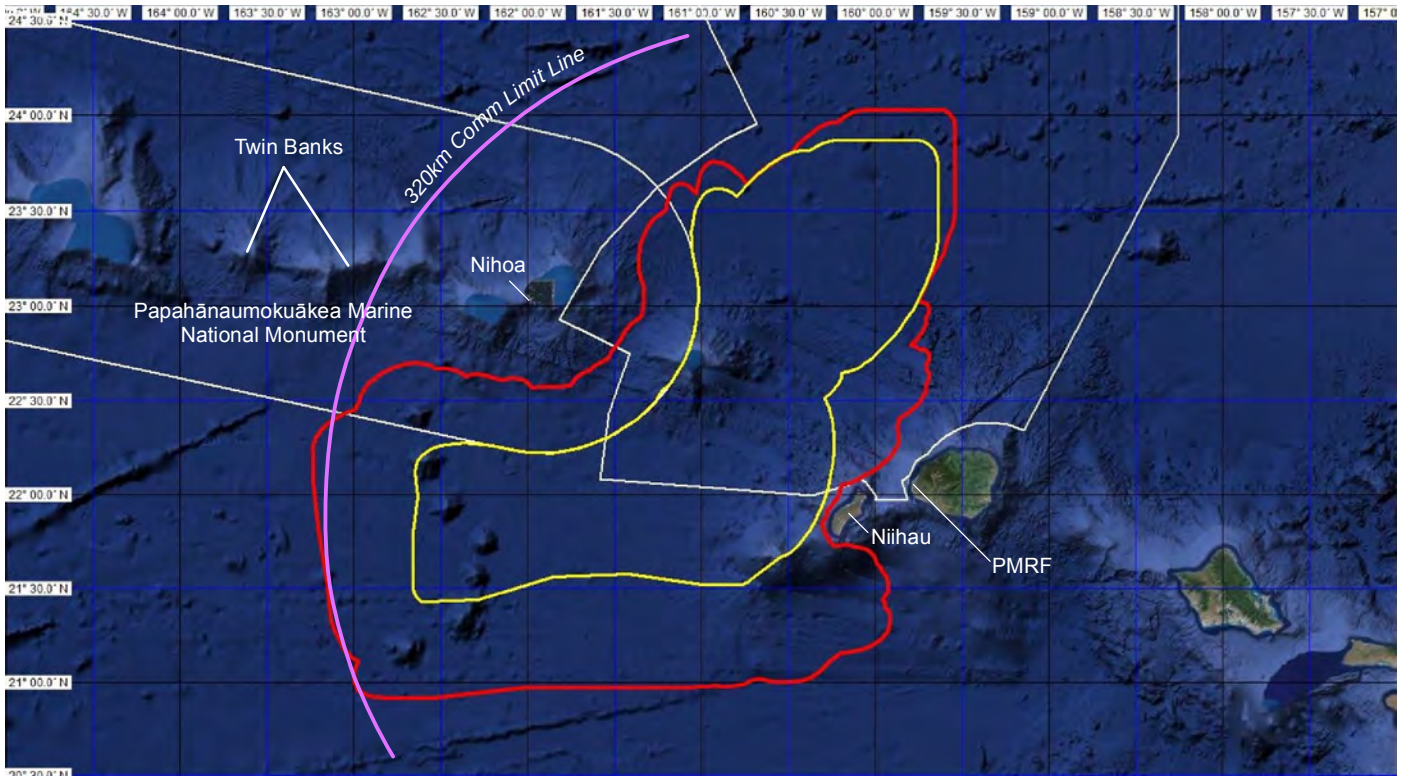
The following Launch Operation sections have been modified from what is stated in the 2013 LDSD Final EA. These sections describe the No-action Alternative for this SEA and are incorporated into Alternatives 1 and 2. These modifications would also apply to Alternative 2 and the No-action Alternative. The 2013 EA section numbers are denoted in parenthesis after each heading.

2.1.1.3.2.1 Day of Launch Timeline (2.4.2.1—Table 2-3)

For the +2.5 hours [Time (T-Minus)] event description, a balloon spotter aircraft could be deployed.

2.1.1.3.2.2 Metric Data (2.4.2.3)

It is critical to the success of the LDSD project that accurate tracking information be captured and analyzed in real-time starting at launch of the balloon, during execution of the SFDT, and through splashdown of expended flight hardware to aid in recovery. NASA and the U.S. Navy would work cooperatively to develop a comprehensive and robust radar tracking plan for both the balloon Launch Platform and the Test Vehicle based on the available radar tracking assets at PMRF. High speed and high resolution memory data storage devices for each flight would be onboard the Test Vehicle and



EXPLANATION

- 320-km Communications Limit Line Approximation
- Nominal Highlighted Trajectory
- Off-Nominal Trajectory

NORTH

Examples of Potential Test Footprints for a Balloon Supersonic Flight Dynamics Test Launch Trajectory

PMRF, Niihau, Open Ocean, and PMNM

Figure 2-2

22_sigma, 4/1/2015

must be recovered. Part of the flight reconstruction process would be physical examination of the actual decelerators, so those too must be recovered.

During the 2014 campaign, the NASA and U.S. Navy team demonstrated the ability to precisely predict and track the scientific balloon, Test Vehicle, and other associated flight hardware through splash down. Lessons learned from the 2014 campaign would be leveraged in future flights (beginning in June 2015) to improve the project's prediction, tracking, and recovery performance.

2.1.1.3.2.3 Other Support Activities (2.4.2.5)

Other launch support activities could be required to execute the Proposed Action. Table 2-1 lists and summarizes those other support activities that have been modified from the 2013 LDSD Final EA and describe the No-action Alternative for this SEA and are incorporated into Alternatives 1 and 2.

Table 2-1. Summary of Other Support Activities (Table 2-5)

Support Activity	Support Activities
Command System	• No modification
Timing Signals	• No modification
Visual Countdown	• No modification
Communications (Air/Ground/Video/ Network/Telephone/ Frequencies	• NASA could use a recovery spotter aircraft and if used, would require voice communications with the recovery spotter aircraft and PMRF's surveillance aircraft that may be supporting recovery efforts.
Real Time Data Display/ Control	• No modification
Photographic	• No modification

2.1.1.3.2.4 Recovery and Recovery Support (2.4.3.1)

NASA and the U.S. Navy have evaluated multiple contingent flight scenarios and terminate conditions in addition to the planned (nominal) test plans. The combined flight system (balloon and Test Vehicle) would be continually tracked by PMRF ground instrumentation providing positional data to the U.S. Navy Range Safety Organization. The present position of the flight system along with individual impact dispersions (which is a variable circle with a maximum radius 26 km [14 nm]) for the balloon carcass, flight train system, and Test Vehicle would be overlaid onto a series of decisional safety displays. The splashdown dispersions would be compared to boundaries designed to protect the general public on Niihau and Kauai islands along with safety criteria established to protect non-participating ships and aircraft. During the 2014 campaign, the NASA and U.S. Navy team demonstrated the ability to precisely predict and track the balloon, Test Vehicle, and other associated flight hardware through splashdown.

Lessons learned from the 2014 campaign would be leveraged in future campaigns to improve the project's prediction, tracking, and recovery performance.

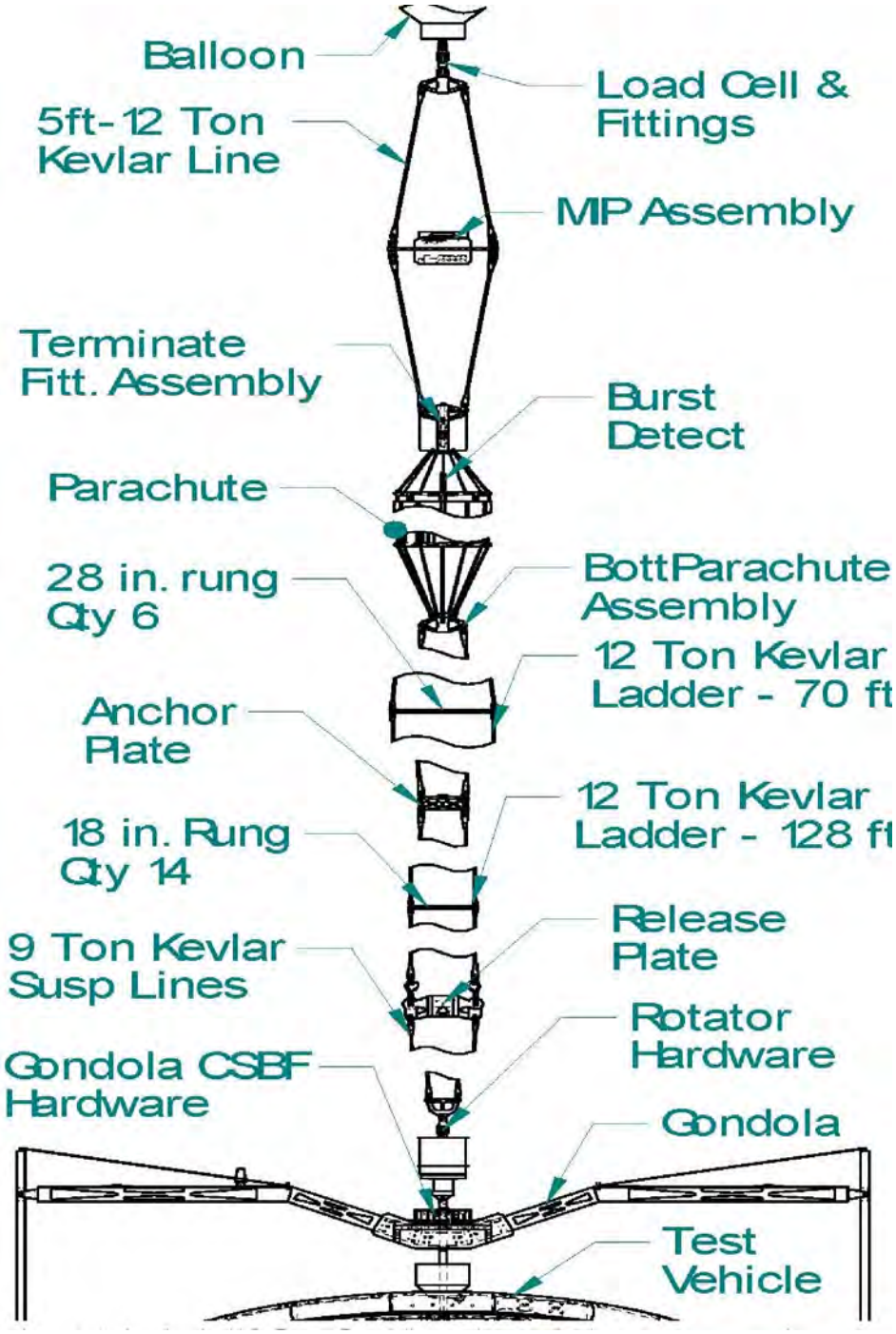
The LDSD project would maintain continuous communications with the supporting seaborne vessels and aircraft to ensure situational awareness during the test. The NASA Recovery Director serves as the responsible Point of Contact for execution of the NASA Recovery Plan once the combined flight system (balloon and Test Vehicle) is over ocean. The NASA Recovery Plan address both planned (i.e., nominal) and contingent procedures associated with the SFDT, early termination, and inflight unplanned scenarios (anomalies) over water. All procedures would be executed in compliance with established NASA and U.S. Navy NEPA requirements for the LDSD project and PMRF.

NASA would utilize up to three seaborne vessels and up to two U.S. Navy aircraft during the future campaigns to execute recovery operations immediately following each SFDT. The recovery operations would be to deploy the seaborne vessels prior to SFDT initiation to Test Support Positions (TSP) based on the predicted Test Vehicle drop location for the following day. The time of the deployment for seaborne vessels would depend on the location of the TSPs and the transit speed of the particular vessels assigned to those TSPs. A TSP flight path would also be assigned for any supporting recovery aircraft along with a test specific timeline. These supporting aircraft would be deployed according to their timeline.

After the SFDT, the NASA Recovery Director would receive confirmation of balloon termination, deployment of decelerators, status of ordnance items, and best estimate of splashdown locations for each item to be recovered. This information would be provided by multiple project elements including the balloon team, Test Vehicle team, and PMRF ground instrumentation. This information would be passed on to supporting recovery assets for verification. When recovery assets encounter expended flight hardware, it would be rendered safe by onboard safety personnel before being brought aboard the appropriate seaborne vessel.

Almost all expended flight hardware is then recovered from the ocean, with the exception of the balloon flight train (Figure 2-3). This flight train connects the Test Vehicle to the balloon. The flight train weighs approximately 376 kg (830 lb); is approximately 302 m (990 feet) long; and consists of a burst parachute (a safety instrument), sensors, connections, and Kevlar® cabling. This system would sink rapidly in the ocean and would be almost impossible to locate. Once the Test Vehicle is dropped, a signal is sent that separates the flight train from the balloon and in the process, rips the balloon to allow descent.

Identified recoverable items would be returned to Port Allen, Kauai, Hawaii and off-loaded to NASA and U.S. Navy personnel. The recovered items would be sorted by destination at Port Allen, then relocated per a coordinated disposition plan.



Flight Train Assembly

Figure 2-3

23_flight_train, 4/1/2015

Table 2-2 lists and summarizes these other potential recovery activities that have been modified from the 2013 LDSD Final EA and describe the No-action Alternative for this SEA and are incorporated into Alternatives 1 and 2.

Table 2-2. Overview of Recovery Aids (Table 2-6)

Flight Hardware	Recovery Aids
Balloon Launch Platform	• Recovery aids such as Global Positioning System (GPS) beacons or other similar transmitting systems could be used on the balloon. • The notional concept of operations (ConOps) for recovering the balloon could be a spotter plane within visual range as the balloon falls and that reports its position once in the water.
Test Vehicle	• Could be equipped with two different types of GPS locators • One GPS locator system could relay data over the Argos satellite network. • One GPS locator system could relay data over the Iridium satellite network. • The GPS locators could be situated on the Test Vehicle such that one or the other could function despite the orientation of the Test Vehicle in the water.
Flight Image Recorder	• Could be equipped with a ruggedized GPS locator developed by the U.S. Army • Could be equipped with a water activated audible pinger developed by Teledyne Benthos • The notional ConOps is that the Flight Image Recorder would stay with the Test Vehicle and, if used, any water activated recovery aids do not engage. In the event of an anomaly, the Flight Image Recorder is designed to separate from the Test Vehicle. Depending on the circumstances of the anomaly, if used, the water activated recovery aids on the Flight Image Recorder may help locate the Test Vehicle.

2.1.1.3.2.5 Potential Test Vehicle Recovery Aids (2.4.3.2)

In addition to recovery aids required by the Range and the LDSD program, other potential test vehicle recovery aids could be used.

2.1.1.3.2.5.1 Flotation Duration (2.4.3.2.1)

All recovery aids may be required to remain active for a minimum of 4 days.

2.1.1.3.2.5.2 Electronic Aids (2.4.3.2.2)

The balloon and the Test Vehicle could use two different types of electronic recovery aids. The first could be Trident's Iridium GPS beacon, which could be used by the

balloon and the Test Vehicle. The second system of the balloon could be a Telonics marine Argos/GPS beacon. The balloon could also be equipped with two audible beacons; one of each could be mounted in the same locations as the other recovery aids (top and bottom of the balloon). The recovery vessel could have an underwater hydrophone designed specifically to listen for these if they are activated.

The Test Vehicle would contain water-tight data enclosures that are intended to stay with the vehicle upon water impact. In the event that these enclosures separate from the vehicle upon impact, they could be equipped with audible beacons for water recovery. The Test Vehicle could also be equipped with three audible beacons mounted on the rear camera boxes in the event the camera boxes become dislodged from the vehicle during impact with the water. The Test Vehicle would utilize the Iridium system to account for either of two possible float orientations in the water.

2.1.1.3.2.5.3 Visual Aids (2.4.3.2.3)

As currently planned, the balloon visual aids could include two strobe lights to aid the spotter planes in the initial location. The units would be located in the same locations as the Iridium and Argos beacons and would be salt water activated.

The Test Vehicle visual aids could also include two strobe lights to aid the spotter planes. The units would be located in the shoulder region of the Test Vehicle and would be salt water activated.

2.2 ALTERNATIVE 1—PREFERRED ALTERNATIVE

The Proposed Action (Alternative 1–Preferred Alternative) incorporates all activities described in the No-action Alternative, with clarification that some recovery aids discussed in the 2013 EA may or may not be employed and provides for additional splashdown area and test opportunities for the SFDT. This would require approved entry into the easternmost part of the Open Ocean Area of PMNM; therefore, NASA has requested authorization for entry into PMNM through a Conservation and Management permit. This entry would consist of the splashdown and recovery of expended flight hardware and potential fly-over of Nihoa Island and its surrounding Special Management Area from scheduled SFDTs beginning in 2015. NASA could have up to two technology testing launches each year for the next 5 years (June through August, 2015 to 2019). These additional test opportunities would increase the probability of successful test flights and lower the risk of a scenario for an unplanned (i.e., anomalous) termination of the test flight.

2.2.1 PROPOSED ADDITIONAL SPLASHDOWN AREA

NASA proposes to use an additional 37,600 km^2 (10,950 nm^2) of splashdown area for future SDFT test flights. Of the approximately 37,600 km^2 (10,950 nm^2), approximately 28,730 km^2 (8,370 nm^2) is Open Ocean Area within PMNM and the other approximately 8,875 km^2 (2,600 nm^2) of Open Ocean Area is north of PMNM (see Figure 1-5).

NASA submitted a Conservation and Management Permit requesting authorization for use of the 28,730 km^2 (8,370 nm^2) of Open Ocean Area within PMNM. If granted, the PMNM Conservation and Management Permit would authorize entry, splashdown, and recovery of expended flight hardware within PMNM.

This additional splashdown area excludes the 70 hectares (170 acres) of Nihoa Island and the approximately 128.5 km^2 (37.5 nm^2) Special Management Area within 5.5 km (3 nm) surrounding Nihoa Island. To ensure the excluded area waters and/or island will not be entered, one of two scenarios would occur: (1) the LDSD Program would initiate the SFDT in such a manner that expended flight hardware, with the exception of the balloon flight train, would be recovered before drifting into the excluded area; or (2) the flight system would overfly the excluded area, and the Test Vehicle would be dropped outside 5.5 km (3 nm) from Nihoa Island. Therefore, expended flight hardware would not be deposited on Nihoa Island or within the Special Management Area surrounding the island (see Figure 1-5).

2.3 ALTERNATIVE 2—ADDITIONAL LAUNCH YEARS

Under Alternative 2, NASA would conduct the No-action Alternative as described in this SEA, which is the Proposed Action as detailed in the 2013 LDSD Final EA with clarification that some recovery aids discussed in the 2013 EA may or may not be employed. Under Alternative 2, NASA would conduct the launch, operation, and recovery of up to two missions per year over the next 5 years (June through August, 2015 to 2019) from a designated location on PMRF using the flight trajectory outlined in the 2013 LDSD Final EA. Under Alternative 2, Sections 2.1.1.1.2.1 (Operational Facilities) and 2.1.1.3 (Launch Operation) of this SEA would apply.

3.0 Affected Environment and Environmental Consequences

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3.0 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

This chapter describes the No-action Alternative, Alternative 1, and Alternative 2. This chapter discusses and analyzes (1) the environmental characteristics that may be affected by the Proposed Action and (2) the environmental impacts to these characteristics. This information serves as a baseline from which to identify and evaluate environmental changes resulting from the LDSD operations that would occur in approximately 28,730 km^2 (8,370 nm^2) of Open Ocean Area within the easternmost part of PMNM and approximately 8,875 km^2 (2,600 nm^2) of Open Ocean Area north of PMNM. To provide a baseline point of reference for understanding any potential environmental effects, the affected environment is briefly described; any components of greater concern are described in greater detail. CEQ regulations for implementing NEPA also require the discussion of environmental impacts in proportion to their significance, with only enough discussion of non-significant issues to show why more study is not warranted. The analysis in this SEA considers the current conditions of the affected environment and compares those to conditions that might occur should NASA implement the Proposed Action.

The Pacific region of PMRF, the island of Niihau, the Open Ocean Area, and the Global Environment were detailed and analyzed in the 2013 LDSD Final EA and are incorporated by reference. All analyses presented in the 2013 LDSD Final EA for these locations apply for all future flight tests.

Available reference materials, including natural resources management plans and EAs, were reviewed. To fill data gaps (questions that could not be answered from the literature) and to verify and update available information, subject matter experts and program personnel were contacted.

Table 3-1 presents the results of the process of identifying resources to be analyzed in this SEA.

Table 3-1. Resources Considered for Analysis in this SEA

Resource	Open Ocean Area (Within and Outside of PMNM)		Nihoa Island	
	Analyzed in Detail in this SEA	If Yes, SEA Section If No, Rationale for Elimination	Analyzed in Detail in this SEA	If Yes, SEA Section If No, Rationale for Elimination
Air Quality	Yes	Section 3.2.1.1	No	No incremental or cumulative adverse environmental impacts to air quality were identified beyond those identified in the detailed analysis presented in the 2013 LDSD Final EA (which is hereby incorporated by reference) and in Section 3.2.1.1 of this SEA.
Airspace	No	No incremental or cumulative adverse environmental impacts to airspace were identified beyond those identified in the detailed analysis presented in the 2013 LDSD Final EA, which is hereby incorporated by reference.	No	No incremental or cumulative adverse environmental impacts to airspace were identified beyond those identified in the detailed analysis presented in the 2013 LDSD Final EA, which is hereby incorporated by reference.
Biological Resources				
Coral	Yes	Section 3.2.1.2.2.1	Yes	Section 3.1.2.1.2.2
Bottomfish	Yes	Section 3.2.1.2.2.2	No	N/A*
Seabirds	Yes	Section 3.2.1.2.2.3	Yes	Section 3.2.2.1.2.4
Terrestrial	No	N/A*	Yes	Section 3.2.2.1.2.1
Marine Mammals	Yes	Section 3.2.1.2.2.4	Yes	Section 3.2.2.1.2.2
Threatened and Endangered Species	Yes	Section 3.2.1.2.2.5 (Cetaceans, Pinnipeds, Sea Turtles)	Yes	Section 3.1.2.1.2.1 and 3.1.2.1.2.2
Environmentally Sensitive Habitat Area	Yes	3.1.1.2.2.5	Yes	Section 3.2.2.1.2.3
Endangered Species Act Section 7 Consultation	Yes	Section 3.2.1.2.3	Yes	Section 3.2.2.1.3

*N/A—Resource not applicable and not analyzed for this location.

Table 3-1. Resources Considered for Analysis in this SEA (Continued)

Resource	Open Ocean Area (Within and Outside of PMNM)		Nihoa Island	
	Analyzed in Detail in this SEA	If Yes, SEA Section If No, Rationale for Elimination	Analyzed in Detail in this SEA	If Yes, SEA Section If No, Rationale for Elimination
Cultural Resources				
PMNM	Yes	Section 3.2.1.2.8.1	No	
Open Ocean Area	Yes	Section 3.2.1.2.8.2	N/A*	
Historic Buildings and Structures	N/A*		Yes	Section 3.2.2.1.2.1
Traditional Resources (including burials)	No		Yes	Section 3.2.2.1.2.2
Geology and Soil	No	N/A*	No	The LDSD Program proposes no ground activities on Nihoa Island.
Hazardous Materials and Waste	No	No incremental or cumulative adverse environmental impacts from hazardous material and waste were identified beyond those identified in the detailed analysis presented in the 2013 LDSD Final EA, which is hereby incorporated by reference.	No	No incremental or cumulative adverse environmental impacts from hazardous material and waste were identified beyond those identified in the detailed analysis presented in the 2013 LDSD Final EA, which is hereby incorporated by reference.
Health and Safety	No	No incremental or cumulative adverse environmental impacts relating to Health and safety were identified beyond those identified in the detailed analysis presented in the 2013 LDSD Final EA, which is hereby incorporated by reference.	No	Undeveloped and unpopulated island
Land Use	No	N/A*	No	Undeveloped and unpopulated island

*N/A—Resource not applicable and not analyzed for this location.

Table 3-1. Resources Considered for Analysis in this SEA (Continued)

Resource	Open Ocean Area (Within and Outside of PMNM)		Nihoa Island	
	Analyzed in Detail in this SEA	If Yes, SEA Section If No, Rationale for Elimination	Analyzed in Detail in this SEA	If Yes, SEA Section If No, Rationale for Elimination
Noise	No	No incremental or cumulative adverse environmental impacts to noise were identified beyond those identified in the detailed analysis presented in the 2013 LDSD Final EA, which is hereby incorporated by reference.	No	No incremental or cumulative adverse environmental impacts to noise were identified beyond those identified in the detailed analysis presented in the 2013 LDSD Final EA, which is hereby incorporated by reference.
Socioeconomics	No	No incremental or cumulative adverse environmental impacts to socioeconomics characteristics were identified beyond those identified in the detailed analysis presented in the 2013 LDSD Final EA, which is hereby incorporated by reference.	No	Undeveloped and unpopulated island
Transportation	No	No incremental or cumulative adverse environmental impacts to transportation were identified beyond those identified in the detailed analysis presented in the 2013 LDSD Final EA, which is hereby incorporated by reference.	No	Undeveloped and unpopulated island
Utilities	No	N/A*	No	Undeveloped and unpopulated island
Visual Aesthetics	No	No incremental or cumulative adverse environmental impacts to visual aesthetics were identified beyond those identified in the detailed analysis presented in the 2013 LDSD Final EA, which is hereby incorporated by reference.	No	Undeveloped and unpopulated island

*N/A—Resource not applicable and not analyzed for this location.

Table 3-1. Resources Considered for Analysis in this SEA (Continued)

Resource	Open Ocean Area (Within and Outside of PMNM)		Nihoa Island	
	Analyzed in Detail in this SEA	If Yes, SEA Section If No, Rationale for Elimination	Analyzed in Detail in this SEA	If Yes, SEA Section If No, Rationale for Elimination
Water	No	No incremental or cumulative adverse environmental impacts to water resources were identified beyond those identified in the detailed analysis presented in the 2013 LDSD Final EA, which is hereby incorporated by reference.	No	No incremental or cumulative adverse environmental impacts to water resources were identified beyond those identified in the detailed analysis presented in the 2013 LDSD Final EA, which is hereby incorporated by reference.

3.1 NO-ACTION ALTERNATIVE

Under the No-action Alternative, the SFDTs would follow the planned (i.e., nominal) launch trajectory path outlined in the 2013 LDSD Final EA and with the clarification that some recovery aids discussed in that EA may or may not be employed. Except as described in Section 2.1.1, the No-action Alternative would be identical to the Proposed Action in the 2013 LDSD Final EA and, as such, would have the same environmental consequences as analyzed in that document, which are hereby incorporated by reference. This proposed test campaign would consist of launch, operation, and recovery of up to four missions from a designated location on PMRF. The purpose of the SFDT campaign is to demonstrate and evaluate development of new SIAD and SSRS parachute technologies. The SFDT campaign would consist of up to four flights from approximately June to July 2014 and June to August 2015. One flight was conducted in 2014, and up to three could be conducted in 2015. Under the No-action Alternative, Sections 2.1.1.1.2.1 (Operational Facilities) and 2.1.1.3 (Launch Operation) of this SEA would apply. Any potential environmental impacts are discussed and analyzed in the 2013 LDSD Final EA.

Under the No-action Alternative, flight activities (expended hardware, vessels and aircraft, and unrecoverable sinkable items) associated with the SFDT would not enter or have an adverse effect on Nihoa Island, the Special Management Area around Nihoa Island, or PMNM as a whole.

3.2 ALTERNATIVE 1—PROPOSED ACTION (PREFERRED ALTERNATIVE)

3.2.1 OPEN OCEAN

Resources Carried Forward for Detailed Analysis for the Open Ocean Area

Table 3-1 presents the results of the process of identifying resources to be analyzed in this SEA, which are air quality, biological resources, and cultural resources. The general organization of resource areas is consistent with the 2013 LDSD Final EA; however, many have been eliminated from the SEA and are detailed in Table 3-1.

Resources Considered but Eliminated from Detailed Analysis for the Open Ocean Area

Fourteen areas of environmental consideration were initially evaluated for the Open Ocean Area to provide a context for understanding the potential effects of the Proposed Action and to provide a basis for assessing the severity of potential environmental effects. These areas included air quality, airspace, biological resources, cultural resources, geology and soils, hazardous materials and waste, health and safety, land use, noise, socioeconomics, transportation, utilities, visual aesthetics, and water resources. Ultimately 3 of the 14 areas of environmental consideration were addressed for the Open Ocean Area (air quality, biological resources, and cultural resources). The

remaining resource areas were not analyzed in such a manner. Those resources not warranting further discussion are presented in Table 3-1.

Papahānaumokuākea Marine National Monument

President George W. Bush established PMNM on 15 June 2006 to protect the resources of the Northwestern Hawaiian Islands (NWHI) (Figure 3-1). The purposes and management regime for PMNM, as well as restrictions and prohibitions regarding activities in PMNM, are set forth in Proclamation 8031 (71 Federal Register 36443, 26 June 2006) (Proclamation).

PMNM is situated in the Pacific Ocean northwest of the Main Hawaiian Islands (MHI). PMNM includes the NWHI Coral Reef Ecosystem Reserve, the Hawaiian Islands National Wildlife Refuge, the Midway Atoll National Wildlife Refuge, and the Battle of Midway National Memorial.

Dedicated to the conservation of the NWHI, PMNM encompasses an area northwest of the MHI from Nihoa Island to Kure Atoll. It is a nearly 362,600-km^2 (140,000-square-mile [mi^2]) area, 160-km (100 miles [mi]) wide and was established to protect marine resources in the area including coral reefs, the endangered Hawaiian monk seal (*Monachus schauinslandi*), the threatened Hawaiian green turtle (*Chelonia mydas*), and the endangered leatherback and hawksbill turtles (*Dermochelys coriacea* and *Eretmochelys imbricata*). PMNM is an approximately 2,220-km (1,200-nm) stretch of coral islands, seamounts, banks, and shoals. (National Oceanic and Atmospheric Administration, 2006).

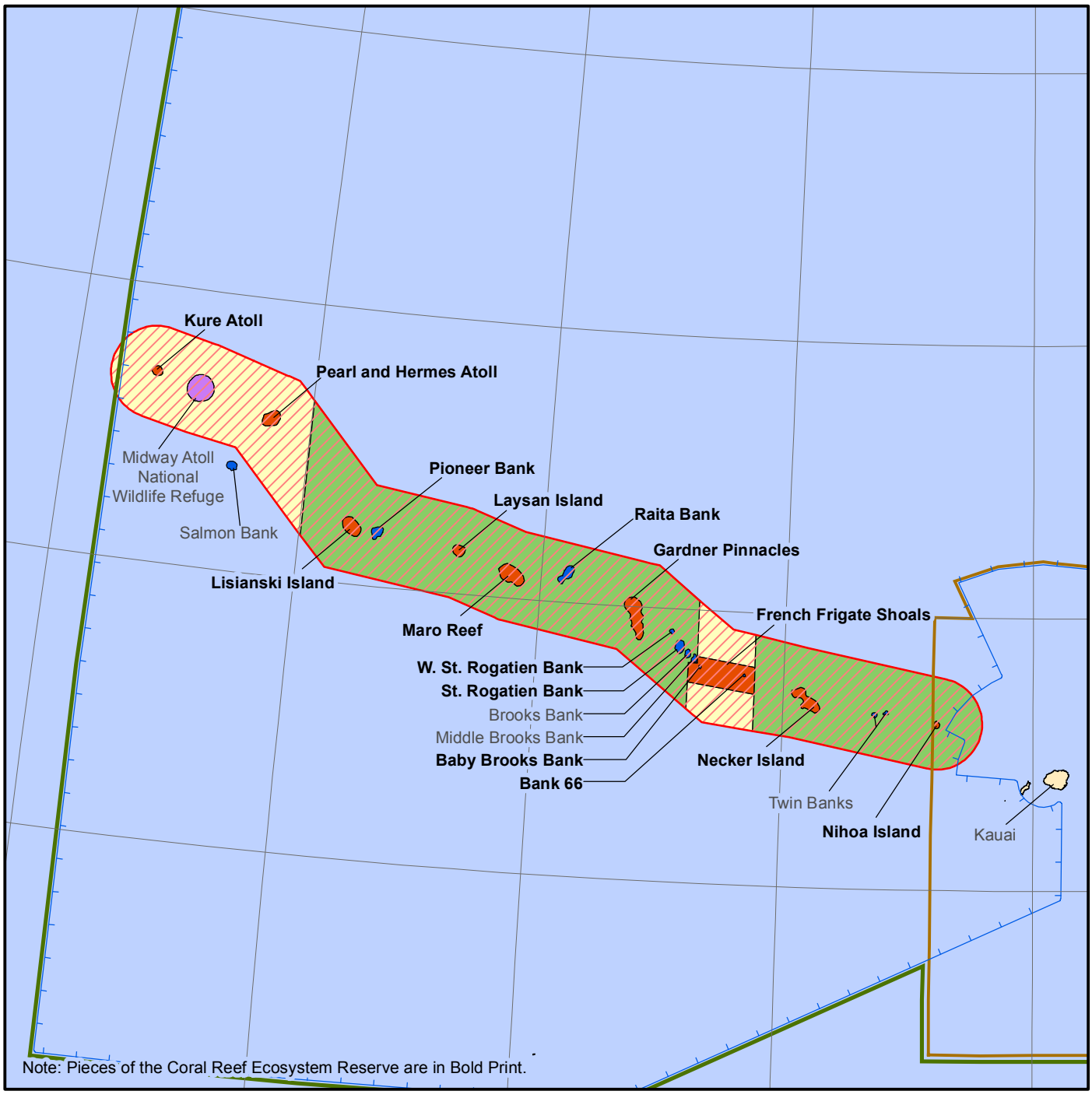
3.2.1.1 Air Quality—Open Ocean (Alternative 1—Proposed Action)

3.2.1.1.1 Region of Influence

The region of influence includes the entire SFDT operations area. The operations area would include the additional splashdown area in the Open Ocean Area, which is approximately 37,600 km^2 (10,950 nm^2), and all operational areas discussed in the 2013 LDSD Final EA. This additional splashdown area includes approximately 28,730 km^2 (8,370 nm^2 within the easternmost part of PMNM and approximately 8,875 km^2 (2,600 nm^2) north of PMNM. Figure 1-5 is an overview of the region of influence.

3.2.1.1.2 Affected Environment

Hawaii's air quality standards (HRS, Chapter 342B, Air Pollution Control and HAR Chapters 11-59 and 11-60.1) are broadly based and adhere to all federal emission standards for hazardous air pollutants. Due to the remote location and low level of human activities, the air of PMNM (NWHI) is relatively pristine. (National Oceanic and Atmospheric Administration, 2014a)



EXPLANATION

- Temporary Operating Area
- Hawaii Range Complex
- Hawaiian Operating Area
- Papahānaumokuākea Marine National Monument
- Bank
- Commercial Fishing Phase-Out Area
- Ecological Reserve
- Hawaiian Islands National Wildlife Refuge
- Midway Atoll National Wildlife Refuge

NORTH

0 100 200 400 Nautical Miles

Papahānaumokuākea Marine National Monument

Northwestern Hawaiian Islands

Figure 3-1

31_monument, 4/1/2015

3.2.1.1.3 Environmental Consequences

The ballast of the balloon system provides stability and control of the balloon during ascent. The LDSD balloon system carries approximately 110 kilograms (kg) (250 pounds [lb]) of ballast consisting of very fine steel shot (grain size 0.3 to 0.5 mm [0.01 to 0.02 inch]), which would be released to adjust the float altitude of the balloon system. In the United States, the U.S. Environmental Protection Agency (EPA) regulates particulate matter of size 2.5 and 10 microns (1 micron is equal to 0.001 mm), as these sizes can be easily breathed into the lungs of humans or animals. However, as the particle size of the ballast exceeds 10 microns, the ballast material is not regulated by EPA. The released ballast would travel in the upper atmospheric winds and be dispersed over hundreds of kilometers. Therefore, under the Proposed Action, the emissions from SFDT would have no significant adverse effect on existing air quality within PMNM.

3.2.1.2 Biological Resources—Open Ocean (Alternative 1—Proposed Action)

3.2.1.2.1 Region of Influence

The region of influence for the Open Ocean Area includes approximately 37,600 km^2 (10,950 nm^2) of additional splashdown area. Of the approximately 37,600 km^2 (10,950 nm^2), approximately 28,730 km^2 (8,370 nm^2) is Open Ocean Area within the easternmost part of PMNM and approximately 8,875 km^2 (2,600 nm^2) of Open Ocean Area north of PMNM. Figure 1-5 is an overview of the region of influence. The following sections provide a summary of biological resources typically located in the region of influence.

3.2.1.2.2 Affected Environment

The affected environment biological resources environment in the Open Ocean Area of influence is described below. Additionally, this area is considered as the same Open Ocean Area described in the 2013 LDSD Final EA and is therefore incorporated by reference. The following sections will remain as outlined and detailed in the 2013 LDSD Final EA. The 2013 EA sections numbers are noted in parenthesis after each section heading bullet.

- Fish (3.3.2.1; page 3-48)
- Essential Fish Habitat (3.3.2.1; page 3-49)

The following sections have been modified from what is stated in the 2013 LDSD Final EA. The corresponding 2013 EA section numbers are denoted in parentheses after each heading.

3.2.1.2.2.1 Coral (3.3.2.2; page 3-47)

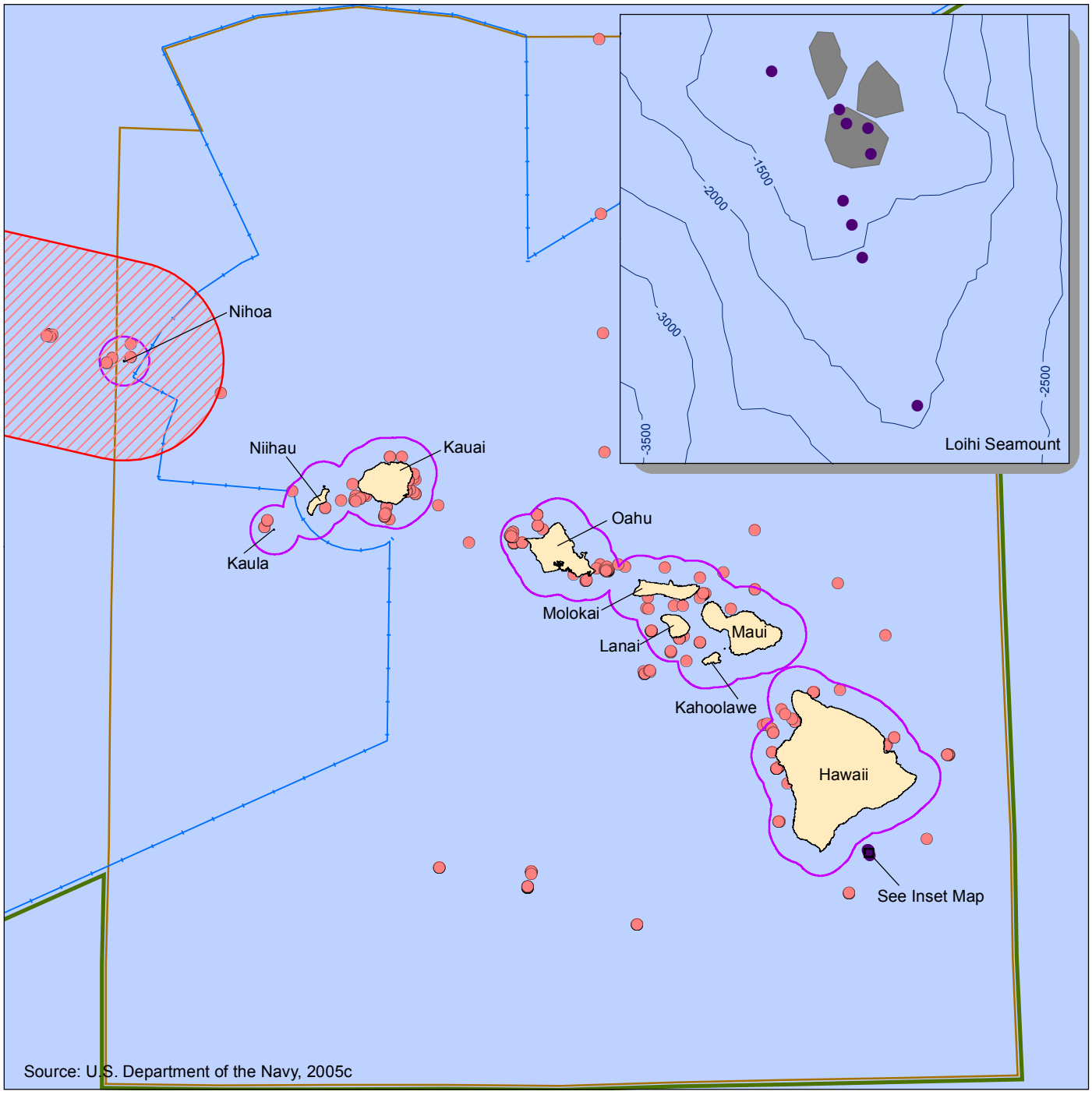
Corals play a critical role in maintaining the reef ecosystem by providing a framework for the ecological community. The Hawaiian Islands have 17,520 km^2 (6,764.5 mi^2) of coral

reef area, representing 84 percent of the coral reef area in the United States (Maragos, 1977). Due to the motion of the Pacific Plate, the Hawaiian Islands have been transported in a north to northwest direction away from their original location of formation over the hot spot at a rate of about 10 cm (4 inches) per year (Grigg, 1988; 1997). The youngest island in the archipelago is Hawaii, where the youngest fringing reefs and barrier reefs are found. Fringing reefs on the western coast of Hawaii are from 100 to 1,000 years old.

Coral reefs in PMNM are relatively isolated from human impacts. There are 57 stony coral species known in the shallow subtropical waters of PMNM (National Oceanic and Atmospheric Administration, 2005). They are found across the world's oceans, in both shallow and deep water, but reef-building corals are only found in shallow subtropical waters such as those surrounding the MHI and NWHI. The algae found in the tissues of shallow water corals need light for photosynthesis and water temperatures between 22-29 degrees Celsius (70-85 degrees Fahrenheit) (Smithsonian, n.d.). Conversely, deep-sea corals, which do not have the same algae and do not need sunlight or warm water to survive, thrive in cold, dark water. NWHI and MHI deep water coral reefs are typically found at depths between 350 to 600 m (1,150 to 2,000 ft), with some species continuing below 1,800 m (6,000 ft) (Parrish and Baco, 2007).

Deep-sea coral communities are prevalent throughout the Hawaiian archipelago (Figure 3-2). They often form offshore reefs that surround all of the MHI at depths between 49 and 199 m (27 and 109 fathoms) (Maragos, 1998). Although light penetrates to these depths, it is normally insufficient for photosynthesis. The term "deep-sea corals" may be misleading because substrate (surface for growth), currents, temperature, salinity, and nutrient supply are more important factors in determining the distribution of growth rather than depth (Chave and Malahoff, 1998).

Shallow and deep-sea coral reef habitats harbor a diversity of macro and micro algae. In addition, deep-sea corals support habitat for a diverse array of species, serve as a hotspot of biological diversity, as well as serve as indicators of past climates. Currently, a total of 355 algal species have been recorded from shallow water coral reef habitats of the NWHI. The NWHI contains a large number of Indo-Pacific algal species not found in the MHI, such as the green calcareous alga (*Halimeda velasquezii*). Unlike the MHI where invasive species (e.g. invasive algae, *Kappaphycus alvarezii*) have overgrown many coral reefs, the reefs of the NWHI are largely free of invasive species. Approximately 98 percent of PMNM's area is deeper than 100 m (330 ft); therefore, deep-sea research is important to understand what is being protected within PMNM.



EXPLANATION

- Deep-Sea Coral
- Hydrothermal Vent
- Hawaii Range Complex
- Temporary Operating Area
- 12-Nautical Mile Limit
- Crater
- Hawaii Operating Area
- Papahānaumokuākea Marine National Monument

NORTH 0 25 50 100 Nautical Miles

Distribution of Deep-Sea Corals and Hydrothermal Vents

Hawaiian Islands

Figure 3-2

32_hydrothermal, 4/1/2015

Deep-sea corals can form large communities in PMNM ranging in size from patches of small solitary colonies to massive reef structures (mounds, banks, and forests) spanning an estimated total spatial coverage of about 2,000 km^2 (800 mi^2) (Cairns, 1994; Freiwald et al., 2004). Much like shallow-water corals, deep-sea corals are fragile, slow growing, and can survive for hundreds of years (Roberts and Hirshfield, 2003). Deep-sea corals can be of two basic types: (1) the hard or stony corals, which are related to those found on tropical coral reefs; and (2) the soft corals, which include the familiar gorgonians of tropical shallow seas, as well as a broad diversity of other fleshy or tree-like forms. Some of the stony corals are small, but they can grow to be very massive. The soft corals may be small and delicate or very large and tree-like (Watling, 2003). Potential threats to deep-sea corals include fishing (e.g., bottom trawling), oil- and gas-related activities, cable laying, seabed aggregate extraction, shipping activities, the disposal of waste in deep waters, coral exploitation, other mineral exploration, and increased atmospheric carbon dioxide (Gass, 2003; Freiwald et al., 2004).

3.2.1.2.2.2 Bottomfish

Prior to the establishment of PMNM, commercial bottomfishing had been conducted in the NWHI for over 60 years. Bottomfish are found concentrated on the steep slopes of deepwater banks of the NWHI. Descriptions of bottomfish habitats in the NWHI indicate that the distribution and abundance of bottomfish are patchy, and appear to be associated with cavities or oceanic current patterns that serve as prey attractants (Kelly et al. 2004). The fishery included 13 species of snapper and carangid and one species of grouper that was commonly caught at depths between 60 to 350 m (200 to 1,150 ft) (National Oceanic and Atmospheric Administration, 2007). Common bottomfish species include onaga (*Etelis coruscans*), ehu (*E. carbunculus*), opakapaka (*Pristipomoides filamentosus*), kalekale (*P. sieboldii*), lehi (*Aphareus rutilans*), gindai (*P. zonatus*), and hapuupuu (*Epinephelus quernus*). In addition, species of Hawaii bottomfish that are federally regulated include uku (*Aprion virescens*), white ulua (*Caranx ignobilis*), black ulua (*C. lugubris*), butaguchi (*Pseudocaranx dentex*), taape (*Lutjanus kasmira*), yellow tail kalekale (*Pristipomoides auricilla*) and kahala (*Seriola dumerili*). With the establishment of PMNM, commercial bottomfishing was phased out and the fishery closed on 15 June 2011 (Monument Proclamation 8031).

3.2.1.2.2.3 Seabirds

Seabird colonies in the NWHI constitute one of the largest and most important assemblages of seabirds in the world, with approximately 14 million birds representing 20 breeding species (Naughton and Flint, 2004). Birds that live at sea and migratory birds are also part of the ecosystem. The NWHI contain over 95 percent of the world's black-footed and Laysan albatrosses. The greatest threats to seabirds in the NWHI are introduced mammals and other invasive species, fishery interactions, contaminants, oil pollution, and climate change.

3.2.1.2.2.4 Marine Mammals (3.3.2.2-page 3-52)

A total of 24 different species of marine mammals have been recorded by research cruises within the U.S. Exclusive Economic Zone in waters surrounding PMNM (NWHI) and are afforded protection under the Marine Mammal Protection Act (Barlow, 2003). Marine mammals observed in PMNM (NWHI) include whales, dolphins, and Hawaiian monk seals.

3.2.1.2.2.5 Threatened and Endangered Species

According to the Endangered Species Act (ESA) of 1973, endangered species are those currently facing extinction. Threatened species are those likely to become endangered within the foreseeable future. Twenty-three species of plants and animals known to occur in PMNM (NWHI) are listed under ESA. Of those listed species that occur in the marine ecosystem, the following 13 ESA-listed marine species are further discussed based on occurrence within the region of influence, or may be affected by the Proposed Action. Table 3-2 is a summary of ESA determination species occurring in the region of influence.

Cetaceans

North Pacific Right Whale

The North Pacific right whale, *Eubalaena japonica*, is ESA-listed as endangered throughout its range (73 FR 12024). Right whale adults typically are 13 to 16 m (43 to 52 ft) in length, but North Pacific individuals may measure up to 18 m (59 ft) and weigh up to 100 metric tons (Kenney, 2009). The North Pacific right whale is composed of two populations—western and eastern—that are considered isolated from each other (Brownell et al., 2001). The population of the eastern North Pacific is considered to be the smallest whale population in the world for which an abundance estimate is known, at approximately 30 animals (Wade et al., 2010). No reliable population estimate presently exists for the species in the western North Pacific; however, it may number at least in the low hundreds (Brownell et al., 2001; Clapham et al., 2004).

Right whales migrate annually between high-latitude feeding grounds and low-latitude calving and breeding grounds (Kenney, 2009). Feeding takes place in spring, summer, and fall in higher-latitude feeding grounds, where ocean temperatures are cooler and overall biological productivity is much higher (Kenney, 2009). The specific locations of such feeding grounds are poorly known. Based on historical whaling records and the few recent sightings, Clapham et al. (2004) found that the principal feeding grounds were most likely in the Sea of Okhotsk, central and eastern Bering Sea, and Gulf of Alaska, all of which are more oceanic (offshore) habitats than those utilized by their well-studied North Atlantic counterparts. Breeding and calving both occur during the winter months, however the locations of such habitats for North Pacific right whales are unknown (Kenney, 2009).

The primary food source for North Pacific right whales is zooplankton (e.g., copepods). Right whales are skim-feeders: they feed by removing prey from the water using baleen

while moving with their mouth open through a patch of zooplankton, typically within the upper 10 to 20 m (33 to 66 ft) of the water column (Watkins and Schevill, 1976; Woodward et al., 2006; Parks et al., 2011).

Occurrence of this species within the Hawaiian Islands, and furthermore, the action area, would be considered rare based on historical sightings data. For example, in April 1996, a right whale was sighted off of Maui (Salden and Mickelsen, 1999). This was the first documented sighting of a right whale in Hawaiian waters since 1979 (Herman et al., 1980; Rowntree et al., 1980). Further supporting this conclusion is earlier work by Scarff (1986), who reviewed information from the mid-1800s and that from Rowntree et al. (1980) and Herman et al. (1980), concluding that individuals in the waters off Hawaii, particularly during the time when the proposed action would occur (i.e., June-July), represented stragglers, not concentrations of wintering right whales. Although Kennedy et al. (2012) recently documented a high- to low-latitude migration of the individual sighted in April 1996, confirming that right whales at least occasionally travel across the North Pacific between Hawaii and Alaska, the authors caution that it is still premature to call the present record definitive proof of an annual migration.

Blue Whale

The blue whale (*Balaenoptera musculus*) is ESA-listed as endangered throughout its range (35 FR 18319). It is the largest of the baleen whales, with lengths exceeding 30 m (100 ft) (Sears and Perrin, 2009). The North Pacific blue whale is composed of two stocks—western and eastern. NMFS considers blue whales found in Hawaii as part of the Western North Pacific stock (Carretta et al., 2005). Blue whales typically migrate between high-latitude feeding grounds and low-latitude wintering areas (Sears and Perrin, 2009); however, some individuals have been observed to remain in the same region year-round (e.g., Watkins et al., 2000). The western stock feeds in summer in the southwest of Kamchatka, south of the Aleutian Islands, and in the Gulf of Alaska (Stafford, 2003; Watkins et al., 2000). In winter, they migrate to lower latitudes in the western Pacific and, much less frequently, in the central Pacific, including Hawaii (Thompson and Friedl, 1982).

Blue whales are “lunge feeders” targeting dense patches of euphausiids and other crustacean meso-zooplankton (Sears and Perrin, 2009) in the upper 150 to 200 m (492 to 256 ft) of the water column (Croll et al. 2001, 2005).

The presence of blue whales in the action area would be considered rare. With the exception of occasional encounters (Oahu: Thompson and Friedl, 1982), there are few records of blue whales in Hawaiian waters. This conclusion is especially true during the time of year when the proposed action would occur, as individuals would be expected to be at higher latitudes in summer foraging grounds.

Fin Whale

The fin whale (*Balaenoptera physalus)* is ESA-listed as endangered throughout its range (35 FR 18319). The second largest of the whales in the family Balaenopteridae, fin whales range in length up to approximately 26 m (85 ft), with females slightly larger than males (Aguilar, 2009). Fin whales are considered a cosmopolitan species and occur from polar to tropical waters, with the greatest concentrations usually outside of the continental slope (Aguilar, 2009). Fin whales engage in north-south movements from wintering grounds to summer feeding areas (Aguilar, 2009). The locations where breeding and calving occur remain largely unknown (Rice, 1998) because, unlike other mysticetes, calving does not appear to take place in distinct inshore areas (Reeves et al., 2002; Mizroch et al., 2009). Reviewing historic catch, acoustic, and observation data, Mizroch et al. (2009) found that during summer, fin whales range from the Chukchi Sea south to 35°N on the Sanriku coast of Honshu, to the Subarctic Boundary (approximately 42°N) in the western and central Pacific. During winter months, Pacific fin whales have been documented over a wide area from 60°N south to 23°N (Mizroch et al., 2009).

A 2002 shipboard line-transect survey of the entire Hawaiian Islands Exclusive Economic Zone resulted in an abundance estimate of 174 fin whales (Barlow, 2003). However, Barlow (2006) did not provide a density estimate for fin whales in Hawaii because the survey (originally analyzed in Barlow 2003) was not conducted during the peak period of abundance (i.e., winter).

Fin whales are “lunge feeders,” feeding at similar depths and prey as blue whales (Goldbogen et al., 2007). Southern Hemisphere fin whales feed almost exclusively on euphausiids (Aguilar, 2009).

Occurrence of this species within the action area, particularly during the time of year when the action would occur, would be highly unlikely. Summarizing observations of fin whales in the Hawaiian Islands, Mizroch et al. (2009) found that while several sightings from the 1970s were during the month of May, no recent reports (e.g., Oahu: Thompson and Friedl, 1982, McDonald and Fox; Kauai: Mobley et al., 1996) were between May and July. As with the other mysticetes potentially within the action area, fin whales would typically be at higher latitude foraging grounds during the summer months.

Sei Whale

The sei whale (*Balaenoptera borealis*) is ESA-listed as endangered throughout its range (35 FR 18319). Individuals range in length up to approximately 20 m (66 ft), which makes it the third largest whale in the family Balaenopteridae (Horwood, 2009). Like most balaenopterids, sei whales are found in all oceans and migrate long distances north-south from high-latitude summer feeding grounds to lower-latitude winter areas. They range even farther offshore than fin whales and tend to be nomadic (Mizroch et al., 1984). In the North Pacific Ocean, their summer distribution extends from California westward to Japan and northward to the Aleutian Islands. In the eastern North Pacific, their winter distribution is known to range from Piedras Blancas in California to the

Revillagigedo Islands off Mexico; however, in the central and western North Pacific their winter distribution is largely unknown (Rankin and Barlow, 2007).

NMFS divides Pacific Ocean sei whales into three stocks, one of which inhabits the waters around Hawaii. A 2002 shipboard line-transect survey of the entire Hawaiian Islands Exclusive Economic Zone located groups of sei whales northeast of Maui (late November) and east of Hawaii, resulting in a summer/fall abundance estimate of 77 sei whales (Barlow, 2003). Barlow (2006) did not provide a density estimate for sei whales in Hawaii because the survey (originally analyzed in Barlow 2003) was not conducted during the peak period of abundance (i.e., winter).

Sei whales are primarily skimmers rather than lunge swallowers, feeding on patches of copepods (their preferred forage), euphausiids, fish, and squid, if available (Horwood, 2009).

Humpback Whale

The humpback whale (*Megaptera novaeangliae*) is ESA-listed as endangered throughout its range (35 FR 18319). Humpback whales are shorter and stouter than most other balaenopterids; at maturity, individuals are typically between 14 and 15 m (46 and 49 ft) (Clapham, 2009). In the North Pacific, there are three separate humpback whale populations, the Central North Pacific stock occurring within Hawaiian waters (Allen and Angliss, 2014). Employing the most recent survey data from the SPLASH study (Calambokidis et al., 2008), Allen and Angliss (2014) conservatively estimated the minimum abundance for the Central West Pacific stock to be approximately 5,800 individuals.

Humpbacks are typically found in coastal or shelf waters in summer and close to islands or reef systems in winter (Clapham, 2009). The species is highly migratory, moving seasonally between low-latitude winter breeding areas and high-latitude summer feeding grounds (Clapham and Mead, 1999). In summer, the majority of whales from the Central North Pacific stock are found in the Aleutian Islands, Bering Sea, Gulf of Alaska, and Southeast Alaska/northern British Columbia (Calambokidis et al., 2001). Humpback whales use Hawaiian waters as a major breeding ground during winter and spring (November through April) (Baker et al., 1986). Calambokidis et al. (1997) estimated that up to half of the North Pacific populations of humpback whales migrate to the Hawaiian Islands during the winter. Peak abundance around the Hawaiian Islands is from late February through early April (Mobley et al., 2001; Carretta et al., 2005). During the fall–winter period, primary occurrence is generally within 92.6 kilometers (50 nm) offshore, which takes into consideration both the available sighting data and the preferred breeding habitat (shallow [< 200 m (656 ft)] waters) (Herman and Antinoja, 1977; Mobley et al., 1999). The greatest densities of humpback whales (including calves) are in the four-island region consisting of Maui, Molokai, Kahoolawe, and Lanai, as well as Penguin Bank (Mobley et al., 1999, 2001) and around Kauai (Mobley, 2005). However, coupling spatial modeling with observation data, Johnston et al. (2007) also

identified extensive areas of suitable wintering habitat within the Northwestern Hawaiian Islands.

Humpbacks have shorter and coarser baleen bristles than other baleen whales and feed on both euphausiids and schooling fish (Clapham 2009). Primarily classified as "swallowers" rather than "skimmers," feeding primarily occurs in the upper 150 m (492 ft) of the water column (Goldbogen et al., 2008; Ware et al., 2011).

Of the mysticetes potentially within the action area, the humpback whale is the species most likely to occur. Its presence during the time the action is conducted (i.e., June–July) would be unlikely, as it would be in northern foraging grounds, returning to the nearshore waters of the action area in late fall.

False Killer Whale

Three stocks of false killer whales, *Pseudorca crasidens*, are recognized within Hawaiian waters: the Hawaii pelagic stock, the MHI insular stock, and the Northwestern Hawaiian Islands insular stock (Carretta et al., 2014). The MHI insular Distinct Population Segment is ESA-listed as endangered throughout its range (77 FR 70915). A member of the dolphin family, females reach lengths of almost 5 m (16 ft), while males are almost 6 m (20 ft) (Baird, 2009). In adulthood, false killer whales can weigh approximately 680 kg (1,500 lb). False killer whales are considered to be very social animals, usually traveling in groups of 20 to 100 individuals (Baird, 2009).

Forney et al. (2010) defined the general boundaries of the MHI insular stock to include a "core" use area extending 40 km (22 nm) from shore and an "extended" offshore boundary ranging from the outer boundary of the "core" area out to 140 km (76 nm) from the MHI. Baird et al. (2012) found three areas of frequent use by the MHI insular population: the north side of the island of Hawaii (both east and west sides), a large area extending from north of Maui to northwest of Molokai, and a small area to the southwest of Lanai. The depth distribution for high-use areas was mean depth of 623 m (2,070 ft), relative to an overall median depth of 1,679 m (5,500 ft; Baird et al., 2012). Tracks from tagged individuals provided documentation that individuals from the central and eastern MHI use the area around Kauai and Niihau (Baird et al. 2010, 2011). Knowledge of seasonal movements of this species is still evolving. Baird et al. (2012) provided satellite tracking data for a large number of individuals; however, their data did not cover the timeframe between March and June. Although the authors acknowledge that the species does use some of the same areas during these months, as in the months for which data is available, more information is needed to determine whether additional areas outside of their identified high use areas are frequented (Baird et al., 2012).

In Hawaii, false killer whales have been documented feeding on a wide variety of large fish, including wahoo (*Acanthocybium solandri*), tunas (*Thunnus* spp.), and broadbill swordfish (*Xiphias gladius*) (Baird et al., 2008). Little is known about the diving behavior of this species in Hawaii (Baird et al., 2012). However, a recent tracking study by Baird

et al. (2014) off the coast of Kauai has contributed to the knowledge base. The single tagged individual in the study was observed to div to median depths of approximately 138 m (453 ft) with a maximum recorded dive of 928 m (3,040 ft). As the median depth of the waters within which the individual was monitored was 710 m (2,330 ft), some of the deepest dives were likely at, or near, the sea floor (Baird et al., 2014).

Sperm Whale

The sperm whale (*Physeter macrocephalus*) is ESA-listed as endangered throughout its range (35 FR 18319). The largest odontocete, male sperm whales are 18.5 m (61 ft) in length, females 12.5 m (41 ft) (Rice, 1989). Sperm whales are typically found in deep oceanic waters, with females almost always inhabiting water deeper than 1,000 m (3,300 ft) (Whitehead, 2009). Baird et al. (2013) most commonly encountered sperm whales in Hawaiian waters deeper than 3,000 m (9,842 ft). Sperm whales are widely distributed throughout the Hawaiian Islands year-round (Au et al. 2014; Baird et al., 2013; Barlow, 2006; Mobley et al., 2000), and have been found to be the most abundant large whale in Hawaiian waters during summer and fall months (Barlow, 2006). Barlow (2006) estimated there to be approximately 6,900 sperm whales in Hawaiian waters based on his survey work conducted between August and November 2002. A recent yearlong acoustic monitoring study conducted by Au et al. (2014) within and adjacent to the action area most frequently identified sperm whales on the southwest side of Kauai between the months of March and June.

In comparison to the other cetacean species in the action area, sperm whales forage at deeper water depths. Maximum-recorded dive depths differ across regions, with values of 644 and 985 m (2,113 and 3,230 ft) for the Gulf of Mexico and Atlantic Ocean, respectively (Watwood et al., 2006); 1,400 m (4,600 ft) in the north Pacific Ocean (Aoki et al., 2012); and up to nearly 1,900 m (6,230 ft) off the coast of Norway (Teloni et al., 2008). Though individuals do forage at the ocean floor, the majority of foraging observed occurred higher in the water column (Aoki et al., 2012; Mathias et al., 2012; Miller et al., 2013; Teloni et al., 2008; Wahlberg, 2002).

Sperm whales spend about 70 to 80 percent of their time at depths of several hundred meters (Amano and Yoshioka, 2003; Watkins et al., 1993), and most of their diet consists of mesopelagic and bathypelagic cephalopods (Clarke, 1980; Clarke et al., 1993; Kawakami, 1980). Multiple hypotheses exist regarding the means sperm whales locate prey; however, it is generally accepted that foraging individuals rely heavily on emitting acoustic “clicks” during dives to echolocate prey items (Madsen et al., 2002; Miller et al., 2004).

Pinnipeds

Hawaiian Monk Seal

The Hawaiian monk seal, *Neomonachus schauinslandi* (formerly *Monachus schauinslandi*), is ESA-listed as endangered throughout its range (41 FR 51611). Adults range in length from 2.1 to 2.4 m (6.9 to 7.9 ft) and weights are between 170 and

240 kg (375 and 529 lb), with females slightly larger than males (Gilmartin and Forcada, 2009). The species occurs only in the central North Pacific and are managed as a single stock, although there are six main reproductive subpopulations at French Frigate Shoals, Laysan Island, Lisianski Island, Pearl and Hermes Reef, Midway Atoll, and Kure Atoll (Ragen and Lavigne, 1999), all of which are outside the action area. The vast majority of the population is present in the NWHI. Monk seal births in Hawaii usually occur from February to August, peaking in April–June, but births are known in all months (Gilmartin and Forcada, 2009).

Until recently, this species occurred almost exclusively at remote atolls in the NWHI. In the last decade, however, sightings of Hawaiian monk seals in the MHI have increased considerably (Baker and Johanos, 2004). Most monk seal haulout events in the MHI have been on the western islands of Niihau and Kauai (Baker and Johanos, 2004). The best estimate of the total population size is approximately 1,060 individuals in the Hawaiian Islands Archipelago, of which at least 150 are in the MHI (Baker et al., 2011) and the remaining 910 in the NWHI. Recent population trends indicate that the population in the MHI is growing, whereas that in the NWHI is decreasing (Baker et al., 2011). A recent analysis of range-wide movements by Johanos et al. (2013) demonstrates connectivity (albeit rare; 10 seals in 30 years of observations) between the NWHI and MHI subpopulations and highlighted an approximately 2,400 km (1,300 nm) transit by a female spanning the entire Hawaiian archipelago. Intra-region movements were more common (Johanos et al., 2013).

Hawaiian monk seals have a diverse prey base, including demersal fish, squid, octopus, eels, and crustaceans (Parrish et al., 2000; Cahoon et al., 2013), with little observed difference between those of the NWHI and MHI subpopulations (Cahoon et al., 2013). They mostly forage within their resident atolls and along the barrier reefs, but may also forage at distant seamounts and submerged reefs hundreds of kilometers from their colonies (Gilmartin and Forcada, 2009; Stewart et al., 2006). Stewart et al. (2006) found most (75 percent) core foraging areas to occur within 20 km (11 nm) of the respective colony. Although individuals have been observed diving to depths approximating 500 m (1,640 ft) (summarized by Stewart et al., 2006), the majority of foraging activity typically occurs at depths less than 100 m (330 ft) (Parrish et al., 2000, 2005, 2008; Stewart et al., 2006).

Hawaiian monk seal critical habitat has been designated under the ESA to include all beach areas, sand spits and islets, including all beach vegetation to its deepest extent inland, and lagoon waters out to a depth of 37 m (120 ft or 20 fathoms) in designated areas of use (53 FR 18988).

Essential features of critical habitat for Hawaiian monk seals include the following: terrestrial coastal areas with characteristics preferred for pupping and nursing; shallow, sheltered aquatic areas adjacent to coastal locations preferred for pupping and nursing; marine areas preferred for foraging; areas with low levels of anthropogenic disturbance;

marine areas with adequate prey quantity and quality; and areas used for hauling out, resting, or molting.

NMFS has proposed to extend critical habitat in the NWHI out to the 500-m (1,640-ft) depth contour and to include Sand Island at Midway Islands; and by designating six new areas in MHI. Specific areas proposed for the MHI include terrestrial and marine habitat from 5 m (16.4 ft) inland from the shoreline extending seaward to the 500-m (1,640-ft) depth contour around Kaula Island, Niihau, Kauai, Oahu, Maui Nui (including Kahoolawe, Lanai, Maui, and Molokai), and Hawaii (76 FR 32026). Several zones within the action area (e.g., PMRF offshore areas) have been excluded from designation in the proposed rule due to national security reasons (76 FR 32026).

Sea Turtles

Green Turtle

The Hawaiian population of green sea turtle (*Chelonia mydas*) is ESA-listed as threatened throughout its range (43 FR 32800). On 16 February 2012, NMFS received a petition to classify the species in Hawaii as a DPS and to delist that DPS under the ESA. On 1 August 2012, NMFS made a positive 90-day finding (77 FR 45571), determining that the petitioned action may be warranted. A comprehensive status review is underway to inform the 12-month finding.

Green sea turtles are the largest of all the hard-shelled sea turtles, but have a comparatively small head. While hatchlings are just 50 millimeters (2 inches) long, adults can grow to more than 1.2 m (4 ft) long and weigh 136 to 159 kg (300 to 350 lb). The green sea turtle is the most common sea turtle species occurring in the waters around the Hawaiian Islands. Green turtles live in nearshore coastal habitats, with high fidelity to specific reef, rock, bay, or lagoon feeding locations. The species' breeding and nesting season ranges between mid-April and mid-August of each year (Balazs, 1976). During the breeding season males and females swim 800 to 1,290 km (500 to 800 mi) from their feeding grounds in the MHI to their nesting beaches. More than 90 percent of all green sea turtle breeding and nesting activity in Hawaiian waters occurs at French Frigate Shoals (Balazs, 1980), with the main rookery on East Island (Tiwari et al., 2010). Upon nesting, most adults migrate to the coastal waters surrounding the MHI (especially around Maui and Kauai) (Balazs, 1976). Hatchling green turtles emerge from their nests and enter the ocean, a time after which little is known until they enter neritic foraging grounds approximately 5 to 10 years later (Reich et al., 2007). Consequently, post-hatchling green sea turtles in this oceanic phase can occur hundreds of kilometers from landmasses in water depths at least kilometers deep (Parker et al., 2011).

Adult green sea turtles are unique among sea turtles in that they are primarily herbivorous, feeding on seagrasses, sea lettuce, and algae, and to a lesser extent, jellyfish, salps, and sponges (Bjorndal, 1997). During the oceanic phase of life, young green turtles are primarily carnivorous, foraging on prey items commonly found within the first 100 m (330 ft) of the water column, including zooplankton, crustaceans, and

mollusks (Parker et al., 2011). Most of the adults' time is spent at depths less than 30 m (100 ft) when on the foraging grounds but they can dive to depths of over 100 m (330 ft) when migrating, although the majority of their migratory dives are usually much shallower (1 to 4 m [3 to 13 ft] diurnal; 35 to 55 m [115 to 180 ft] nocturnal) (Rice and Balazs, 2008).

Hawksbill Turtle

The hawksbill sea turtle, *Eretmochelys imbricata*, is ESA-listed as endangered throughout its range (35 FR 8491). Hawksbill sea turtles are the second most common species in the offshore waters of the Hawaiian Islands, yet they are far less abundant than green sea turtles. In Hawaii, hawksbills nest on MHI beaches, primarily along the east coast of the island of Hawaii and to a much lesser extent Maui, Oahu, and Molokai (National Marine Fisheries Service and U.S. Fish and Wildlife Service, 1998a). Peak nesting activity occurs from late July to early September (Katahira et al. 1994). Similar to other species of sea turtles, upon hatching young hawksbills inhabit an oceanic habitat, returning years later to neritic habitats as larger juveniles (Musick and Limpus, 1997).

In a study of satellite-tracked females, Parker et al. (2009) found post-nesting movements of adult Hawaiian hawksbills to be relatively short-range (90 to 345 km [49 to 186 nm] from nesting beaches), and largely confined to coastal waters (depths less than 30 m [100 ft]) within the MHI. The west coast of Oahu was the farthest west that the individuals tracked in the Parker et al. (2009) study traveled when foraging. Previous sightings of immature Hawaiian hawksbills (e.g., Keuper-Bennett and Bennett, 2002) have also been in very shallow areas of the MHI.

Sightings of hawksbills in the NWHI are even rarer (National Marine Fisheries Service and U.S. Fish and Wildlife Service, 1998a). Summarizing historic and contemporary sightings of hawksbill sea turtles in the NHWI, Van Houten et al. (2012) identified six definitive observations and three potential nesting records. Based on this information, the authors conclude that hawksbills currently occur within the NWHI (albeit in low numbers), with a lack of regular monitoring within this geographic area likely contributing to the infrequency of documented observations (Van Houten et al., 2012).

Studies of hawksbill diet have identified sponges (Caribbean: Meylan, 1988) and to a lesser extent, tunicates (eastern Pacific: Carrión-Cortez et al., 2013) as primary forage items. In a study of Eastern Pacific hawskbills, Gaos et al. (2012) rarely observed adult hawksbills diving deeper than 20 m (66 ft) in the water column.

North Pacific Loggerhead Turtle

The North Pacific DPS of the loggerhead sea turtle, *Caretta caretta*, is ESA-listed as endangered throughout its range (75 FR 58868). This reddish-brown turtle averages approximately 0.9 m (3 ft) in length and 136 kg (300 lb) in weight. Nesting in the Pacific basin is restricted to the western region (primarily Japan and Australia), with those in

U.S. waters likely originating from Japanese beaches (National Marine Fisheries Service and U.S. Fish and Wildlife Service, 1998c). There is no loggerhead nesting on the western seaboard of the United States or in Hawaii (Balazs, 1982); however, southern California and western Mexico serve as important coastal foraging areas (National Marine Fisheries Service and U.S. Fish and Wildlife Service, 1998c). Only four records of occurrence exist for Hawaii, all of which were juveniles and most likely drifted over from Mexico or Japan (National Marine Fisheries Service and U.S. Fish and Wildlife Service, 1998c).

Central North Pacific loggerheads in oceanic habitats have been shown to forage primarily on floating organisms, including gastropods, pelagic crabs, barnacles and, to a lesser extent, pyrosomas, among others (Parker et al., 2002). In a study of tagged North Pacific loggerheads within the open ocean, Polovina et al. (2004) found individuals to associate with oceanic eddies and fronts, most frequently occupying the uppermost stratum of the water column, spending approximately 90 percent of their time at depths less than 40 m (130 ft) (40 percent of time at the surface), with occasional dives to depths in excess of 100 m (330 ft).

Olive Ridley Turtle

The olive ridley sea turtle, *Lepidochelys olivacea*, is ESA-listed as threatened throughout its range (43 FR 32800). They are regarded as the most abundant sea turtles in the world, with nesting occurring primarily on beaches of India, southern Mexico, and northern Costa Rica (National Marine Fisheries Service and U.S. Fish and Wildlife Service, 1998d). Balazs and Hau (1986) reported a single Hawaiian nesting event on the island of Maui in September 1985. In-water sightings are also rare, with the majority of those observed as takes within the Hawaiian-based longline fishery (e.g., Work and Balazs, 2010).

An analysis of stomach contents from eight olive ridleys caught in the Hawaii-based longline fishery indicates that while olive ridleys do forage on some organisms at the ocean's surface, their most common prey are pyrosomas and salps which are found at deeper depths (Polovina et al., 2004). In this same study, Polovina et al. (2004) found olive ridleys to most frequently occupying the epipelagic stratum of the water column (albeit deeper than loggerheads), spending approximately 60 percent of their time at depths less than 40 m (130 ft) (20 percent of time at the surface), with occasional dives to depths in excess of 150 m (490 ft). Swimmer et al. (2006) recorded an olive ridley in the eastern Pacific Ocean diving in excess of 400 m (1,310 ft); however, most dives were less than 100 m (330 ft).

Leatherback Turtle

The leatherback sea turtle, *Dermochelys coriacea*, is ESA-listed as endangered throughout its range (35 FR 8491). Leatherbacks are the largest marine turtle, with a curved carapace length often exceeding 1.5 m (5 ft) and front flippers that can span 2.7 m (9 ft) (National Marine Fisheries Service and U.S. Fish and Wildlife Service, 1998b). Leatherback sea turtles are a highly oceanic species and undertake long journeys of

over 2,800 km (1,510 nm), in some cases reaching cold seas far from their tropical nesting grounds (Hughes et al., 1998).

Two populations of leatherbacks occur in the Pacific Ocean – eastern and western. Eastern Pacific leatherback turtles nest in Mexico and Costa Rica during the boreal winter (October–March) (Eckert et al., 2012). In contrast, western Pacific leatherback turtles nest year-round at beaches across Australia, Malaysia, Indonesia, and Papua New Guinea (Eckert et al., 2012). Once leatherback hatchlings enter the oceanic environment, little is known about this portion of their life until they recruit to neritic habitats as juveniles; it is hypothesized that areas of upwelling and/or convergence zones may serve as nursery grounds (Musick and Limpus, 1997).

Migratory routes of adult leatherbacks are not entirely known. However, recent satellite telemetry studies have documented transoceanic migrations between nesting beaches and foraging areas in the Pacific Ocean basin (Bailey et al., 2012) and have characterized the post-nesting movements of summer and winter nesters (Benson et al. 2011). The oceanic areas visited by foraging turtles are mainly characterized by sea currents and related features, which can influence leatherback feeding-related movements. In particular, convergence zones and eddies may concentrate nutrients and organisms, and thus represent patches of high prey abundance targeted by foraging turtles (Carr, 1987). Recent research by Seminoff et al. (2012) demonstrates that most adult Pacific leatherbacks demonstrate fidelity to foraging areas between nesting events. Leatherbacks are regularly observed in the offshore waters at the southern end of the Hawaiian archipelago, potentially during their movement from one area of the Pacific Ocean to another (National Marine Fisheries Service and U.S. Fish and Wildlife Service, 1998b).

Leatherbacks primarily forage gelatinous zooplankton, including cnidarians (jellyfish and siphonophores) and, to a lesser extent, tunicates (pyrosomes and salps) at or just below the sea surface (Bjorndal, 1997). Leatherback sea turtles are the deepest reptilian divers: maximum dives ranging from 630 m (2,070 ft) (Hays et al., 2004) up to 1,280 m (4,200 ft) (Doyle et al. 2008) have been observed in the oceanic Atlantic. However, dives are typically much shallower (generally < 300 m [980 ft]) (Houghton et al., 2008).

3.2.1.2.3 Endangered Species Act Section 7 Consultation for Open Ocean

Regulatory Context

Section 7 of the ESA requires Federal agencies to evaluate the effects of their actions on listed species and consult with either USFWS or NMFS if the agency determines that its action “may affect” an individual or critical habitat of the respective species. Federal agencies are directed, under Section 7(a)(1) of the ESA, to utilize their authorities to carry out programs for the conservation of threatened and endangered species. Therefore, the SFDT program will be completed prior to NASA issuing a FONSI for the Proposed Action.

U.S. Fish and Wildlife Service

Under Section 7, Federal agencies must consult with USFWS when any action the agency carries out, funds, or authorizes (such as through a permit) *may affect* a listed endangered or threatened species. This process usually begins as informal consultation. A Federal agency, in the early stages of project planning, approaches USFWS and requests informal consultation. Discussions between the two agencies may include what types of listed species may occur in the Proposed Action area, and what effect the Proposed Action may have on those species. If the Federal agency, after discussions with USFWS, determines that the Proposed Action is not likely to affect any listed species in the project area, and if USFWS concurs, the informal consultation is complete and the proposed project moves ahead. If it appears that the agency's action may affect a listed species, that agency may then prepare a biological assessment to assist in its determination of the project's effect on a species. (U.S. Fish and Wildlife Service, 2014)

National Oceanic and Atmospheric Administration/National Marine Fisheries Service

Federal agencies must also consult with NMFS, under section 7(a)(2) of the ESA, on activities that may affect a listed marine species. These interagency consultations, or Section 7 consultations, are designed to assist Federal agencies in fulfilling their duty to ensure Federal actions do not jeopardize the continued existence of a species or destroy or adversely modify critical habitat. Should an action be determined by NMFS, to jeopardize a species or adversely modify critical habitat, NMFS may authorize an Incidental Take and suggest corresponding Reasonable and Prudent Alternatives. (National Oceanic and Atmospheric Administration, 2014c)

As indicated in Table 3-3, threatened and endangered marine species could be found in the region of influence.

3.2.1.2.4 Environmental Consequences

The analytical approach for biological resources involved evaluating the degree to which the proposed activities could environmentally impact threatened or endangered species, and sensitive habitat within the affected area. Criteria for assessing potential environmental impacts to biological resources are based on the number or amount of the resource that would be environmentally impacted relative to its occurrence at the project site, the sensitivity of the resource to proposed activities, and the duration of the environmental impact. Species impacts are considered substantial if they have the potential to result in reduction of the population size of federally listed threatened or endangered species, degradation of biologically important unique habitats, substantial long-term loss of vegetation, or reduction in capacity of a habitat to support wildlife. The proposed activities of concern for analysis are (1) expended flight hardware, (2) unrecovered sinkable hardware, and (3) sea vessels and airplanes.

3.2.1.2.4.1 Section 7 Consultation

In 2013 NASA submitted a LDSD Coordinating Draft EA and an LDSD Public Draft EA to NMFS and USFWS for review and concurrence. Both agencies provided comments on the LDSD Coordinating Draft EA, and NMFS provided comments on the LDSD Public Draft EA.

In accordance with Section 7 of the ESA, NASA initiated informal consultation for the SEA with NMFS on 9 January 2015 and with USFWS on 15 January 2015. Following ESA consultation guidance developed by NMFS (2013a), NASA applied the following rationale to arrive at its final determinations of effect on listed species in the LDSD splashdown (operating) area*:*

First, based on the analysis in the Biological Evaluation, the Proposed Action is likely to produce stressors to which listed individuals would respond if exposed. However, the likelihood of such exposure has been determined to be extremely remote. Therefore, NASA's determination process is based on "Proposition B" in the NMFS guidance document, which is:

> *The action is likely to produce potential stressors..., endangered or threatened individuals are not likely to be exposed to one or more of those potential stressors or subsidies or one or more of the Action's direct or indirect consequences on the environment;*

Next, once NASA accepted Proposition B as true, NASA identified the first of four potential determination outcomes (identified as outcome 3.1 in the NMFS guidance document) as being applicable to the action considered in the Biological Evaluation, which is:

> *If an agency … accepts Proposition B as true (the action produces stressor or subsidies, but the probability of exposing listed individuals to those stressors is so small that it would not be reasonable to expect them to occur) and can defend that acceptance based on all of the relevant evidence available and the appropriate background, the agency is justified in a "may affect, but not likely to adversely affect" determination (because the probability of effects would be discountable).*

As such, NASA concludes that the Proposed Action "may affect, not likely to adversely affect," all listed species in the action area. Table 3-2 summarizes the determinations for each species potentially affected by NASA's action.

(1) Expended Flight Hardware (Including Flight Train)

Threatened and Endangered Species

The threatened and endangered species (cetaceans, pinnipeds, and sea turtles) and critical habitat (Hawaiian monk seal) listed on Table 3-3 (located at the end of this section) have been observed and designated in the region of influence. Post-launch activities could involve an unplanned (i.e., anomalies) test execution which would produce expended flight hardware within PMNM.

The balloon and Test Vehicle would be recovered from the open ocean. Under the assumption that all possible trajectories were allowed to fly, NASA estimates the balloon has approximately a 0.4 percent chance of reaching float altitude within PMNM and a 20 percent chance of entering PMNM after reaching float altitude. These probabilities are reduced when NASA and the U.S. Navy apply the project's established Go/No Go criteria. (Combs, 2014)

The term "stress" is often used ambiguously to describe a broad range of conditions that threaten the well-being of an organism (National Oceanic and Atmospheric Administration, 1999). Based on the Biological Evaluation, the Proposed Action is likely to produce stressors (i.e., 1. supersonic flight, 2. direct or proximate strike, 3. entanglement, 4. ingestion, 5. aircraft overflight, and 6. recovery vessel operations) to which listed individuals would respond if exposed.

1. Supersonic Flight: Individuals exposed to a sonic boom could potentially change their behavior, such as becoming alert, diving, or swimming laterally. The shock waves from the supersonic flight process at the ocean's surface would be minor. As such, the most probable exposure route would be if an individual were at the surface.

Cetaceans: For cetaceans, when considered in conjunction with the infrequent nature of the testing, it may be concluded that the potential for exposing an individual to a weak sonic boom would be highly unlikely. Even if it were to occur, it is doubtful that even a behavioral response would be evoked.

Pinnipeds: For monk seals and their Critical Habitat, in consideration of the relatively lower sonic boom profile generated by the Proposed Action, and its infrequent nature, it may be reasoned that if an individual were exposed to a sonic boom created by the LDSD Test Vehicle, the resultant physiological or behavior effects would be negligible. Sonic booms would have only a negligible effect on either designated or proposed Hawaiian monk seal critical habitat. Although it is possible that some sound could enter the aquatic habitat, particularly during rough sea conditions (Richardson et al., 1995), it would be small in intensity (given the flight altitudes and limited potential for air-to-water sound transmission [Richardson et al., 1995]) and transient in nature. Likewise, aside from the transient low pressure sound from a sonic boom, terrestrial critical habitat would be unaffected.

Sea Turtles: With the exception of green sea turtles, and to a much lesser extent, hawksbills, the potential for exposing other species of sea turtles to the Test Vehicle-generated sonic boom would be unlikely based on historic sightings data. However, should a sea turtle be exposed to a sonic boom, it is unlikely to evoke much, if any, of a physiological or behavioral response at the levels and frequencies which would be propagated to the ocean's surface.

2. Direct or Proximate Strike: During the oceanic landing of flight hardware, there would be only a remote likelihood of the Test Vehicle, balloon, or MET rocket stages striking or landing near a listed species.

Cetaceans: The occurrence of either mysticete species within the action area at the time of either flight termination or test execution and subsequent descent of flight hardware would be rare, as all species are known to migrate to northern waters outside the action area during the summer months. Furthermore, the infrequent nature of the action (up to twice per year over a 5-year term) renders a direct or proximate strike a highly unlikely event.

Although sperm whales would be within the action area during the time when the action would occur, they spend about 70 to 80 percent of their time at depths of several hundred meters (Amano and Yoshioka, 2003; Watkins et al., 1993). When coupled with the infrequent nature of the testing, and low density of individuals within the action area, the chance of a direct or proximate strike would also be very low.

Pinnipeds: Hawaiian monk seals would be within the action area during the time of test execution; however, the probability of a direct or proximate strike would be very low for the following reasons. First, the core locations of all six reproductive subpopulations are outside the action area. Second, while some individuals have been shown to undergo long distance movements from their "home" colonies (Johanos et al., 2014), the majority of Hawaiian monk seals tend to remain within 50 km (30 mi) of these areas (Curtice et al., 2011), which, again for most, would be outside the action area. Third, although birthing and nursing would be spread over a much wider window than just the June to August timeframe, during this time a portion of the adult females and young of the year would be on land (largely outside the action area), further reducing the number of individuals potentially within the action area. Finally, the infrequent nature of the Proposed Action supports the conclusion that a direct strike would be unlikely.

Should either the Test Vehicle, balloon, or MET rocket stage land within aquatic Hawaiian monk seal critical habitat, it would temporarily occupy a small portion of the epipelagic portion of the water column that would have otherwise been available for use as foraging grounds for the species. Additionally, in consideration of the mandatory recovery of all major hardware items, the resultant effects would be only transient in nature. Should unrecoverable flight hardware (i.e., the flight train or MET rocket stages) enter critical habitat upon descent, it would only occupy the water column for a very short time, and upon landing on the ocean floor, would represent a very small portion of

the overall habitat available for the species. It is possible over time that the material would either trap, or otherwise become covered with sediment, further reducing the detraction from habitat value. The occurrence of floating expended hardware entering aqueous critical habitat would be possible; however, unlikely due to the low number of these items being flown per year and the very large areal extent of the action area.

Sea Turtles: All sea turtles could be in the action area during the summer months when the action would occur. However, with the exception of green, and to a much lesser extent, hawksbill sea turtles, their occurrence would be rare based on historic sightings data. Even in the case of green sea turtles, the most populous species within the action area, when considering the infrequent nature of the action, the low density of individuals within the action area, and the fact that sea turtles spend a significant portion of their time below the sea surface (Lutcavage and Lutz, 1997); the probability of a direct or proximate strike would be very low.

3. Entanglement: According to the literature (major reviews by Laist, 1987, 1997; Derraik, 2002), entanglement of marine species can lead to injury, compromised health, or mortality.

Cetacean: For either cetacean species, the relative size difference between the (comparatively small) floating MET balloons and Rocket Balloon Instruments (ROBIN) spheres and a (much larger) individual of either species renders the probability of entanglement negligible. Being hollow aluminum columns, MET rocket stages do not pose a risk of entanglement. For mysticetes, traveling or feeding baleen whales could potentially become entangled in the floating Test Vehicle or balloon or sinking balloon flight train once they enter the water column. However, multiple factors render this potential stressor highly unlikely. First, the occurrence of either mysticete species within the action area at the time when the action is conducted (and, therefore, when the majority of flight hardware would be in-water) would be rare. Second, the rapid recovery of the larger Test Vehicle and balloon system from the water column would further reduce the risk of potential entanglement with the largest flight hardware items. For odontocetes, although false killer whales have not been definitively reported as becoming entangled in marine debris (Baulch and Perry 2014), the potential exists for such a stressor to occur should flight hardware land within the species' range. However, multiple factors render this outcome highly unlikely. First, the greatest concentrations of the species are farther east in the MHI, outside the action area (Baird et al., 2012). Second, the species generally forages on prey that is typically found in the uppermost water column. Because the floating balloon system and Test Vehicle would be recovered after landing in the water, the potential for this stressor would be short in duration. Furthermore, the rapid descent of the unrecoverable flight hardware to depths beyond which false killer whales typically forage render the chance of encountering the item remote. Finally, the infrequent nature of the action and the low density of the species (when compared to the size of its range within the action area) render this event highly improbable. Sperm whales may feed at greater depths than mysticetes (e.g., 400 to 600 m [1,310 to 1970 ft]) and sometimes at or near the benthos (Mathias et al., 2012; Miller et al., 2013; Teloni et al., 2008), potentially putting them at higher risk for

entanglement with the unrecovered materials once they are on the seafloor. However, dive depth data from studies of sperm whales indicate that, while individuals occasionally forage at the seafloor, typical feeding is at lesser water depths. The analysis indicated that approximately 96 percent of the waters in the action are deeper than 2,000 m (6,560 ft), which is more than the deepest recorded high-latitude sperm whale foraging dive (1,900 m [6,230 ft]; Teloni et al., 2008). Therefore, in summary, while a sperm whale undertaking a deeper (greater than 2,000 m [6,560 ft]) foraging dive to the ocean floor (where the unrecovered flight hardware would remain) is possible, when considered in conjunction with the fact that most recorded foraging has occurred at shallower depths, the low density of individuals in the action area, and the infrequent nature of the action, it may be concluded that the probability of a foraging sperm whale becoming entangled in the items on the sea floor would be very low. Likewise, given the sink rate of the unrecovered flight hardware, it is expected that the items would be below the stratum of the water column most commonly used for sperm whale foraging in approximately 1 to 2 hours, rendering the potential for entanglement negligible.

Pinnipeds: Hawaiian monk seals are particularly susceptible to entanglement with marine debris, with pups and juveniles the most vulnerable life stage (Henderson, 1990; Henderson, 2001). Entanglement most often involves derelict fishing gear including nets, fish line, and associated hardware. As discussed under *Direct or Proximate Strike,* the majority of seal colonies are outside the action area, with most individuals remaining in close proximity to the islands. Furthermore, the rapid recovery of floating materials from the water column and rapid sinking of unrecovered materials renders the chance of entanglement unlikely. Although the unrecovered material theoretically could present an entanglement hazard if it were to land in shallow nearshore depths, the vast majority (greater than 99 percent) of waters in the action area are deeper than the maximum recorded dive depths of Hawaiian monk seals, below which there would be no potential for interaction. Finally, the historic reports of entanglement support the conclusion that the potential for entanglement with unrecovered items under the proposed action is negligible. There are no known cases of Hawaiian monk seals being entangled in military expended material (National Marine Fisheries Service 2014), which is analogous to the MET balloons and ROBIN spheres. The entanglement stressor is not applicable to either designated or proposed Hawaiian monk seal critical habitat.

Sea Turtles: It is possible that sea turtles might encounter or approach the floating MET balloons or ROBIN spheres. Likewise, in-water turtles could encounter the floating Test Vehicle or balloon and subsequently become entangled (Carr, 1987), as sea turtles have been observed to feed under floating debris. However, multiple factors render this potential stressor highly unlikely. First, SFDT flights from PMRF would be infrequent, not exceeding two per year over a 5-year term. Second, the majority of buoyant materials (i.e., balloon, Test Vehicle) would be recovered. The unrecovered flight train's expected sink rate would effectively remove it from the water column stratum most commonly frequented by migrating and foraging sea turtles in less than 1 hour. Though it is possible that the ultimate location of the flight train on the seafloor could be within the range of depths observed for diving sea turtles, particularly leatherbacks (maximum

recorded dive depths to 1,280 m [4.200 ft] [Doyle et al., 2008]), it has recently been determined from satellite telemetry that very deep dives (>300 m [984 ft]) are rare (Houghton et al., 2008). Finally, the low density of sea turtles in the action area makes the likelihood of an individual becoming entangled in the descending or seafloor-resting flight hardware highly unlikely.

4. Ingestion*:* Foraging individuals at or near the sea surface could ingest portions of the expended flight hardware, particularly the floating MET balloons or ROBIN spheres.

Cetaceans: The likelihood of mysticete whales encountering large pieces of floating or descending flight hardware (i.e., Test Vehicle, balloon, or flight train) would be negligible because of (1) their absence from the action area during testing; (2) the recovery of the balloon and Test Vehicle shortly after landing on the ocean's surface; and (3) and the rapid descent of the unrecovered flight train to the seafloor. For false killer whales, in consideration of the infrequency of the Proposed Action, the low density of individuals within the action area, the large size of most floating materials (rendering ingestion unlikely), and their recovery upon landing in the water, the probability of an individual encountering the floating material is very low; and for sperm whales, given the large proportion (96 percent) of deep water (greater than 2,000 m [6,562 ft]) in the action area, and shallower "typical" foraging depths (400 to 800 m [1,312 to 2,625 ft]) observed in sperm whales, the likelihood of a foraging sperm whale encountering the descended flight hardware would be remote. In the long term, the possibility of the MET balloons or ROBIN spheres fragmenting into smaller pieces, which would be more readily ingested by foraging individuals, could occur. However, when considered over the entire pelagic portion of the action area and the distributed/dilute nature of the degraded particles, the probability of an individual encountering a concentration of plastic items from the degraded balloon system years into the future is very low. Finally, the low density of sperm whales in the action area makes the likelihood of an individual interacting with the expended materials at any point during their presence in the water column or on the seafloor highly unlikely.

Pinnipeds: Although Hawaiian monk seals have not been definitively reported ingesting marine debris (Baulch and Perry, 2014), the potential exists for such a stressor to occur should flight hardware land within the species' range. However, in consideration of the infrequency of the Proposed Action, the low density of individuals within the action area, the large size of most floating materials (rendering ingestion unlikely), and their recovery upon landing in the water, the probability of an individual encountering the floating material is very low. The entanglement stressor is not applicable to either designated or proposed Hawaiian monk seal critical habitat.

Sea Turtles: In a comprehensive review of 37 sea turtle/debris ingestion studies undertaken since Balazs (1985), Schuyler et al. (2014) found that while all species potentially within the action area had been reported as ingesting debris, leatherbacks and green sea turtles were the most susceptible to plastic ingestion, likely due to their feeding preferences. However, multiple factors render the potential of an individual sea

turtle encountering either of the floating items unlikely. First, with the exception of green sea turtles, the potential for other species to occur within the action area would be low, and likely only when transiting between other areas in the Pacific Ocean. Second, the infrequent nature of the action makes the likelihood of an individual interacting with the expended materials at any point during their presence in the water column or on the seafloor highly unlikely. Finally, when considered over the entire pelagic portion of the action area and the distributed/dilute nature of the degraded particles, the probability of an individual encountering a concentration of plastic items from the degraded balloon system years into the future is very low.

5. Aircraft Overflight: Transmission of noise from aircraft into the water would be possible; however, individuals would have to be at or near the surface at the time of an overflight to be exposed to elevated sound levels. Likewise, a visual stimulus could also lead to a change in behavior, although likely temporary.

Cetaceans: Consideration of the facts that (1) mysticete species would not likely be within the action area during the time when aircraft surveillance and recovery flights would occur, and (2) the flights are infrequent in nature, support the conclusion that exposing a mysticete to this stressor would he highly unlikely. Although sperm whales would be within the action area during the time when the action would occur, they spend about 70 to 80 percent of their time at depths of several hundred meters (Amano and Yoshioka, 2003; Watkins et al., 1993), at which they would not likely be exposed to aircraft-induced stressors (i.e., visual and/or acoustic cues). Furthermore, in consideration of the infrequent nature and short duration of aircraft flights, the relatively high altitude (above 457 m [284 ft] AGL) at which they would surveil, and limited behavioral responses documented in available research, it is expected that potential effects on marine mammals, should they even occur, would be negligible.

Pinnipeds: Based on the responses of other pinniped species to aircraft overflight, it is expected that Hawaiian monk seals would be most responsive to aircraft-induced visual or acoustic stimuli when hauled out for pupping or molting (Richardson et al., 1995). Observed reactions would vary in severity, and could range from becoming alert to rushing into the water. While not specific to the Hawaiian monk seal, Richardson et al. (1995) presented available research at the time, which in summary supports the conclusion that the surveillance and recovery aircraft under the proposed action would have limited, if any, potential for disturbance at the altitudes at which they would fly. Aircraft overflight would have only a negligible effect on either designated or proposed Hawaiian monk seal critical habitat. Although it is possible that some aircraft-induced sound could enter the water column, particularly during rough sea conditions (Richardson et al., 1995), it would be small in intensity (given the flight altitudes and limited potential for air-to-water sound transmission [Richardson et al., 1995]) and transient in nature. Likewise, aside from the transient sound transmitted at ground level by aircraft overflight, the terrestrial critical habitat would be otherwise unaffected.

Sea Turtles: Based on sea turtle sensory biology (Bartol and Musick, 2003), sound from low flying aircraft could likely be heard by a sea turtle at or near the surface. Turtles might also detect low flying aircraft via visual cues such as the aircraft's shadow (similar to the findings of Hazel et al. [2007] regarding watercraft), potentially eliciting a brief startle reaction such as a dive or lateral movement. However, in consideration of (1) the fact that sea turtles spend a significant portion of their time below the sea surface (Lutcavage and Lutz, 1997); (2) with the exception of green sea turtles, the rarity of other species within the action area; and (3) the infrequent nature of the surveillance flights, the probability of exposing an individual to an acoustically- or visually-induced stressor from aircraft overflight would be very low. Furthermore, because the surveillance and recovery aircraft would be flown at altitudes (i.e., above 457 m [1,500 ft] AGL) well above those which are employed by wildlife agencies when performing aerial surveys of in-water sea turtles (e.g., 152 m [500 ft]): Epperly et al. 1995), it can be reasoned that potential effects on an individual, even should it be overflown, would be insignificant.

6. Recovery Vessel Operation: Collisions with vessels could result in either non-lethal (blunt trauma, lacerations) or lethal injuries, depending on a number of factors, including vessel speed. In the case of a proximate approach, the acoustic or visual stimulus (or combination of the two) from recovery vessels could result in exposed individuals changing their behavior, including diving or swimming laterally to avoid the oncoming vessel. Additionally, to ensure that in-water species are not exposed to ship-induced stressors (e.g., ship strike), vessel operators would employ all vessel operating protocols stipulated in Section 2.4.2 of the Biological Evaluation (Appendix D).

Cetaceans: Collisions with ships have been a stressor imparted upon large whale species for many years, particularly since vessels began to attain speeds in excess of 24 km/hr (13 knots) (Laist et al., 2001). In the event that a vessel strikes a whale, studies have found that the probability of its lethality increases with ship speed (Gende et al., 2011; Vanderlaan and Taggart, 2007). However, several factors render this stressor highly unlikely. First, with the exception of sperm whales, the other species of cetaceans would occur in very low numbers, if at all, within the action area during the time when ship-based recovery operations would be conducted. Although sperm whales could be in the action area during this time, they spend about 70 to 80 percent of their time at depths of several hundred meters (Amano and Yoshioka, 2003; Watkins, et al., 1993), at which there would be no possibility of an individual encountering a project vessel. Coupled with the infrequent nature of the action, the small number of recovery vessels employed in support of the activity, and the employment of vessel operating protocols, the probability of striking a listed cetacean would be very low. In the event of a proximate approach, the potential reactions of cetaceans to various types of vessels vary considerably among populations, locations, and time of year (Scheidat et al., 2004). However, as discussed in the Biological Evaluation (Appendix D) regarding ship strike, the probability of a project vessel encountering a listed whale species would be unlikely, and even if it were to occur, the temporary behavioral reaction (e.g., humpback increase in speed: Scheidat et al., 2004; change in sperm

whale ventilation rate: Richter et al., 2006) associated with a proximate approach would not measurably affect an individual's fitness.

Pinnipeds: In general, very little data exists regarding the reactions of seals to vessels; however, available information (largely anecdotal) suggests that seals are rather tolerant of them (Richardson et al., 1995). Likewise, little data is available regarding the potential for (and effects of) ship strikes. However, given that the flight hardware would only land within or adjacent to terrestrial areas in the event of an off-nominal flight termination scenario, the probability of the need for ship use in shallow waters around terrestrial areas (where seals would be hauled out) would be low. Additionally, because the terrestrial areas within the action area (e.g., Nihoa Island) are only home to a small number of monk seals and since vessel operating protocols would be employed to avoid monk seals, the possibility of exposing an individual to a vessel-induced stressor such that a behavioral response is evoked is also considered very low. It is unlikely that vessels would enter, and therefore affect, designated or proposed Hawaiian monk seal critical habitat. Should entry into critical habitat occur, the resultant effects would be transient and infrequent, and limited to the propagation of vessel noise into the water column and the physical movement of waters in the epipelagic stratum of the water column due to the ships' wake. NASA would require its vessel operators to prepare for and take all necessary precautions to prevent discharges of oil and releases of waste or hazardous materials that may impair water quality. In the event of such an occurrence, notification and response would be in accordance with applicable requirements of 40 CFR Part 300. Additionally, to prevent the introduction of marine alien species, all submerged and waterline vessel surfaces would be cleaned of algae or other organisms prior to vessel use, and ballast water would be managed in accordance with U.S. Coast Guard Regulations (33 CFR Part 151). As such, the Proposed Action would only have negligible effects on the water column comprising either the designated or proposed Hawaiian monk seal critical habitat.

Sea Turtles: The potential exists for a project recovery vessel to strike a sea turtle. However, several factors render this stressor highly unlikely. First, with the exception of green sea turtles, the other species of sea turtles occur in very low numbers within the action area. Coupled with the infrequent nature of the action, the small number of recovery vessels employed in support of the proposed activity, and the employment of vessel operating protocols, the probability of striking a listed sea turtle would be very low.

Therefore, based on the data presented above, NASA concludes that the Proposed Action may affect, but is not likely to adversely affect, all listed species and critical habitat in the action area. Table 3-2 lists the possibility for presence of the species in the LDSD operating area during the launch season (June–August) and Table 3-3 is a summary of NASA's ESA determinations.

Deep-sea Corals, Bottomfish, and Seabirds

The balloon and Test Vehicle would be recovered from the Open Ocean Area and therefore not anticipated to have an adverse environmental impact on deep-sea corals

or bottomfish. As was demonstrated during the 2014 mission, it took the respective vessels approximately 5 hours to reach and recover the ring-sail parachute, 6.5 hours to reach and recover the balloon carcass, and 4 hours to reach and recover the Test Vehicle. Therefore, it is anticipated that the LDSD program would be able to locate and recover the balloon and Test Vehicle.

For seabirds, it would be expected that the splashdown of the expended flight hardware would be likely to produce short-term stressors (i.e., supersonic flight, direct or proximate strike, entanglement, ingestion, aircraft overflight, and recovery vessel operations). Seaborne vessels and spotter aircraft, directed to locate and remove the floating expended hardware, would also cause stressors to seabirds. However, vessel operating protocols employed to reduce risks to marine mammals and sea turtles would ensure a reduction in the stressors to seabirds. Therefore, these short-term stressors would have the potential to cause seabirds to leave the immediate area for a short time to permanently.

Table 3-2. ESA Species Occurrence in the Region of Influence During Launch

Order	Species	Scientific Name	Present in Splashdown (Operating) Area during June–August
Cetaceans			
Mysticetes	North Pacific right whale	*Eubalaena japonica*	Rare
	Blue whale	*Balaenoptera musculus*	Rare
	Fin whale	*Balaenoptera physalus*	Highly Unlikely
	Sei whale	*Balaenoptera borealis*	Not Known
	Humpback whale	*Megaptera novaeangliae*	Unlikely
Odontocetes	False killer whale (MHI Insular)	*Pseudorca crasidens*	Undeterminable for Splashdown Timeframe
	Sperm whale	*Physeter macrocephalus*	Undeterminable for Splashdown Timeframe
Pinnipeds			
	Hawaiian Monk Seal	*Neomonachus schauinslandi*	Likely
	Hawaiian Monk Seal Critical Habitat	N/A	Unlikely
Sea Turtles			
	Green sea turtle	*Chelonia mydas*	Unlikely (Breading season at French Frigate Shoals)
	Hawksbill sea turtle	*Eretmochelys imbricata*	Rare
	Loggerhead sea turtle	*Caretta caretta*	Highly Unlikely
	Olive ridley sea turtle	*Lepidochelys olivacea*	Unlikely
	Leatherback sea turtle	*Dermochelys coriacea*	Rare

Table 3-3. Summary of ESA Species to Occur in the Region of Influence

Order	Species	Scientific Name	ESA Status	NASA Inclusion in 2013 LDSD Final EA*	NASA ESA Determ-ination 2015
Cetaceans					
Mysticetes	North Pacific right whale	*Eubalaena japonica*	E	Yes (Page 3-54)	NLAA
	Blue whale	*Balaenoptera musculus*	E	Yes (Page 3-55)	NLAA
	Fin whale	*Balaenoptera physalus*	E	Yes (Page 3-54)	NLAA
	Sei whale	*Balaenoptera borealis*	E	Yes (Page 3-54)	NLAA
	Humpback whale	*Megaptera novaeangliae*	E	Yes (Page 3-54)	NLAA
Odontocetes	False killer whale (MHI Insular)	*Pseudorca crasidens*		Yes (Page 3-24)	NLAA
	Sperm whale	*Physeter macrocephalus*	E	Yes (Page 3-55)	NLAA
Pinnipeds					
	Hawaiian monk seal	*Neomonachus schauinslandi*	E	Yes (Page 3-55)	NLAA
	Hawaiian monk seal critical habitat	N/A	D	No	NLAA
Sea Turtles					
	Green sea turtle	*Chelonia mydas*	T	Yes (Page 3-51)	NLAA
	Hawksbill sea turtle	*Eretmochelys imbricata*	E	Yes (Page 3-51)	NLAA
	Loggerhead sea turtle	*Caretta caretta*	E	Yes (Page 3-50)	NLAA
	Olive ridley sea turtle	*Lepidochelys olivacea*	T	Yes (Page 3-50)	NLAA
	Leatherback sea turtle	*Dermochelys coriacea*	E	Yes (Page 3-50)	NLAA

Key:
NLAA = May affect, not likely to adversely affect.
E=Endangered
D=Designated
T=Threatened
N/A=Not Applicable
*NMFS did not require formal Section 7 Consultation for the 2013 LDSD Final EA

(2) Unrecovered Sinkable Hardware

The balloon flight train would rapidly sink in the Open Ocean Area and/or PMNM and would be almost impossible to locate.

Threatened and Endangered Species

The balloon flight train would be left in the open ocean and/or PMNM, and the sinking of the balloon flight train may cause environmental impacts to biological/marine wildlife in the form of stressors (i.e. supersonic flight, direct or proximate strike, entanglement, ingestion, aircraft overflight, and recovery vessel operations) to which listed individuals would respond if exposed. Potential impacts from stressors caused by the discarded balloon flight train on ESA species have been analyzed in the Biological Evaluation (Appendix D) and are discussed above under Threatened and Endangered Species-Expended Flight Hardware (including Flight Train).

Deep-sea Corals, Bottomfish, and Marine Mammals

It is conceivable that the balloon train could settle on deep-sea coral as it reaches the ocean floor. NASA would not recover the balloon train from the ocean floor because it would be almost impossible to locate. However, review of NOAA and United Nations Environment Programme surveys of coral reefs in the NHI and NWHI indicate that coral reefs are not expected in the splashdown area and, therefore, significant impacts to corals from the balloon flight train are not anticipated.

It is conceivable that the balloon train could come in contact with bottomfish as it reaches the ocean floor. Based on the natural behavior of fish and marine mammals (e.g. startled by noise, vibrations), it is anticipated that bottomfish and marine mammals would leave the immediate area as the balloon flight train is descending to the ocean floor.

To ensure that in-water species are not exposed to ship-induced stressors (e.g., ship strike) constant vigilance would be maintained for the presence of ESA-listed marine mammals and sea turtles. Vessels would remain at least 92 m (300 ft) from Hawai‘ian monk seals and humpback whales and at least 46 m (150 ft) from all other marine mammals and sea turtles. Vessel speeds would be reduced to 18.5 kilometers per hour (km/hr) (10 knots) or less when piloting in proximity of marine mammals and further reduced to 9.25 km/hr (5 knots) or less when piloting in areas of known or suspected sea turtle activity. If marine mammals or sea turtle approach a vessel, activity would stop, allowing the animal to safety depart the immediate area prior to resuming operation. Additionally, to prevent the introduction of marine alien species, all submerged and waterline surfaces would be cleaned of algae or other organisms prior to vessel use, and ballast water would be managed in accordance with U.S. Coast Guard Regulations (33 CFR Part 151).

(3) Seaborne Vessels and Aircraft

NASA would utilize up to three seaborne vessels and up to two U.S. Navy aircraft during future campaigns to execute recovery operations immediately following each SFDT (Table 3-4). The proposed activities of concern for seaborne vessels are (1) vessel strike and (2) vessel anchoring.

Table 3-4. Proposed Seaborne Vessels and Aircraft for Proposed Action

Seaborne Vessels			
Name/Type	**Length**	**Max Speed**	**Cruise Speed**
M/V Kahana	56 m (185 ft)	22 km/hr (12 knots)	15-18.5 km/hr (8-10 knots)
M/V Honua	45.7 m (150 ft)	20 km/hr (11 knots)	15 km/hr (8 knots)
MV Manao II	19.5 (64 ft)	28 km/hr (15 knots)	22 km/hr (12 knots)
Aircraft			
Name	**Type**	**Purpose**	**Flight Altitude**
U.S. Navy G-2/3	G-2/3	Spotter Aircraft/Safety Surveillance	15,000-24,000
U.S. Navy C-12/26	C-12/26	Spotter Aircraft/Safety Surveillance	15,000-24,000

Vessel Strike

Threatened and Endangered Species

Potential impacts from the recovery vessel operation may cause stress to ESA species. This potential has been analyzed in the Biological Evaluation (Appendix D) and is discussed above under Threatened and Endangered Species—Expended Flight Hardware (Including Flight Train)—Recovery Vessel Operation.

Deep-sea Corals, Bottomfish, and Seabirds

The vessels are not anticipated to come in contact with deep-sea coral, bottomfish, or seabirds. The deep-sea coral and bottomfish are located at depths beyond the natural hull reach of the vessels. It is anticipated that seabirds would depart the immediate area.

Vessel Anchoring

The three seaborne vessels would not anchor during the recovery process.

Aircraft

Threatened and Endangered Species

Potential impacts from the Aircraft Overflight may cause stress to ESA species. This potential stress has been analyzed in the Biological Evaluation (Appendix D) and is discussed above under Threatened and Endangered Species- Expended Flight Hardware (including Flight Train)-Aircraft Overflight.

Deep-sea Corals, Bottomfish, Marine Mammals, Turtles and Seabirds

The operators of LDSD search and recovery aircraft are required to operate at an altitude greater than 457 m (1,500 ft), at which the effects of overflight (e.g., startle) would be minimal. Furthermore, should aircraft operators observe sea birds, marine mammals, or sea turtles, they would not undertake potentially harassing (e.g., repeated circling) patterns until the individuals are no longer under the aircraft's flight path. It is not anticipated that the aircraft would have an adverse environmental impact on corals or bottomfish.

3.2.1.2.5 Cultural Resources—Open Ocean Area (Alternative 1—Proposed Action/Preferred Alternative)

3.2.1.2.6 Regulatory Content

The National Historic Preservation Act (NHPA) of 1966, as amended, outlines Federal policy to protect historic properties and promote historic preservation in cooperation with other nations, Tribal governments, States, and local governments. Section 106 of the NHPA and its implementing regulations outline the procedures for Federal agencies to follow to take into account their actions on historic properties. Under Section 106, Federal agencies are responsible for identifying historic properties within the Area of Potential Effects for an undertaking, assessing the effects of the undertaking on those historic properties, if present, and considering ways to avoid, minimize, and mitigate any adverse effects.

3.2.1.2.7 Region of Influence

The region of influence for Open Ocean Area cultural resources includes approximately 37,600 km^2 (10,950 nm^2) of splashdown area encompasses locations where the Test Vehicle system equipment splashdown and debris might affect submerged sites, features, wrecks, or ruins. Of the approximately 37,600 km^2 (10,950 nm^2), approximately 28,730 km^2 (8,370 nm^2) is Open Ocean Area within the easternmost part of PMNM and approximately 8,875 km^2 (2,600 nm^2) is Open Ocean Area north of PMNM. Figure 1-5 is an overview of the affected area.

3.2.1.2.8 Affected Environment

The affected environment is discussed for PMNM and the Open Ocean Area outside of PMNM.

3.2.1.2.8.1 Papahānaumokuākea Marine National Monument

Papahānaumokuākea is the name given to a vast and isolated linear cluster of small, low lying islands and atolls, with their surrounding ocean, extending some 1,931 km (1,200 mi) to the northwest of the main Hawaiian Archipelago, located in the north-central Pacific Ocean. The property comprises PMNM, which extends almost 2,000 km (1,080 nm) from southeast to northwest. The property includes a significant portion of the Hawaii-Emperor hotspot trail, constituting an outstanding example of island hotspot progression. Much of the property is made up of pelagic and deepwater habitats, with notable features such as seamounts and submerged banks, extensive coral reefs, lagoons, and 14 km^2 (5.4 mi^2) of emergent lands distributed between a number of eroded high islands, pinnacles, atoll islands, and cays. With a total area of around 362,075 km^2 (105,564 nm^2), it is one of the largest marine protected areas in the world. The geomorphological history and isolation of the archipelago have led to the development of an extraordinary range of habitats and features, including an extremely high degree of endemism (i.e., unique to a specific place). Largely as a result of its isolation, marine ecosystems and ecological processes are virtually intact, leading to exceptional biomass accumulated in large apex predators. Island environments have, however, been altered through human use, and although some change is irreversible, there are also examples of successful restoration. The area is host to numerous endangered or threatened species, both terrestrial and marine, some of which depend solely on Papahānaumokuākea for their survival. All the cultural attributes that reflect Outstanding Universal Value are within the boundaries of the property. The archaeological sites remain relatively undisturbed by cultural factors. Although none of the attributes are under severe threat, some of the archaeological sites need further conservation and protection against damage from plants and wildlife. (World Heritage Convention, 2015)

In Hawaiian traditions, Papahānaumokuākea (NWHI) is considered a sacred place, a region of primordial darkness from which life springs and spirits return after death (Kikiloi, 2006). Much of the information about Papahānaumokuākea (NWHI) has been passed down in oral and written histories, genealogies, songs, dance, and archaeological resources. Through these sources, Native Hawaiians are able to recount the travels of seafaring ancestors between the NWHI and the MHI. Hawaiian language archival resources have played an important role in providing this documentation, through a large body of information published over a hundred years ago in local newspapers (e.g., Kaunamano 1862 in *Hōkū o ka Pakipika*; Manu 1899 in *Ka Loea Kalaiʻāina*; Wise 1924 in *Nūpepa Kuokoʻa*). More recent ethnological studies (Maly, 2003) highlight the continuity of Native Hawaiian traditional practices and histories in PMNM (NWHI). Only a fraction of these have been recorded, and many more exist in the memories and life histories of kupuna. (National Oceanic and Atmospheric Administration, 2015)

Today, Native Hawaiians remain deeply connected to the NWHI on genealogical, cultural, and spiritual levels. Kauai and Niihau families voyaged to these islands, indicating that they played a role in a larger network for subsistence practices into the 20th century (Tava and Keale, 1989; Maly, 2003). In recent years, Native Hawaiian

cultural practitioners voyaged to the NWHI to honor their ancestors and perpetuate traditional practices. (National Oceanic and Atmospheric Administration, 2015)

Maritime archaeologists conduct archaeological surveys to characterize the maritime heritage resources on the seafloor as a pivotal part of the effort to develop an inventory and a better understanding of the resource base in PMNM. Characterization begins with a historical inventory of the potential resources and proceeds to the field research component: physically locating and documenting these sites. Field research to date has resulted in the documentation of 20 maritime heritage sites. These sites have been documented at both Phase 1 (general site description) and Phase 2 (thorough site documentation and evaluation of a site for eligibility for inclusion in the National Register of Historic Places) levels. (Papahānaumokuākea Marine National Monument, 2011)

3.2.1.2.8.2 Open Ocean Area

In the waters surrounding the Hawaiian Islands, there are thousands of submerged cultural resources. The types of wrecks most likely to occur are 19th century cargo ships, submarines, old whaling and merchant ships, fishing boats, or 20th century U.S. warships, aircraft, recreational craft, and land vehicles. There is no definitive count of the number of wrecks surrounding the Hawaiian Islands, as they are located at depths that make them difficult to locate and record. Pacific Ocean currents and storms are also quick to destroy these types of submerged resources.

The State of Hawaii's Geographic Information System and the Marine Resources Assessment for the Hawaiian Islands Operating Area, Final Report (U.S. Department of the Navy, 2005) were reviewed to determine the potential for submerged cultural resources within the Area of Potential Effects; none were noted.

3.2.1.2.9 Environmental Consequences

NASA would conduct up to two SFDT test flight per year over the next 5 years (2015–2019). If expended flight hardware should splashdown or drift into PMNM, NASA would recover all floating hardware as quickly as possible, thereby avoiding adverse impacts to cultural resources. As PMNM is considered in Hawaiian traditions as a sacred place from which life springs and to which spirits return, unavoidable cultural impacts may occur, if either of the up to 10 balloon flight trains (up to two per year, over 5 years) should sink to the PMNM sea floor. However, given the unlikely probability of splashdown occurring in PMNM and that the balloon flight train is most likely to sink outside PMNM, the risk of impact is small. No Section 106 Consultation was required for this Proposed Action.

3.2.2 NIHOA ISLAND (INCLUDING THE SPECIAL MANAGEMENT AREA)

Resources Carried Forward for Detailed Analysis for Nihoa Island

The LDSD project has the potential for overflight of Nihoa Island and the Special Management Area, and only in the event of a catastrophic failure of the flight system would flight hardware descend into these areas. Therefore, 2 of the 14 areas of environmental consideration have been addressed in detail in this SEA. Table 3-1 presents the results of the process of identifying resources to be analyzed in this SEA, which are biological resources, cultural resources and health and safety. The general organization of resource areas is consistent with the 2013 LDSD Final EA; however, many have been eliminated from the SEA and are detailed in Table 3-1.

Resources Considered but Eliminated from Detailed Analysis for Nihoa Island

Fourteen areas of environmental consideration were initially evaluated for Nihoa Island to provide a context for understanding the potential effects of the Proposed Action and to provide a basis for assessing the severity of potential environmental effects. These areas included air quality, airspace, biological resources, cultural resources, geology and soils, hazardous materials and waste, health and safety, land use, noise, socioeconomics, transportation, utilities, visual aesthetics, and water resources. Ultimately 2 of the 14 areas of environmental consideration were addressed for Nihoa Island and the Special Management Area surrounding the island (biological and cultural resources). The remaining resource areas were not analyzed in such a manner. Those resources not warranting further discussion are presented in Table 3-1.

3.2.2.1 Biological Resources—Nihoa Island (Alternative 1—Proposed Action)

3.2.2.1.1 Region of Influence

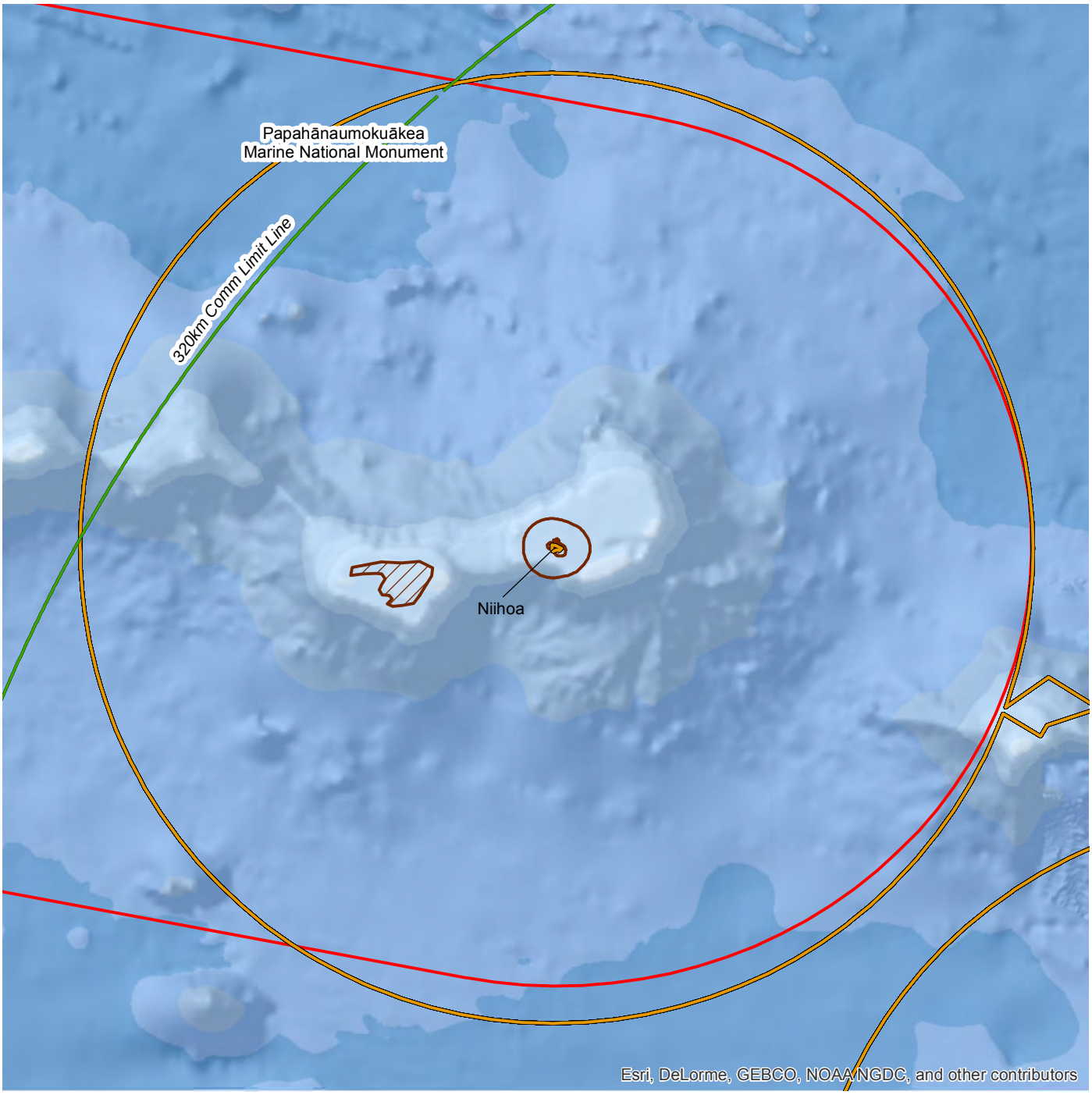
The region of influence for biological resources includes the area within the Nihoa Island boundary that could be affected by the proposed activities. Figure 3-3 is an overview of the biological resources surrounding Nihoa Island.

3.2.2.1.2 Affected Environment

3.2.2.1.2.1 Terrestrial

Vegetation

Endemic endangered plants on Nihoa Island include the Nihoa fan palm (*Pritchardia remota*), the only species of tree on the island, and the leguminous ‘ohai shrub (*Sesbania tomentosa*). Most of the ridges are covered with two species of grass, and the valleys are densely covered with shrubs and bushes. (National Oceanic and Atmospheric Administration, 2013)



EXPLANATION

- 320-km Communications Limit Line
- Coral
- Monk Seal Critical Habitat
- Nihoa 3-nautical mile Special Management Area
- Papahānaumokuākea Marine National Monument

NORTH

0 12.5 25 50 Nautical Miles

Biological Resources Surrounding Nihoa Island

Nihoa

Figure 3-3

33_niihau_coral, 4/1/2015

Threatened and Endangered Terrestrial Vegetation

Nihoa Fan Palm (Pritchardia remota)

The Nihoa fan palm *(Pritchardia remota)* is one of the endemic Hawaiian species that has a very narrow geographic distribution. It is one of only four Pritchardia species that are found in low-elevation dryland vegetation as all the other species are found in mesic or wet vegetation. This species is found on Nihoa Island at the base of cliffs and on high cliff terraces ranging from an elevation of 200 to 800 m (656 to 2,625 ft) in East and West Palm valleys. *Nihoa pritchardia* grows to only 4 to 5 m (13 to 16 ft) in height with a narrow trunk that is less than 15 cm (6 inches) in diameter. This species may also be present on Laysan Island, northwest of Nihoa Island. (National Tropical Botanical Garden, 2015)

A 1996 survey found a total of four plant populations of 680 palms on the island. Groves of Nihoa fan palms grow in coastal mesic valley depressions in two valleys on Nihoa Island: The largest population grows in the West Palm Valley, while the three smaller populations are found in the East Palm Valley. (Gemmill, 1998)

Leguminous ʻOhai Shrub (Sesbania tomentosa)

ʻOhai *(Sesbania tomentosa)* is a variable species. It is usually a low, spreading shrub with horizontal or arching branches; it is can also have a treelike habit up to approximately 5 m (15 ft) tall. In the wild, a single plant can cover a large area, but in cultivation it will tend to be under approximately 3 m (10 ft) in diameter. It is an endangered, endemic Hawaiian plant. It used to grow in dry areas at elevations below 762 m (2,500 ft) on all of the main islands. However, destruction of these habitats has greatly diminished its natural occurrence within its former range. (Hawaiian Native Plant Propagation Database, 2001)

Ohai are naturally found on sandy beaches, dunes, soil pockets on lava, and along pond margins (only Mānā, Kauai). In the NWHI ʻohai is a rather common component in the shrubland on Nihoa (Moku Manu) and is also found on Necker (Mokumanamana). Formerly widespread, ʻohai is now extinct on Niihau and rare and restricted to relict populations elsewhere in the MHI. On Oahu, it is restricted to a few locations such as Kaʻena, Mokuʻauia, and Kāohikaipua; on Kahoʻolawe it is only found on Puʻukoaea Islet. (Native Plants Hawaii, 2009)

Amaranthus brownii

Amaranthus brownii is endemic to the island of Nihoa in the NWHI. Nihoa is part of the Hawaiian Islands National Wildlife Refuge, and has an area of only 0.65 km². *Amaranthus brownii*, a member of the amaranth family (Amaranthaceae), is an annual herb with leafy upright or ascending stems, 1 to 3 ft (30 to 90 cm) long. The slightly hairy, alternate leaves are long and narrow, 1.6 to 2.8 in (4 to 7 cm) long, 0.06 to 0.16 in (1.5 to 4 mm) wide, and more or less folded in half lengthwise. Flowers are either male or female, and both sexes are found on the same plant. The green flowers are subtended by two oval, bristle-tipped bracts about 0.04 in (1 mm) long and 0.03 in (0.7

mm) wide. The flattened, oval fruit, which does not split open at maturity, is 0.03 to 0.04 in (0.8 to 1 mm) long and 0.02 to 0.03 in (0.6 to 0.8 mm) wide and contains one shiny, lens-shaped, reddish black seed. This species can be distinguished from other Hawaiian members of the genus by its spineless leaf axils, its linear leaves, and its fruit which does not split open when mature. (Department of Land and Natural Resources, 2005)

When *Amaranthus brownii* was first collected in 1923, it was recorded as "most common on the ridge leading to Millers Peak, but abundant also on the ridges to the east." The two known populations are separated by a distance of 0.4 km (0.25 mi) and contain approximately 35 plants: about 23 plants near Millers Peak and about 12 plants in Middle Valley. Threats include competition from invasive alien plant species, landslides, fire, possible hybridization with non-native amaranth species, small number of populations and individuals and limited distribution that increase threats by stochastic extinction, and reduced reproductive vigor. (Department of Land and Natural Resources, 2005)

Terrestrial Wildlife (Animal)

The terrestrial fauna includes monk seals *(Monachus schauinslandi*), 72 species of anthropods including giant crickets and earwigs, 2 species of endemic land birds—the endangered Nihoa finch *(Telespyza ultima)* and the endangered Nihoa millerbird *(Acrocephalus familiaris kingi)*—and several species of seabirds, such as terns, shearwaters, petrels, boobies, albatrosses, tropic birds, and frigate birds. (National Oceanic and Atmospheric Administration, 2013)

Threatened and Endangered Terrestrial Wildlife

Nihoa Finch (Telespyza ultima)

Nihoa finch is an endemic species that lives only on Nihoa Island. It prefers open but vegetated habitat, nesting in small holes in rock outcrops 30.5 to 244 m (100 to 800 ft) above sea level. (National Oceanic and Atmospheric Administration, 2013) The species occurs on more than two-thirds of the island, but its entire range is still less than 0.5 km^2 (0.2 mi^2) (BirdLife International, 2014). Threats to the Nihoa finch include introduced plants and animals, and fire.

Identification. Nihoa finches are medium-sized finches (17 cm ([6.7 inches]) with heavy, silver-colored bills. Adult males have yellow heads, yellow underparts, grayish backs with a yellow patch in the middle, and yellowish wings. Females and juveniles have a very different appearance; they too have yellow breasts, but their underparts, heads, and backs are all heavily streaked with brown and black. (BirdLife International, 2014)

Distribution and Population Trends. *Telespiza ultima* once occurred at least on the island of Molokai in the MHI, but was extirpated in prehistory probably by a combination of predation by introduced mammals and habitat loss (Morin and Conant, 2002). Today, this species is restricted to the steep, rocky island of Nihoa in the NWHI (Berger,

1972, Morin et al., 1997). Numbers fluctuate (James and Olson, 1991; Morin and Conant 2002), although some variation may be due to differences in survey methods and time of year. Numbers on Nihoa have ranged from 6,686 in 1968 to 946 in 1987 (James and Olson, 1991; Morin and Conant, 2002). The most recent population estimate based on surveys in 2012 is 4,475 individuals (VanderWerf, 2012), which roughly equates to 3,000 (2,400–3,600) mature individuals. (BirdLife International (2015)

Between 1967 and 1996, population estimates for Nihoa finches ranged from a high of 6,686 in 1968 to a low of 946 in 1987. This species' numbers are thought to naturally fluctuate somewhat, but some of the variation in annual population estimates might be the result of different survey protocols (including time of year). (BirdLife International, 2014)

Ecology. Nihoa island is a steep, rocky island largely covered by low shrubs and grasses. Nihoa finches are omnivorous, feeding on seabird eggs, seeds, flowers, and insects. These birds nest in rock crevices. As with other Hawaiian finches, Nihoa finches are loud singers with complex, canary-like songs. (Audubon, 2014). Egg laying begins in February and may extend to early July, with an average clutch of three eggs. (U.S. Fish and Wildlife Service, 2012)

The Nihoa finch whistles, trills, and warbles loudly and melodiously. Males are showy when singing, holding their wings horizontally away from their bodies and sometimes swaying back and forth. The distress call is a loud, harsh chip. (U.S. Fish and Wildlife Service, 2012)

Threats. The major threats to Nihoa finches are the introduction of non-native plant and insect species, and large catastrophic events, such as hurricanes, droughts, and major storms. Nihoa finches' extremely limited range makes them extremely susceptible to extinction from a single major catastrophe. (BirdLife International, 2014)

Conservation. Nihoa finches were listed as Endangered by USFWS in March 1967. Nihoa Island is part of the Hawaiian Islands National Wildlife Refuge, thereby providing protection for the species' habitat. Nihoa is not a populated island, and access to it is strictly controlled. Biologists and other researchers who are permitted access to the island are carefully inspected to ensure that they do not accidentally introduce seeds, eggs, or insects to Nihoa Island via their clothes or equipment. In addition, researchers visiting the island regularly perform hand weeding of introduced plants to control their growth. To establish another population of Nihoa finches, and thereby reduce the risk of complete extinction via one cataclysmic event, a group of birds was introduced to French Frigate Shoals (also in the Hawaiian Islands National Wildlife Refuge), but those birds did not survive. (BirdLife International, 2014)

Nihoa Millerbird (Acrocephalus familiaris kingi)

The Nihoa millerbird is an endemic bird found only on Nihoa Island. The population size of the Nihoa millerbird has fluctuated between 300 and 700 individuals in the last 30 years. Threats to the Nihoa millerbird include introduced plants and animals, and fire. (National Oceanic and Atmospheric Administration, 2013)

Biologists are considering the translocation of sufficient millerbirds to create a second population on another Hawaiian island to reduce the risk of extinction. A ranking of potential translocation sites for the millerbird indicated that Laysan Island is the first choice for a translocation effort. Planning is underway for this project. (U.S. Fish and Wildlife Service, 2012b)

Identification**.** The Nihoa millerbird is a tiny land bird measuring approximately 12.7 cm (5 inches) in length that was discovered on the Nihoa Island in 1923. It has dark gray-brown feathers above, a buffy-white belly, and a thin dark colored bill. This bird got its name because its favorite food is the miller moth. Male and female birds are similar looking. (U.S. Fish and Wildlife Service, 2012)

Distribution and Population Trends. The millerbird is known only from two islands within the Hawaiian Archipelago. The Laysan Island population was considered abundant prior to the introduction of rabbits around 1903. Somewhere between 1916 and 1923 the Laysan population disappeared as rabbits consumed all living plants that provided food, shelter, and nest sites for this little warbler. Another population was discovered on Nihoa Island in 1923, the same year that the Laysan population was confirmed extinct. The logistics of accessing Nihoa Island and conducting accurate surveys have made it difficult to track population changes or dynamics, but it seems that the population has remained stable within its extremely small range (40 hectares [99 acres] of vegetation on a 63-hectare [156-acre] island). Over the last 30 years of annual surveys, estimates of population sizes have ranged from 31 to 731 birds, while the carrying capacity of the island has been estimated at around 600 birds. (Audubon, 2014)

Ecology. Very little is known about the Laysan millerbird, while limited and difficult access to Nihoa Island has significantly reduced opportunities to learn about the species from its extant population. Birds on Laysan Island were characterized as energetic and confiding, often seen around buildings or camps searching in crannies for insects or even hopping around and landing on visitors. On Nihoa Island, millerbirds are known to prefer dense cover near the ground, where they search for insects and larvae and build nests in dense shrubs. The first nest on Nihoa Island was discovered in 1962, and the nesting season is now suspected to run from January to September. Their food consists entirely of insects and larvae, especially moths and caterpillars. (Audubon, 2014)

Threats. As with any limited population, random events could have catastrophic effects. The tiny exposed island of Nihoa is especially susceptible to weather events, and weather events probably account in part for changes in millerbird population estimates

over the past 30 years. The fragile nature of this tiny ecosystem and the chance that human visitors could introduce an alien species are an ongoing cause for concern. At this time only three alien plants are thought to be established on Nihoa Island, and disease-bearing mosquitoes that have decimated other Hawaiian endemic birds have not become established on the island. Rats, mosquitoes, or new plants are all possible threats. (Audubon, 2014)

Conservation. The species was federally listed as Endangered in 1967. Nihoa Island is part of the Hawaiian Islands National Wildlife Refuge, and access is strictly controlled through a permitting process. While visiting scientists make an effort to pull invasive weeds, no other substantive efforts on behalf of the millerbird have been undertaken. The option of translocating millerbirds to other islands (including Laysan, Necker, and Kaho'olawe) has been seriously considered, with the option of returning millerbirds to Laysan receiving the most serious attention. Computer models show that the current population has an unacceptably high probability for extinction unless efforts are made to establish supplemental populations either on other islands or in captivity. (Audubon, 2014)

In 2011 and 2012, a small number of ulūlu were translocated from Nihoa Island to Laysan Island to improve the long-term survival of the species and to fill a gap in Laysan's ecosystem that was once filled by the now-extinct Laysan millerbird. (National Oceanic and Atmospheric Administration, 2014d)

3.2.2.1.2.2 Marine

Corals

Nihoa Island's submerged coral reef habitat totals approximately 570 km^2 (141,000 acres) and is the remnant of a former volcanic cone. The northern edge of the reef is a steep cliff made up of successive layers of lava through which numerous volcanic extrusion (dikes) are visible. Nihoa Island supports coral communities with very limited total habitat, most of which is protected from the heavy and chronic wave action that strikes this small island from all directions. These habitats consist of the submerged portions of sea cliffs close to shore, caves and lava tubes, ledges, overhangs, basalt pinnacles, boulders, cobbles, sand deposits, basalt benches and slopes, trenches and shelves. All of these features have been shaped by and are constantly eroded by the pounding waves. The rigorous environment and isolated nature of Nihoa Island has limited the number of corals that have successfully colonized the shallow habitats encircling the island. Due to the scouring effects of sand and turbulent waves, most of the 20 species of corals only survive at depths greater than 9 m (30 ft), and nowhere is coral cover greater than 25 percent. (National Oceanic and Atmospheric Administration, 2012)

Seventeen species of scleractinian (stony) coral were found at Nihoa Island. Small encrusting forms of the lobe coral, *Porites lobata*, and rose coral colonies (*Pocillopora meandrina*) were the most common. Encrusting pink coralline algae covered many rocky surfaces in very shallow water. Some red, brown, and green algae were common

around the island. The red alga, *Asparagopsis taxiformis*, is an edible species that is no longer common in the MHI. (National Oceanic and Atmospheric Administration, 2013) Stony corals are also less abundant and diverse off the exposed basalt islands to the southeast (Nihoa, Necker, La Perouse, Gardner), where soft corals (Sinularia, Palythoa) are more abundant. Exposure to severe wave action appears to limit coral development off these small islands and surrounding deep platforms. The lowest live coral values were concentrated at ocean facing reefs off Nihoa, Necker, Gardner, and Laysan Islands, which are more exposed to large waves and swells from any direction. (National Oceanic and Atmospheric Administration, 2005)

Other Marine Life (Nihoa Island)

Reef fish, sharks, jacks, and other predators are common to Nihoa Island. Due to a limited number of habitat types, however, species diversity of reef fishes is low when compared to other atolls and islands in the PMNM chain. Although Nihoa Island was populated during the 16th century, human disturbances have been minimal in the near shore waters around the island in recent times. (National Oceanic and Atmospheric Administration, el al., 2008)

The most common invertebrates found (excluding corals and other cnidarians) are the smaller encrusting species, such as sponges, ectoprocts (*bryozoans*), and tunicates. Large invertebrates are uncommon, except for a couple of species of rock-boring sea urchins, starfish, shark, jack, monk seals, and other apex predators (predatory animals which are at the top of their food chain and are not normally preyed upon by other predators) that are common to the island. However, due to the limited number of habitat types, species diversity of reef fishes is low when compared to other atolls and islands in the NWHI (PMNM). (National Oceanic and Atmospheric Administration, 2012)

Threatened and Endangered Marine Wildlife Species

Hawaiian Monk Seal (Monachus schauinslandi)

Nihoa Island supports a small population of endangered Hawaiian monk seals (*Monachus schauinslandi*) with limited reproduction, probably maintained by immigration from other breeding colonies. The endangered Hawaiian monk seal is an indigenous mammal that has been observed at Nihoa Island. Nihoa Island supports a small population of endangered Hawaiian monk seals with limited reproduction, probably maintained by immigration from other breeding colonies. (National Oceanic and Atmospheric Administration, 2013) The primary occurrence of Hawaiian monk seals within the region of influence is expected to be in a continuous band between Nihoa Island, Kaula, Niihau, and Kauai.

In PMNM (NWHI), there are eight discrete monk seal subpopulations from Nihoa Island to Kure Atoll (excluding Gardner Pinnacles and Maro Reef), a distance of 2,000 km (1,080 nm). (National Oceanic and Atmospheric Administration, undated).

Despite the fact that Hawaiian monk seals are one contiguous species, the subpopulations in PMNM (NWHI) and MHI face different threats. In PMNM (NWHI), primary threats include food limitation for juveniles, shark predation on juveniles, entanglement in marine debris, male seal aggression on females and juveniles, and shoreline habitat loss. Threats in the MHI include disease and various types of human-induced impacts, such as disturbance at haul-out areas, fishery interactions, feeding and other interactions that cause habituation to humans, and most recently, intentional killings. (National Oceanic and Atmospheric Administration, 2011) Table 3-5 lists the threatened and/or endangered species known/expected to occur on Nihoa Island.

Table 3-5. Listed Species Known/Expected to Occur On and Around Nihoa Island

Scientific Name	Common Name	Federal Status
Terrestrial		
Plants[1]		
Pritchardia remota	Loulu (Nihoa fan palm)	E
Sesbania tomentosa	`Ohai	E
Amaranthus brownii	No common name	E
Birds		
Acrocephalus familiaris kingi	Nihoa millerbird	E
Telespyza ultima	Nihoa finch	E
Marine*		
Mammals		
Monachus schauinslandi	Hawaiian monk seal	E

Source: U.S. Fish and Wildlife Service, 2003; National Oceanic and Atmospheric Administration, 2006

1 Note: The entire island of Nihoa other than manmade features has been designated as critical habitat for these plants.

Key to Federal Status:
*See Table 3-2 for Cetacean, Pinnipeds, and Sea Turtles
E = Endangered

3.2.2.1.2.3 Environmentally Sensitive Habitat Area

An environmentally sensitive habitat area can be defined as a designated protective area within the zone of a specific area (e.g., wetlands). The entire island of Nihoa other than manmade features has been designated as critical habitat for the endangered plants *Pritchardia remota, Sesbania tomentosa and* Amaranthus brownii. The 10 km^2 (3 nm^2) surrounding Nihoa is designated as a Special Management Area; the boundary extends 5.5 km (3 nm) from shore.

3.2.2.1.2.4 Seabirds

Nihoa's seabird colony boasts one of the largest populations of Tristam's storm-petrel. Bulwer's petrel, and blue noddies in the Hawaiian Islands, and very possibly the world.

The island is a unique example of a lowland native community, resembling those lowland communities that once occurred on the MHI but are now almost completely gone (Wagner et al., 1990).

3.2.2.1.3 Section 7 Consultation for Nihoa Island

U.S. Fish and Wildlife Service

In accordance with Section 7 of the ESA, NASA initiated informal consultation *for the SEA* with USFWS on 15 January 2015. The Final Biological Evaluation was submitted to USFWS on 6 March 2015, and NASA received a letter of concurrence on 5 April 2015 (Appendix E).

3.2.2.1.4 Environmental Consequences

Proposed Action

The analytical approach for biological resources involved evaluating the degree to which the proposed activities could impact vegetation, wildlife, threatened or endangered species, and sensitive habitat within the affected area. Criteria for assessing potential impacts to biological resources are based on the following: the number or amount of the resource that would be impacted relative to its occurrence at the project site, the sensitivity of the resource to proposed activities, and the duration of the impact. Impacts are considered substantial if they have the potential to result in reduction of the population size of federally listed threatened or endangered species, degradation of biologically important unique habitats, substantial long-term loss of vegetation, or reduction in capacity of a habitat to support wildlife. The proposed activities of concern for analysis are ((1) expended flight hardware and (2) sea vessels and airplanes.

(1**) Expended Flight Hardware (Including the Flight Train)**

Terrestrial Resources

The primary concern regarding terrestrial resources would be the potential for SFDT hardware to crash, burn, and/or bury an individual endangered animals (Nihoa millerbird [*Acrocephalus familiaris kingi*], the Nihoa finch [*Telespyza ultima*]), Amaranthus brownii and endangered plants (Nihoa fan palm *[Pritchardia remota]* and Ohai *[Sesbania tomentosa])* on Nihoa Island. The Nihoa finch's egg laying begins in February and may extend to early July, and the nesting season for the Nihoa millerbird is suspected to run from January to September. Up to two annual SFDT test flights would occur between June and August of each year, which could have an adverse environmental impact on the nesting season of both birds if the expended flight hardware landed on island.

To mitigate (reduce) the potential for environmental impact to Nihoa Island and the Special Management Area, one of two scenarios would occur: (1) the flight system would overfly the excluded area, and the Test Vehicle would be dropped outside 5.5 km (3 nm) from Nihoa Island; or (2) the LDSD Program would initiate the SFDT in such a manner that expended flight hardware would be recovered before drifting into the excluded area. Additionally, under the assumption that all possible trajectories were

allowed to fly, NASA estimates that the balloon has approximately a 20 percent chance of entering PMNM after reaching float altitude and a 0.4 percent chance of reaching float altitude within PMNM. These probabilities are further reduced when NASA and the U.S. Navy apply the project's established Go/No Go criteria.

If an unplanned scenario occurs (e.g., crash, fire) and there is indication of an adverse environmental impact, NASA would contact the Monument Permit Coordinator as soon as reasonably possible.

Marine Resources

The endangered Hawaiian monk seal has been observed at Nihoa Island. Nihoa Island supports a small population with limited reproduction. Potential adverse environmental effect would be associated with an unplanned scenario (anomalies) which would allow SFDT hardware to encounter a Hawaiian monk seal. However, one of two scenarios listed above would occur and the same probability assumption applied to terrestrial resources is applicable to the unexpected adverse environmental impacts to the Hawaiian monk seal. Therefore, based on the planned (nominal) trajectory, no potential adverse environmental impacts marine resources are expected. If an unplanned scenario occurs (e.g., crash, fire) and there is indication of an adverse environmental impact, NASA would contact the Monument Permit Coordinator as soon as reasonably possible.

Should either the Test Vehicle, balloon, or MET rockets land within terrestrial Hawaiian monk seal critical habitat, it would occupy a small portion of habitat that would have otherwise been available for pupping, basking, or resting. The physical impact of the descending items could crush shoreline vegetation or penetrate the surface of the beach (i.e., create a "divot"). However, such effects would be transient as all materials would be located and removed by the project as soon as practicable. Likewise, any physical disturbance created would be remediated to pre-project conditions.

Nonetheless, the potential for this stressor to occur would be highly unlikely. As discussed in Section 2.5 of the Biological Evaluation (Appendix D), Nihoa Island and its 5.6-km (3-nm) buffer would be categorically avoided when conducting each SFDT. Under normal conditions, these areas would be overflown. It would only be in the case of a catastrophic failure of the flight system that flight hardware would descend into designated terrestrial critical habitat.

The rigorous environment and isolated nature of Nihoa Island have limited the number of corals that have colonized in the shallow habitats encircling the island. Stony corals are less abundant and diverse and are not anticipated to be adversely affect by the Proposed Action. There are no endangered corals, fish, or other invertebrates found within the region of influence, and due to the limited habitat types, the diversity of fish and other invertebrates is also limited.

(2) Seaborne Vessels and Aircraft

NASA would utilize up to three seaborne vessels and up to two aircraft (see Table 3-4) during future campaigns to execute recovery operations immediately following each SFDT.

Seaborne Vessels

In general, very little data exists regarding the reactions of seals to vessels; however, available information (largely anecdotal) suggests that seals are rather tolerant of them (Richardson, et al., 1995). Based on the planned (nominal) trajectory, the test flights would not overfly Nihoa which would mitigate the need for the seaborne vessel are aircraft to sail near or fly over Nihoa Island. Given that the flight hardware would only land within or adjacent to terrestrial areas in the event of an unplanned flight termination scenario, the probability of the need for ship use in shallow waters around terrestrial areas (where seals would be hauled out) would be low. Additionally, because the terrestrial areas within the action area (e.g., Nihoa Island) are only home to a small number of monk seals, and since vessel operating protocols would be employed to avoid monk seals, the possibility of exposing an individual to a vessel-induced stressor such that a behavioral response is evoked is also considered very low.

Aircraft

If overflight of Nihoa Island is needed, one of two scenarios would occur: (1) the LDSD Program would initiate the SFDT in such a manner that expended flight hardware would be recovered before drifting into the excluded area; or (2) the flight system would overfly the excluded area, and the Test Vehicle would be dropped outside 5.5 km (3 nm) from Nihoa Island. With either scenario, the LDSD Program would mitigate the need to place seaborne vessel and aircraft inside or above the Special management Area. Additionally, given that the flight hardware would only land within or adjacent to terrestrial areas in the event of an off-nominal flight termination scenario, the probability of the need for repeated flights around terrestrial areas (where seals would be hauled out) would be low. Furthermore, because the terrestrial areas within the action area (e.g., Nihoa Island) are only home to a small number of monk seals, the possibility of exposing an individual to an aircraft-induced stressor such that a behavioral response is evoked is also considered very low. If an unplanned scenario occurs (e.g., plane crash, vessel run aground) and there is indication of an adverse environmental impact, NASA would contact the Monument Permit Coordinator as soon as reasonably possible.

Therefore, no potential adverse impacts to terrestrial and marine resources are expected from the utilization of the seaborne vessels and aircraft.

3.2.2.2 Cultural Resources—Nihoa Island (Alternative 1—Proposed Action)

3.2.2.2.1 Regulatory Content

The National Historic Preservation Act (NHPA) of 1966, as amended, outlines Federal policy to protect historic properties and promote historic preservation in cooperation with

other nations, Tribal governments, States, and local governments. Section 106 of the NHPA and its implementing regulations outline the procedures for Federal agencies to follow to take into account their actions on historic properties. Under Section 106, Federal agencies are responsible for identifying historic properties within the Area of Potential Effects for an undertaking, assessing the effects of the undertaking on those historic properties, if present, and considering ways to avoid, minimize, and mitigate any adverse effects.

3.2.2.2.2 Region of Influence

The region of influence for cultural resources would be the approximately 70 hectares (170 acres) of land that constitute Nihoa Island. This island is the closest to the MHI.

3.2.2.2.3 Affected Environment

A sacred place in the history and cosmology of Native Hawaiian people, Nihoa Island especially, is considered exceptional for its numerous and intact ritual sites (heiau—shrines) and its connection to living cultural traditions (National Park Service, n.d.). This remote land of rugged cliffs and steep valleys provided a home for Hawaiians between A.D. 1000 and A.D. 1700. (National Oceanic and Atmospheric Administration, 2014b)

In 1822, Queen Ka‘ahumanu organized and participated in an expedition to locate and claim Nihoa under the Kamehameha Monarchy. Nihoa was reaffirmed as part of the existing territory of Hawai‘i in 1856 by authority of Alexander Liholiho, Kamehameha IV (March 16, 1856, Circular of the Kingdom of Hawai‘i). (PMNM, 2008) In 1997, the Native Hawaiian group Hui Mälama I Nä Küpuna O Hawai`i Nei returned ancestral bones to Nihoa that had been removed from the island decades earlier. (National Oceanic and Atmospheric Administration, 2014b)

Nihoa also has a rich cultural heritage, with at least 88 known wahi kupuna (ancestral sites) constructed by the precontact Hawaiians who inhabited the island for 700 years (until 1700 A.D.), and is listed on the National Register of Historic Places. (Papahānaumokuākea Marine National Monument, 2008) The impressions left by ancient Hawaiians can be seen through the distinctive archaeology of Nihoa Island and Mokumanamana. The ceremonial terraces and platform foundations with upright stones found on both Nihoa Island and Mokumanamana are not only amazing examples of unique traditional Hawaiian architectural forms of stone masonry work, but they also show similarities to samples from inland Tahiti (Emory, 1928). The structures are some of the best preserved early temple designs in Hawai‘i and have played a critical role in understanding Hawaii’s strong cultural affiliation with the rest of Polynesia, and the significant role of Native Hawaiians in the migratory history and human colonization of the Pacific (Cleghorn, 1988).

The sites date from before the 13th century and include 25 to 35 house terraces, 15 ceremonial structures, burial caves, bluff shelters, and agricultural terraces. As many as 175 people are estimated to have lived there during prehistoric times. Numerous

artifacts found on Nihoa establish a close relationship with Native Hawaiian culture in the MHI, and to the first settlers of Hawaii who sailed through the Pacific on large voyaging canoes. Because the island had sufficient soil and water for limited agriculture, Nihoa Island was a good place for voyagers to stop and resupply their canoes. This is evidenced by the remains of stone terraces that suggest an investment in agricultural food production (U.S. Department of Commerce, The Under Secretary of Commerce for Oceans and Atmosphere, 2007; Bishop Museum Fact Sheet, n.d).

3.2.2.2.3.1 Historic Buildings and Structures

There are no modern historic buildings or structures on Nihoa Island; however, there are a number of pre-contact stone structures representing habitation, agricultural, and ceremonial features (Emory, 1928).

3.2.2.2.3.2 Traditional Resources (Including Burials)

Among the recorded sites on Nihoa Island are religious and ceremonial features (cairns, terraces, stone platforms, upright stones, and burial sites) (Emory, 1928; TenBruggencate, 2005; U.S. Department of Commerce, The Under Secretary of Commerce for Oceans and Atmosphere, 2007).

There are no maritime heritage resources associated with Nihoa Island (National Oceanic and Atmospheric Administration (Graphic, 2014).

3.2.2.2.4 Environmental Consequences

All identified cultural properties on Nihoa Island are situated some distance from the planned (nominal) trajectory of the Proposed Action. NASA estimates that the balloon has approximately a 0.4 percent chance of reaching float altitude within PMNM and a 20 percent chance of entering PMNM after reaching float altitude. These probabilities are further reduced when NASA and the U.S. Navy apply the project's established Go/No Go criteria. Additionally, to further mitigate (reduce) the potential for environmental impact, Nihoa Island and the Special Management Area would be excluded and one of two scenarios would occur: one of two scenarios would occur: (1) the LDSD Program would initiate the SFDT in such a manner that expended flight hardware would be recovered before drifting into the excluded area; or (2) the flight system would overfly the excluded area, and the Test Vehicle would be dropped outside 5.5 km (3 nm) from Nihoa Island.

Under unplanned (i.e., anomalous) scenarios, the Proposed Action has the potential for overflight of the Balloon and Test Vehicle over Nihoa Island and the Special Management Area [70 hectares (170 acres) of Nihoa Island and the approximately 128.5 km^2 (37.5 nm^2) Special Management Area within 5.5 km (3 nm) surrounding Nihoa Island]. In the highly unlikely probability that an unplanned scenario occurs (e.g., crash, fire) and indication of a culturally or historically significant site is adversely impacted, NASA would contact the Monument Permit Coordinator as soon as reasonably possible. NASA understands that if an archeological activity needs to occur

in PMNM, it must be permitted and undergo a National Historic Preservation Act consultation prior to issuance of a PMNM permit. No Section 106 Consultation was required for this Proposed Action.

3.3 ALTERNATIVE 2—ADDITIONAL LAUNCH YEARS

3.3.1 REGION OF INFLUENCE

The region of influence would be the same as that discussed in detailed the 2013 LDSD Final EA. This includes the Pacific region of PMRF (Section 3.1), Niihau (Section 3.2), the Open Ocean Area (Section 3.3) and the Global Environment (3.4).

3.3.2 AFFECTED ENVIRONMENT

The corresponding 2013 EA section numbers are denoted in parentheses after each heading.

3.3.2.1 Pacific Missile Range Facility (Section 3.1: Page 3-1)

The majority of PMRF's facilities and equipment are at the Main Base, which occupies a land area of 779 hectares (1,925 acres) and lies just south of Polihale State Park. PMRF/Main Base is generally flat and is approximately 0.8 km (0.5 mi) wide and 10.5 km (6.5 mi) long with a nominal elevation of 4.6 m (15 ft) above mean sea level. PMRF is a multi-environment range capable of supporting surface, subsurface, air, and space events and activities simultaneously. (U.S. Department of the Navy, 2008)

3.3.2.2 Niihau (Section 3.2: Page 3-40)

The only element of the LDSD Program with the potential to affect the island of Niihau is the possible overflight of the balloon and Test Vehicle and any effects of equipment or debris unexpectedly impacting the island. Although that potential is extremely unlikely, 4 of the 14 areas of environmental consideration have been addressed in detail in this SEA.

3.3.2.3 Open Ocean Area (Section 3.3: Page 3-44)

The Open Ocean Area for PMRF is the area that is greater than 22.2 kilometers (12 nm) offshore of the Hawaiian Islands. The Open Ocean Area also includes PMRF Warning Areas, Oahu Warning Areas, and the Temporary Operating Area (TOA). The Open Ocean Area, as part of the high seas (outside 22.2 km [12 nm] from land), is subject to Executive Order 12114. Both sea and air operations are covered in this section.

3.3.2.4 Global Environment (Section 3.4: Page 3-58)

In addition to actions at PMRF, Niihau, and the Open Ocean, this SEA considered the environmental effects on the global environment in accordance with the requirements of EO 12114. Specifically, potential impacts on the global atmosphere are discussed.

3.3.3 ENVIRONMENTAL CONSEQUENCES (CHAPTER 4: PAGES 4-1 THROUGH 4-26)

The environmental consequences for all affected environments are discussed and analyzed in detail in the 2013 Final EA and therefore incorporated by reference. The environmental consequences have been summarized under cumulative effects in Section 3.6.2 of this SEA.

3.4 FEDERAL ACTIONS TO ADDRESS ENVIRONMENTAL JUSTICE IN MINORITY POPULATIONS AND LOW-INCOME POPULATIONS (EXECUTIVE ORDER 12898)

An Environmental Justice analysis is included in this document to comply with the intent of EO 12898 and DoD guidance. The EO states that "each Federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations." In addition, the EO requires that minority and low-income populations be given access to information and opportunities to provide input to decision-making on Federal actions.

Proposed activities would be conducted in a manner that would not substantially affect human health and the environment. This SEA has identified no human health or environmental effects that would result in disproportionately high or adverse effects on minority or low-income populations in the area.

The activities would also be conducted in a manner that would not exclude persons from participating in, deny persons the benefits of, or subject persons to discrimination because of their race, color, national origin, or socioeconomic status.

3.5 FEDERAL ACTIONS TO ADDRESS PROTECTION OF CHILDREN FROM ENVIRONMENTAL HEALTH RISKS AND SAFETY RISKS (EXECUTIVE ORDER 13045, AS AMENDED BY EXECUTIVE ORDER 13229)

This SEA has not identified any environmental health and safety risks that may disproportionately affect children, in compliance with EO 13045, as amended by EO 13229.

3.6 CUMULATIVE EFFECTS

The CEQ defines cumulative effects as "the impacts on the environment which result from the incremental impact of the actions(s) 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" (40 CFR 1508.7). Cumulative

impacts result when the effects of an action are added to or interact with other effects in a particular place and within a particular time. It is a combination of these effects and the resulting environmental degradation that should be the focus of the cumulative effects analysis (U.S. Environmental Protection Agency, 1999). The Proposed Action, to be implemented over approximately the next 5 years, includes all of the projects associated with additional projects at or associated with PMNM and PMRF. While a single project may individually have minor impacts, when it is considered together with other projects on a regional scale, the effect may be collectively significant. A cumulative impact is the additive effect of all projects in the geographic area. Other projects for PMNM and PMRF that are likely to result in cumulative impacts over the next 3 years are provided in Table 3-6.

Table 3-6. Past and Proposed Projects

Project	Related Project Location	Project Sponsor	Project Description	Project Completion Date	Relevance to LDSD Program
Pending Permits	PMNM		Projects may allow additional peoples and boats in the area	Ongoing	Additive
AUV Sentry & Sikuliaq Vessel Entry	PMNM	Florida State University University of Alaska-Fairbanks	Research using an Autonomous Unmanned Vehicle within PMNM	2016	Additive
Air Traffic	PMNM Open Ocean Area	FAA	N/A	Continuous	Additive
Commercial Shipping	Open Ocean Area	PMNM/DOT/ Dept. of Commerce	N/A	Continuous	Additive
ORS-Super Strypi Proof-of-Principle Satellite Launches	PMRF	Operationally Responsive Space (ORS)	Launching two proof-of-principle launch vehicles from PMRF, Kauai, Hawaii. The Proposed Action would reestablish a rail launcher at Kokole Point to support the development of a sun-synchronous and/or polar orbit launch site, establish and demonstrate space launch capabilities in Hawaii with the flights for the Super Strypi Project.	2015	Additive

Cumulative Impact Analysis

This section addresses the additive effects of the Proposed Action in combination with the projects identified in Table 3-6. Since environmental analyses for some of the projects listed are not complete or do not include quantitative data, cumulative environmental impacts are addressed qualitatively and are described below.

3.6.1 ALTERNATIVE 1

Air Quality

No significant adverse impacts to air quality are anticipated as a result of the Proposed Action. The location of PMNM is remote and vast, and access is regulated resulting in minimal accesses per year. On average 17 vessel entries and exits occur each year and 50 flights per year. Two runways were operational within PMNM (Midway Atoll and Tern Island, French Frigate Shoals) until 2011. In 2011 the runway on Tern Island was closed, leaving only one operational runway within PMNM (located on Midway Atoll). As a result, the number of flights drastically decreased starting in 2012 and is expected to either remain the same or decrease in future years. In addition, emissions resulting from vessel operations are minimal and result in no known cumulative impacts to the environment, especially given the remote location and relatively pristine environment. Therefore, the Proposed Action would not result in cumulative impacts.

Biological Resources

NASA does not anticipate direct, indirect, secondary, or cumulative effects to biological or cultural resources within the affected environment. Up to two LDSD vehicles test flights would be launched annually from PMRF beginning with the June to August 2015 timeframe through the June to August 2019 timeframe. Entry into the eastern part of PMNM would be on an as-needed basis only. If entered, NASA would make every effort to limit the time spent within the easternmost part of PMNM. Analogous to the 2014 demonstration mission, NASA would deploy three recovery vessels immediately upon splashdown of the scientific balloon and Test Vehicle; the vessels would be directed to the different floating hardware locations to begin recovery. During the 2014 mission, it took the respective vessels approximately 5 hours to reach and recover the ring-sail parachute, 6.5 hours to reach and recover the balloon, and 4 hours to reach and recover the Test Vehicle.

In the short and long term, NASA would continue to follow the terms and conditions of its Conservation and Management permit, the 2013 LDSD Final EA, and this SEA. When considered collectively, no cumulative effects are anticipated as a result of the Proposed Action.

Cultural Resources

When reviewed against past, present, and reasonably foreseeable projects at PMNM, this project would not have an appreciable cumulative effect. There are no known submerged features that might be within this effected environment. For those areas identified under this Proposed Action (crash, fire) that have the potential to adversely

impact cultural material on Nihoa Island due to an extremely unlikely overflight of the island, NASA would contact the Monument Permit Coordinator as soon as reasonably possible. NASA understands that Nihoa Island is a sacred place in the history and cosmology of Native Hawaiian people; Nihoa Island, especially, is considered exceptional for its numerous and intact ritual sites (heiau—shrines) and its connection to living cultural traditions.

3.6.2 ALTERNATIVE 2

Under Alternative 2, NASA would conduct the Proposed Action as detailed in the 2013 LDSD Final EA and with the clarification that some recovery aids discussed in that EA may or may not be employed. The proposed test campaign for Alternative 2 would consist of launch, operation, and recovery of up to two missions per year over the next 5 years (June through August, 2015 to 2019) from a designated location on PMRF using the flight trajectory outlined in the 2013 LDSD Final EA. Under Alternative 2, Sections 2.2.2.1 (Operational Facilities) and 2.4.2 (Launch Operation) of this SEA would apply. Analyses for the affected environments were detailed in the 2013 LDSD Final EA, and results are incorporated by reference. The corresponding 2013 Final EA section numbers are denoted in parentheses after each heading. Table ES-2 is a summary of the cumulative effects associated with 5 additional years of SFDT launches from PMRF.

Pacific Missile Range Facility (Pages 4-1 through 4-15)

Based on the analysis of resources analyzed and presented in the 2013 LDSD Final EA for PMRF (air quality [4.1.1], airspace [4.1.2], biological resources [4.1.3], hazardous materials and waste [4.1.4], health and safety [4.1.5], socioeconomics [4.1.6], and water resources [4.1.7]), negligible temporary increases would occur in emissions, and activities would be minor and transitory; airspace would continue to be coordinated through the FAA; the addition of 10 flights over 5 years and other activities combined would be performed at varying times and locations on PMRF and should have negligible adverse cumulative environmental impacts on biological resources; pre-launch and launch activities represent routine types of hazardous material and waste as well as health and safety activities at PMRF, and as a result, no substantial adverse environmental impacts from the management of SFDT project related hazardous materials and waste and routinely provided safety support are anticipated. There would continue to be no negative environmental impacts on the permanent population size, employment characteristics, schools, and type of housing available on island. The amount of exhaust products from the SFDT that could potentially be deposited due to the launch activity would be small, and no cumulative impacts are expected. The Test Vehicle hardware, debris, and propellants that could fall into the ocean are expected to have only a localized, short-term effect on water quality.

Niihau (Pages 4-16 through 4-18)

Based on the analysis of resources analyzed and presented in the 2013 LDSD Final EA for Niihau (airspace [4.2.1], biological resources [4.2.2], cultural resources [4.2.3], and health and safety [4.2.4]), the additional LDSD launches may still require overflight of

Niihau. The overflight is not anticipated to result in adverse environmental impacts to the airspace over Niihau; is not anticipated to environmentally impact biological and cultural resources on the island; and all missions or projects are closely reviewed and analyzed to ensure that there are no unacceptable risks to the public, Government and military personnel, and contractors.

Open Ocean Area (Pages 4-18 through 4-18)

Based on the analysis of resources analyzed and presented in the 2013 LDSD Final EA for the Open Ocean Area (airspace [4.3.1], biological [4.3.2], cultural [4.3.3], hazardous materials and waste [4.3.4], health and safety [4.3.5], and water resources [4.3.6]), the launch activity will continue the use of the required scheduling and coordination process for area airspace, and adherence to applicable DoD directives and FAA regulations. The proposed activities would not result in any direct environmental impacts on coral or degradation of water/sediment quality in the vicinity of corals. Any submerged features that might be within this area are at considerable depth, and the potential for disturbance is extremely remote. The implementation of Alternative 2 would not introduce new types of hazardous materials and waste into the Open Ocean Area, and only small increases in quantities of previously introduced types of hazardous wastes are expected. For health and safety, rocket launches are short-term, discrete events that are actively managed by PMRF range safety. The launch activities would not be scheduled to occur at the same time as other launch programs. The effect of any rocket motor emission products deposited in the open ocean would be very transient due to the buffering capacity of sea water and dilution by current ocean mixing and would not be expected to result in any cumulative adverse effects.

Global Environment

Because the LDSD launches would release little or no ozone depleting substance, there would be no adverse cumulative environmental impacts on the stratospheric ozone layer.

3.6.3 COASTAL ZONE MANAGEMENT

Previously, on 7 January 2013, NASA in coordination with the Navy (PMRF) determined that the LDSD Test program at PMRF is covered by the Navy Coastal Zone Management Act De Minimis List, which was approved by the Hawaii Coastal Zone Management Program on 9 July 2009. The proposal included the launch, operation, and recovery of up to four missions originating from PMRF.

On 9 March 2015, NASA contacted the Regional Counsel, Command Navy Region Hawaii. The Regional Counsel stated that the LDSD SEA's Proposed Action (launch, operation, and recovery through 2019) still falls within the Coastal Zone Management Act De Minimis List and has been determined consistent with the Hawaii Coastal Zone Management Program.

4.0 References

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4.0 REFERENCES

Aguilar, A., 2009. Fin whale, *Balaenoptera physalus*. In Perrin, W.F., B. Wursig, and J.G.M. Thewissen, (Eds.), *Encyclopedia of marine mammals (2nd Ed.)* (pp. 433-437). Accessed online via Elsevier.

Allen, B.M., and R.P. Angliss, 2014. Alaska marine mammal stock assessments, 2013. U.S. Department of Commerce, NOAA Technical Memorandum. NMFS-AFSC-277, 294 p.

Amano, M., and M. Yoshioka, 2003. Sperm whale diving behavior monitored using a suction-cup-attached TDR tag. *Marine Ecology Progress Series*, *258*(6).

Aoki, K., M. Amano, K. Mori, A. Kourogi, T. Kubodera, and N. Miyazaki, 2012. Active hunting by deep-diving sperm whales: 3D dive profiles and maneuvers during bursts of speed. Marine Ecology Progress Series, 444, 289-301.

Au, W.W., G. Giorli, J. Chen, A. Copeland, M.O. Lammers, M. Richlen, and D. Moretti, 2014. Presence and seasonal variation of deep diving foraging odontocetes around Kauai, Hawaii using remote autonomous acoustic recorders. The Journal of the Acoustical Society of America, 135(1), 521-530.

Audubon, 2014. National Audubon Society, Inc. Millerbird—*Acrocephalus familiaris* [Online]. Available: http://birds.audubon.org/species/miller.

Baird, R.W. 2009. False killer whale, Pseudorca crassidens. In Perrin, W.F., B. Wursig, and J.G.M. Thewissen, (Eds.). Encyclopedia of marine mammals (2nd Ed.) (pp. 405-406). Accessed online via Elsevier.

Baird, R.W., A.M. Gorgone, D.J. McSweeney, D.L. Webster, D.R. Salden, M.H. Deakos, and S.D. Mahaffy, 2008. False killer whales (*Pseudorca crassidens*) around the main Hawaiian Islands: Long-term site fidelity, inter-island movements, and association patterns. *Marine Mammal Science*, *24*(3), 591-612.

Baird, R.W., M.B. Hanson, G.S. Schorr, D.L. Webster, and R.D. Andrews, 2012. Range and primary habitats of Hawaiian insular false killer whales: informing determination of critical habitat. *Endangered Species Research*, 18:47-61.

Baird, R.W., G.S. Schorr, D.L. Webster, D.J. McSweeney, M.B. Hanson, and R.D. Andrews, 2010. Movements and habitat use of satellite-tagged false killer whales around the main Hawaiian Islands. Endangered Species Research, 10: 107−121.

Baird, R.W., G.S. Schorr, D.L. Webster, D.J. McSweeney, M.B. Hanson, R.D. Andrews, 2011. *Movements and spatial use of false killer whales in Hawai'i: satellite tagging studies in 2009*. Report prepared under Order No. AB133 F09SE 4132 from the Pacific Islands Fisheries Science Center, Honolulu, HI. http://www.cascadiaresearch.org/hawaii/publications.htm.

Baird, R.W., S.M. Jarvis, D.L. Webster, B.K. Rone, J.A. Shaffer, S.A. Mahaffy, A.M. Gorgone, and D.J. Moretti, 2014. Odontocete studies on the Pacific Missile Range Facility in July/August 2013; satellite-tagging, photo-identification, and passive acoustic monitoring. Prepared for Commander, U.S. Pacific Fleet, submitted to the Naval Facilities Engineering Command, Pacific, by HDR Environmental, Operations, and Construction, Inc.

Baird, R.W., D.L. Webster, J.M. Aschettino, G.S. Schorr, and D.J. McSweeney, 2013. Odontocete Cetaceans Around the Main Hawaiian Islands: Habitat Use and Relative Abundance from Small-Boat Sighting Surveys. *Aquatic Mammals*, *39*(3).

Baker, C.S., 1986. Migratory movement and population structure of humpback whales (*Megaptera novaeangliae*) in the central and eastern North Pacific. *Marine Ecology Progress Series*, *31*, 105-119.

Baker, J.D., A.L. Harting, T.A. Wurth, and T.C. Johanos, 2011. Dramatic shifts in Hawaiian monk seal distribution predicted from divergent regional trends. *Marine Mammal Science*, *27*(1), 78-93.

Bailey, H., S.R. Benson, G.L. Shillinger, S.J. Bograd, P.H. Dutton, S.A. Eckert, and J.R. Spotila, 2012. Identification of distinct movement patterns in Pacific leatherback turtle populations influenced by ocean conditions. *Ecological Applications*, *22*(3), 735-747.

Baker, J.D. and T.C. Johanos, 2004. Abundance of the Hawaiian monk seal in the main Hawaiian Islands. *Biological Conservation*, 116:103-110.

Balazs, G.H., 1976. Green turtle migrations in the Hawaiian Archipelago. *Biological Conservation*, *9*(2), 125-140.

Balazs, G.H., 1980. *Synopsis of biological data on the green turtle in the Hawaiian Islands*. NOAA-TM-NMFS-SWFC-7. 141 pp.

Balazs, G.H., 1982. Status of sea turtles in the central Pacific Ocean. Pages 243-252 in K.A. Bjorndal (ed.), Biology and Conservation of Sea Turtles. Smithsonian Inst. Press, Washington, D.C., 583 pp.

Balazs, G.H., 1985. Impact of ocean debris on marine turtles: entanglement and ingestion. In *Proceedings of the Workshop on the Fate and Impact of Marine Debris* (Vol. 2729).

Balazs, G.H., and S. Hau, 1986. Geographic distribution: *Lepidochelys olivacea* in Hawaii. *Herpetological Review*, *17*(2), 51.

Barlow, J., 2003. *Cetacean abundance in Hawaiian waters during summer/fall 2002*. Admin. Rep. LJ-03-13. Southwest Fisheries Science Center, National Marine Fisheries Service, 8604 La Jolla Shores Drive, La Jolla, CA 92037.

Barlow, J., 2006. Cetacean abundance in Hawaiian waters estimated from a summer/fall survey in 2002. *Marine Mammal Science*, *22*(2), 446-464.

Bartol, S.M., and J.A. Musick, 2003. Sensory biology of sea turtles. In Lutz, P.L., J.A. Musick, and J. Wyneken (Eds.), *The biology of sea turtles, Volume II (*pp. 79-102). CRC Press, Boca Raton, Florida.

Bauer, G.B., J.R. Mobley, and L.M. Herman, 1993. Responses of wintering humpback whales to vessel traffic. *The Journal of the Acoustical Society of America*, *94*(3), 1848-1848.

Baulch, S., and C. Perry, 2014. Evaluating the impacts of marine debris on cetaceans. *Marine Pollution Bulletin*, *80*(1), 210-221.

Benson, S.R., T. Eguchi, D.G. Foley, K.A. Forney, H. Bailey, C. Hitipeuw, and P.H. Dutton, 2011. Large-scale movements and high-use areas of western Pacific leatherback turtles, *Dermochelys coriacea*. *Ecosphere*, *2*(7), 84.

Berger, A.J., 1972. *Hawaiian birdlife*. University Press of Hawaii, Honolulu.

Birdlife International, 2015. Nihoa Finch (*Telespiza ultima*)—Birdlife species factsheet [Online]. Available: http://www.birdlife.org/datazpne/speciesfactsheet.php?id=8897.

BirdLife International, 2014 Species Factsheet: *Telespiza ultima* [Online]. Available: http://www.birdlife.org/datazone/speciesfactsheet.php?id=8897.

Bishop Museum Fact Sheet, n.d. Northwestern Hawaiian Islands Fact Sheet: The Hawaii Coral Reef Initiative Research Program.

Bjorndal, K., 1997. Foraging ecology and nutrition of sea turtles. In Lutz, P.L. and J.A. Musick (Eds.), *The biology of sea turtles (*pp. 199-232). CRC Press, Boca Raton, Florida.

Brownell, Jr., R.L., P.J. Clapham, T. Miyashita, and T. Kasuya, 2001. Conservation status of North Pacific right whales. *Journal of Cetacean Research and Management*, Special Issue, 2:269-286.

Cahoon, M.K., C.L. Littnan, K. Longenecker, K., J.R. Carpenter, 2013. Dietary comparison of two Hawaiian monk seal populations: the role of diet as a driver of divergent population trends. *Endangered Species Research*, *20*, 137-146.

Cairns, S.D., 1994. Scleractinia of the Temperate North Pacific. Smithsonian Contributions to Zoology, No. 557, 150 pp.

Calambokidis, J., G.H. Steiger, J.M. Straley, T.J. Quinn II, L.M. Herman, S. Cerchio, D.R. Salden, and K. Rasmussen, 1997. Final Report—Abundance and population structure of humpback whales in the North Pacific basin. Unpublished contract report to the National Marine Fisheries Service, La Jolla, California.

Calambokidis, J., E.A. Falcone, T.J. Quinn, A.M. Burdin, P.J. Clapham, J.K.B. Ford, C.M. Gabriele, R. LeDuc, D. Mattila, L. Rojas-Bracho, J.M. Straley, B.L. Taylor, J. Urbán R., D. Weller, B.H. Witteveen, M. Yamaguchi, A. Bendlin, D. Camacho, K. Flynn, A. Havron, J. Huggins, and N. Maloney, 2008. *SPLASH: Structure of Populations, Levels of Abundance and Status of Humpback Whales in the North Pacific*. Final report for Contract AB133F-03-RP-00078. 58p.

Calambokidis, J., G.H. Steiger, J.M. Straley, L.M. Herman, S. Cerchio, D.R. Salden, and T.J.Q Ii, 2001. Movements and population structure of humpback whales in the North Pacific. *Marine Mammal Science*, *17*(4), 769-794.

Carr, A., 1987. Impact of nondegradable marine debris on the ecology and survival outlook of sea turtles. *Marine Pollution Bulletin*, *18*(6), 352-356.

Carretta, J.V., K.A. Forney, M.M. Muto, J. Barlow, J.D. Baker, and M.S. Lowry, 2005. U.S. Pacific Marine Mammal Stock Assessments: 2004. US Department of Commerce. NOAA Technical Memorandum, NMFS-SWFSC-375, La Jolla, California, USA.

Carretta, J.V., E. Oleson, D.W. Weller, A.R. Lang, K.A. Forney, J. Baker, B. Hanson, and Mattila, D.K., 2014. U.S. Pacific Marine Mammal Stock Assessments, 2013. NOAA-TM-NMFS-SWFSC-532. 406 pp.

Carrión-Cortez, J., C. Canales-Cerro, R. Arauz, and R. Riosmena-Rodríguez, 2013. Habitat Use and Diet of Juvenile Eastern Pacific Hawksbill Turtles (*Eretmochelys imbricata*) in the North Pacific Coast of Costa Rica. *Chelonian Conservation and Biology*, *12*(2), 235-245.

Chave, C.H. and A. Malahoff, 1998. In deeper waters. Photographic studies of Hawaiian deep-sea habitats and life-forms. Univ. Hawaii Press, Honolulu, Hawaii.

Clapham, P.J., C. Good, S.E. Quinn, R.R. Reeves, J.E. Scarff, and R.L. Brownell, 2004. Distribution of North Pacific right whales (*Eubalaena japonica*) as shown by 19th and 20th century whaling catch and sighting records. *Journal of Cetacean Research and Management*, 6:1-6.

Clapham, P.J., 2009. Humpback whale, *Megaptera novaeangliae*. In Perrin, W.F., B. Wursig, and J.G.M Thewissen, (Eds.), *Encyclopedia of marine mammals (2nd Ed.)* (pp. 582-585). Accessed online via Elsevier.

Clapham, P.J., C. Good, S.E. Quinn, R.R. Reeves, J.E. Scarff, and R.L. Brownell, 2004. Distribution of North Pacific right whales (*Eubalaena japonica*) as shown by 19th and 20th century whaling catch and sighting records. *Journal of Cetacean Research and Management*, 6:1-6.

Clapham, P.J., and J.G. Mead, 1999. *Megaptera novaeangliae*. *Mammalian Species,* 604, 1-9.

Clark, M.R., 1980. "Cephalopoda in the Diet of Sperm Whales of the southern hemisphere and their bearing on sperm whale biology. Discovery Rep. 37, 1-324.

Clarke, M.R., H.R. Martins, P. Pascoe, 1993. The diet of sperm whales (*Physeter macrocephalus*) off the Azores. *Philosophical Transactions of the Royal Society B, 339*, 67–82.

Cleghorn, P., 1988. The Settlement and Abandonment of Two Hawaiian Outposts: Nihoa and Necker. In: Bishop Museum Occasional Papers 28:35-49. Bishop Museum Press, Honolulu.

Combs, S.K., 2014. Email correspondence between Shad Combs (WFF-840.0) [LJT and Associates, Inc.] and Dr. Karen Barnes, KAYA Associates, Inc.

Croll, D.A., A. Acevedo-Gutiérrez, B.R. Tershy, J. Urbán-Ramírez, 2001. The diving behavior of blue and fin whales: is dive duration shorter than expected based on oxygen stores? *Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology*, *129*(4), 797-809.

Croll, D.A., B. Marinovic, S. Benson, F.P. Chavez, N. Black, R. Ternullo, and B.R. Tershy, 2005. From wind to whales: trophic links in a coastal upwelling system. *Marine Ecology Progress Series*, *289*(117), 30.

Curtice, C., R. Schick, D. Dunn, P.N. Halpin, 2011. Home range analysis of Hawaiian monk seals (*Monachus schauinslandi*) based on colony, age, and sex. Aquatic Mammals, 37, 360-371.

Department of Land and Natural Resources, 2005. *Amaranthus brownii* http://dlnr.hawaii.gov/wildlife/files/2013/09/Fact-Sheet-Amaranthus-brownii.pdf.

Derraik, J.G.B., 2002. The pollution of the marine environment by pplastic degris; a review. Marine Polluction Bulletin 44 (2002) 842-852 [Online]. Available: http://5gyres.org/media/Derraik_2002_Plastic_pollution.pdf.

Doyle, T.K., J.D. Houghton, P.F. O'Súilleabháin, V.J. Hobson, F. Marnell, J. Davenport, and G.C. Hays, 2008. Leatherback turtles satellite-tagged in European waters. *Endangered Species Research*, *4*(1-2), 23-31.

Eckert, K.L., 1993. The biology and population status of marine turtles in the North Pacific Ocean, pp. 155. Honolulu, HI: U.S. Department of Commerce, NOAA-TM-NMFS-SWFSC-186.

Eckert, K.L., B.P. Wallace, J.G. Frazier, S.A. Eckert, and P.C.H. Pritchard, 2012. Synopsis of the biological data on the leatherback sea turtle (*Dermochelys coriacea*). Washington, DC: US Department of Interior, Fish and Wildlife Service.

Emory, K.P., 1928. Archaeology of Nihoa and Necker Islands. Bernice P. Bishop Museum, Bulletin 53. Tanager Expedition, Publication Number 5. Honolulu, Hawaii.

Environmental Systems Research Institute, 2010. ArcGIS 10.0. Redlands, California.

Epperly, S.P., J. Braun, and A.J. Chester, 1995. Aerial surveys for sea turtles in North Carolina inshore waters. Fishery Bulletin, 93(2), 254-261.

Forney, K. A., R.W. Baird, and E.M. Oleson, 2010. Rationale for the 2010 Revision of Stock Boundaries for the Hawaii Insular and Pelagic Stocks of False Killer Whales, *Pseudorca crassidens*. NOAA-TM-NMFS-SWFSC-741. 7 pp.

Friedlander, A.M. and E.E. DeMartini, 2002. Contrasts in density, size, and biomass of reef fishes between the northwestern and the main Hawaiian islands: the effects of fishing down apex predators. Marine Ecology Progress Series 230:253-264.

Freiwald A., J.H. Fossa, A. Grehan, T. Koslow, and J.M. Roberts, 2004. Coldwater coral reefs. UNEP-WCMC, Cambridge

Gaos, A.R., R.R. Lewison, B.P. Wallace, I.L. Yañez, M.J. Liles, A. Baquero, and J.A. Seminoff, 2012. Dive behaviour of adult hawksbills (*Eretmochelys imbricata*, Linnaeus 1766) in the eastern Pacific Ocean highlights shallow depth use by the species. *Journal of Experimental Marine Biology and Ecology*, *432*, 171-178.

García-Godos, I., K.V. Waerebeek, J. Alfaro-Shigueto, and J.C. Mangel, 2013. Entanglements of large Cetaceans in Peru: Few records but high risk. *Pacific Science*, *67*(4), 523-532.

Gass, S., 2003. “Conservation of deep-sea corals in Atlantic Canada.” World Wildlife FundGraphic, 2014. Papahānaumokuākea Marine National Monument Known Maritime Heritage Resource.

Gemmill, C. 1998. *Pritchardia remota*. 2011 IUCN Red List of Threatened Species. [Online]. Available http://www.iucnredlist.org/details/38652/0

Gende, S.M., A.N. Hendrix, K.R. Harris, B. Eichenlaub, J. Nielsen, and S. Pyare, 2011. A Bayesian approach for understanding the role of ship speed in whale-ship encounters. *Ecological Applications*, *21*(6), 2232-2240.

Gilmartin, W.G. and J. Forcada, 2009. Monk seals, *Monachus monachus, M. tropicalis, and M. schauinslandi*. In Perrin, W.F., B. Wursig, and J.G.M. Thewissen (Eds.), *Encyclopedia of marine mammals (2nd Ed.)* (pp. 741-744). Accessed online via Elsevier.

Goldbogen, J.A., J. Calambokidis, D.A. Croll, J.T. Harvey, K.M. Newton, E.M. Oleson, and R.E. Shadwick, 2008. Foraging behavior of humpback whales: kinematic and respiratory patterns suggest a high cost for a lunge. *Journal of Experimental Biology*, *211*(23), 3712-3719.

Goldbogen, J.A., N.D. Pyenson, and R.E. Shadwick, 2007. Big gulps require high drag for fin whale lunge feeding. *Marine Ecology Progress Series*, *349*, 289-301.

Graphic, 2014. Figure 7; Papahānaumokuākea Marine National Monument Known Maritime Heritage Resources.

Grigg, R.W., 1988. "Paleoceanography of coral reefs in the Hawaiian-Emperor chain," *Science, 240:1737*-1743.

Grigg, R.W., 1997. "Paleoceanography of coral reefs in the Hawaiian-Emperor chain – Revisited," pp. 117-121 in Proceedings of the Eighth Helfman, G.S., B.B. Collette, and D.E. Facey. 1999. The diversity of fishes. 4th ed. Malden, Massachusetts: Blackwell Science.

Hawaiian Native Plant Propagation Database, 2001. Hawaiian Native Plant Propagation Database—*Sesbania tomentosa*, September [Online]. Available: http://www2.hawaii.edu/~eherring/hawnprop/ses-tome.htm.

Hays, G.C., J.D. Houghton, C. Isaacs, R.S. King, C. Lloyd, and P. Lovell, 2004. First records of oceanic dive profiles for leatherback turtles, *Dermochelys coriacea*, indicate behavioural plasticity associated with long-distance migration. *Animal Behaviour*, *67*(4), 733-743.

Hazel, J., I.R. Lawler, H. Marsh, and S. Robson, 2007. Vessel speed increases collision risk for the green turtle *Chelonia mydas*. *Endangered Species Research*, *3*, 105-113.

Henderson, J.R., 1990. Recent Entanglements of Hawaiian Monk Seals in Marine Debris. In Shomura, R.S. and M.L. Godfrey (Eds.), *Proceedings of the 2nd International Conference on Marine Debris*, *vol. 1* (pp. 540–553). United States Department of Commerce, Honolulu, Hawaii, USA.

Henderson, J.R., 2001. A pre-and post-MARPOL Annex V summary of Hawaiian monk seal entanglements and marine debris accumulation in the Northwestern Hawaiian Islands, 1982–1998. *Marine Pollution Bulletin*, *42*(7), 584-589.

Herman, L.M. and R.C. Antinoja, 1977. Humpback whales in Hawaiian waters: Population and pod characteristics. *Scientific Report of the Whales Research Institute*, 29:59-85.

Herman, L.M., C.S. Baker, P.H. Forestell, and R.C. Antinoja, 1980. Right whale, *Balaena glacialis*, sightings near Hawaii: a clue to the wintering grounds?. *Marine Ecology Progress Series*, *2*, 271-275.

Horwood, J., 2009. Sei Whale, *Balaenoptera borealis*. In Perrin, W.F., B. Wursig, and J.G.M. Thewissen, (Eds.), *Encyclopedia of marine mammals (2nd Ed.)* (pp. 1001-1003). Accessed online via Elsevier.

Houghton, J.D., T.K. Doyle, J. Davenport, R.P. Wilson, and G.C. Hays, 2008. The role of infrequent and extraordinary deep dives in leatherback turtles (*Dermochelys coriacea*). *Journal of Experimental Biology*, *211*(16), 2566-2575.

Hughes, G.R., P. Luschi, R. Mencacci, and F. Papi, 1998. The 7000-km oceanic journey of a leatherback turtle tracked by satellite. *Journal of Experimental Marine Biology and Ecology*, *229*(2), 209-217.

International Oceanographic Commission, International Hydrographic Organization, and British Oceanographic Data Centre (IOC, IHO, and BODC), 2003. *Centenary Edition of the GEBCO Digital Atlas*, published on CD-ROM on behalf of the Intergovernmental Oceanographic Commission and the International Hydrographic Organization as part of the General Bathymetric Chart of the Oceans, British Oceanographic Data Centre, Liverpool, U.K.

James, H.F. and S.L. Olson, 1991. Descriptions of thirty-two new species of birds from the Hawaiian Islands: Part 2. Passeriformes. *Ornithological Monographs* 46: 1-88.

Jensen, A.S., and G.K. Silber, 2003. *Large Whale Ship Strike Database*. U.S. Department of Commerce, NOAA Technical Memorandum. NMFS-OPR, 37 pp.

Johanos, T.C., A.L. Harting, T.A. Wurth, and J.D. Baker, 2013. Range-wide movement patterns of Hawaiian monk seals. *Marine Mammal Science*, 30(3): 1165-1174.

Johanos, T.C., A.L. Harting, T.A. Wurth, and J.D. Baker, 2014. Range-wide movement patterns of Hawaiian monk seals. Mar Mamm Sci 30(3):1165-1174.

Johnston, D.W., M.E. Chapla, L.E. Williams, and D.K. Mattila, 2007. Identification of humpback whale *Megaptera novaeangliae* wintering habitat in the Northwestern Hawaiian Islands using spatial habitat modeling. *Endangered Species Research*, *3*(3), 249-257.

Katahira, L.K., C.M. Forbes, A.H. Kikuta, G.H. Balazs, and M. Bingham, 1994. Recent findings and management of hawksbill turtle nesting beaches in Hawaii. Page 69 in Bjorndal, K.A., A.B. Bolton, D.A. Johnson, and P.J. Eliazar (compilers), *Proceedings of the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation*. NOAA Technical Memorandum NMFS-SEFSC-351. 323 pp.

Kawakami, T., 1980. A review of sperm whale food. *Scientific Reports of the Whales Research Institute*, *32*:199–218.

Kennedy, A.S., D.R. Salden, P.J. Clapham, 2012. First high-to low-latitude match of an eastern North Pacific right whale (*Eubalaena japonica*). *Marine Mammal Science*, *28*(4), E539-E544.

Kelley, C., R. Moffitt, and W. Ikehara, 2004. Mega to macro-scale descriptions of bottom- 99 fish habitats on Raita, West St. Rogatien Bank, Brooks Bank, and Bank 66. Paper 100 read at Northwestern Hawaiian Islands 3rd Scientific Symposium, Honolulu.

Kenney, R.D., 2009. Right whales, *Eubalaena glacialis, E. japonica, and E. australis*. In Perrin, W.F., B. Wursig, and J.G.M. Thewissen, (Eds.), *Encyclopedia of Marine Mammals (2nd Ed.)* (pp. 962-972). Accessed online via Elsevier.

Keuper-Bennett, U., and P.A. Bennett, 2002. Home sweet home: Aspects of green turtle and hawksbill presence in their feeding, resting and cleaning areas off Honokowai, West Maui, Hawaii (1989–1999). In Mosier, A., A. Foley, and B. Brost, comps*. Proceedings of the 20th Annual Symposium on Sea Turtle Biology and Conservation.* NOAA Technical Memorandum NMFS-SEFSC-477 (pp. 57-59).

Kikiloi, S., 2006. Reconnecting with Ancestral Islands: Examining historical relationships between kānaka maoli and the Northwestern Hawaiian Islands. Report to NOAA for the Kia'i Kai [Guardians of the Sea] Project, Kamakakūokalani, Center for Hawaiian Studies U.H. Mānoa, January.

Laist, D.W., 1987. Overview of the biological effects of lost and discarded plastic debris in the marine environment. Marine Pollution Bulletin 18(6): 319–326.

Laist, D.W., A.R. Knowlton, J.G. Mead, A.S. Collet, M. Podesta, 2001. Collisions between ships and whales. *Marine Mammal Science*, *17*(1), 35-75.

Lammers, M., A. Pack, E. Lyman, and L. Espiritu, 2013. Trends in collisions between vessels and North Pacific humpback whales (*Megaptera novaeangliae*) in Hawaiian waters (1975–2011). *Journal of Cetacean Research and Management*, *13*(1), 73-80.

Lutcavage, M.E. and P.L. Lutz, 1997. Diving Physiology. In Lutz, P.L. and J.A. Musick (Eds.), *The biology of sea turtles* (pp. 277-296). CRC Press, Boca Raton, Florida.

Madsen, P., M. Wahlberg, and B. Møhl, 2002. Male sperm whale (*Physeter macrocephalus*) acoustics in a high-latitude habitat: implications for echolocation and communication. *Behavioral Ecology and Sociobiology*, *53*(1), 31-41.

Maly, K., 2003. Ka Hana Lawai‘a a me na ko‘a o na kai ‘ewalu: A history of fishing practices and marine fisheries of the Hawaiian Islands. Kumu Pono Associates LLC. Prepared for The Nature Conservancy.

Maragos, 1977. Order Scleractinia: stony corals. In: “Reef and Shore Fauna of Hawaii. Section 1: Protozoa through Ctenophora.” Bishop Museum Press Special Publication 64, Honolulu, HI. Pp. 158–241.

Maragos, J.E., 1998. “Marine ecosystems,” pp. 111-120 in Juvik, S.P. and J.O. Juvik, Eds. *Atlas of Hawai`i*, 3rd ed. Honolulu, Hawaii: University of Hawaii Press.

Mathias, D., A.M. Thode, J. Straley, J. Calambokidis, G.S. Schorr, and K. Folkert, 2012. Acoustic and diving behavior of sperm whales (*Physeter macrocephalus*) during natural and depredation foraging in the Gulf of Alaska. *The Journal of the Acoustical Society of America*, *132*(1), 518-532.

McDonald, M.A., and C.G. Fox, 1999. Passive acoustic methods applied to fin whale population density estimation. *The Journal of the Acoustical Society of America*, *105*(5), 2643-2651.

Meylan, A., 1988. Spongivory in hawksbill turtles: a diet of glass. *Science (Washington)*, *239*(4838), 393-395.

Miller, B., S. Dawson, and R. Vennell, 2013. Underwater behavior of sperm whales off Kaikoura, New Zealand, as revealed by a three-dimensional hydrophone array. *The Journal of the Acoustical Society of America*, *134*(4), 2690-2700.

Miller, P.J., M.P. Johnson, and P.L. Tyack, 2004. Sperm whale behaviour indicates the use of echolocation click buzzes ‘creaks’ in prey capture. *Proceedings of the Royal Society of London Series B: Biological Sciences*, *271*(1554), 2239-2247.

Minamikawa, S., H. Watanabe, and T. Iwasaki, 2013. Diving behavior of a false killer whale, *Pseudorca crassidens*, in the Kuroshio–Oyashio transition region and the Kuroshio front region of the western North Pacific. *Marine Mammal Science*, *29*(1), 177-185.

Mizroch, S.A., D.W. Rice, and J.M. Breiwick, 1984. The sei whale, *Balaenoptera borealis*. *Marine Fisheries Review*, *46*(4), 25-29.

Mizroch, S.A., D.W. Rice, D. Zwiefelhofer, J. Waite, and W.L. Perryman, 2009. Distribution and movements of fin whales in the North Pacific Ocean. *Mammal Review*, *39*(3), 193-227.

Mobley, J.R., 2005. Assessing responses of humpback whales to North Pacific Acoustic Laboratory (NPAL) transmissions: Results of 2001–2003 aerial surveys north of Kauai. *Journal of the Acoustical Society of America*, 117:1666-1673.

Mobley, J.R., G.B. Bauer, and L.M. Herman, 1999. Changes over a ten-year interval in the distribution and relative abundance of humpback whales (*Megaptera novaeangliae*) wintering in Hawaiian waters. *Aquatic Mammals*, 25:63-72.

Mobley, J.R., M. Smultea, T. Norris, and D. Weller, 1996. Fin whale sighting north of Kauai, Hawaii. *Pacific Science*, 50, 230–233.

Mobley, J.R., S.S. Spitz, K.A. Forney, R. Grotenfendt, and P.H. Forestell, 2000. *Distribution and abundance of odontocete species in Hawaiian waters: preliminary results of 1993–98 aerial surveys*. Administrative Report LJ-00–14C. Available from the NOAA Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037. 26 pp.

Mobley, J.R., S.S. Spitz, and R. Grotefendt, 2001. *Abundance of humpback whales in Hawaiian waters: Results of 1993-2000 aerial surveys*. Report prepared for the Hawaii Department of Land and Natural Resources and the Hawaiian Islands Humpback Whale National Marine Sanctuary, NOAA, U.S. Department of Commerce.

Morin, M.P. and S. Conant, 2002. Nihoa Finch (*Telespiza ultima*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology [Online]. Available: http://bna.birds.cornell.edu/bna/ species/639b.

Morin, M.P., S. Conant, and P. Conant, 1997. Laysan and Nihoa Millerbird (*Acrocephalus familiaris*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology [Online]. Available: http://bna.birds.cornell.edu/bna/species/302

Musick, J.A. and C.J. Limpus, 1997. Habitat utilization and migration in juvenile sea turtles. In Lutz, P.L. and J.A. Musick (Eds.), *The biology of sea turtles* (pp. 137-163). CRC Press, Boca Raton, Florida.

National Aeronautics and Space Administration, 2013. *National Aeronautics and Space Administration Low Density Supersonic Decelerator Technology Demonstration Mission Pacific Missile Range Facility Environmental Assessment*, May.

National Marine Fisheries Service, 2013. *Effects Determination Guidance.* Pacific Islands Regional Office, NOAA Fisheries Service. Retrieved from http://www.fpir.noaa.gov/Library/PRD/ESA%20Consultation/Effects_Determination_Guidance_05-06-2013.pdf.

National Marine Fisheries Service and U.S. Fish and Wildlife Service, 1998a. Recovery Plan for U.S. Pacific Populations of the Hawksbill Turtle (*Eretmochelys imbricata*). National Marine Fisheries Service, Silver Spring, MD.

National Marine Fisheries Service and U.S. Fish and Wildlife Service, 1998b. Recovery Plan for U.S. Pacific Populations of the Leatherback Turtle (*Dermochelys coriacea*). National Marine Fisheries Service, Silver Spring, MD.

National Marine Fisheries Service and U.S. Fish and Wildlife Service, 1998c. Recovery Plan for U.S. Pacific Populations of the Loggerhead Turtle (*Caretta caretta*). National Marine Fisheries Service, Silver Spring, MD.

National Marine Fisheries Service and U.S. Fish and Wildlife Service, 1998d. Olive Ridley Sea Turtle (*Lepidochelys olivacea*) 5-year review: summary and evaluation. National Marine Fisheries Service, Silver Spring, MD.

National Oceanic and Atmospheric Administration, undated. Hawaiian Monk Seal Population at a Glance [Online]. Available: http://www.pifsc.noaa.gov/hawaiian_monk_seal/population_at_a_glance.php.

National Oceanic and Atmospheric Administration, 2005. The State of Coral Reef Ecosystems of the Northwestern Hawaiian Islands [Online]. Available: http://ccma.nos.noaa.gov/ecosystems/coralreef/coral_report_2005/NWHI_Ch10_C.pdf.

National Oceanic and Atmospheric Administration, 2006. Northwestern Hawaiian Islands Proposed National Marine Sanctuary Draft Environmental Impact Statement and Management Plan, Vol. ll of II, Honolulu Hawaii, April [Online]. Available: http://www.papahanaumokuakea.gov/PDFs/NWHI_OLD_MP1_042006.pdf.

National Oceanic and Atmospheric Administration, 2007. Draft Environmental Assessment. Issuance of a Conservation and Management Permit to the National Marine Fisheries Service Pacific Islands Regional Office for Anchoring in Noncoral areas by the Northwestern Hawaiian Islands Bottomfish Fishery.

National Oceanic and Atmospheric Administration, 2011. Hawaiian Monk Seal Recovery 2009-2011. Program Update and Accomplishment Report.

National Oceanic and Atmospheric Administration, 2012. *A Marine Biogeographic Assessment of the Northwestern Hawaiian Island to Support the Papahānaumokuākea Marine National Monument* [Online]. Available: http://ccma.nos.noaa.gov/ecosystems/sanctuaries/nwhi/.

National Oceanic and Atmospheric Administration, 2013. Papahānaumokuākea Marine National Monument [Online]. Available: http://www.papahanaumokuakea.gov/pdf/national_wildlife_refuges_of_pmnm_2013.pdf.

National Oceanic and Atmospheric Administration, 2014a. Enviromental Assessment-Papahānaumokuākea Marine National Monument Northwestern Hawaiian Islands Hawai'i, October.]Online]. Available http://www.papahanaumokuakea.gov/permit/ea/ea_bacotaylor_110414_final.pdf

National Oceanic and Atmospheric Administration, 2014b. Nihoa Island [Online]. Available: http://www.papahanaumokuakea.gov/visit/nihoa.html

National Oceanic and Atmospheric Administration, 2014c. NOAA Fisheries Consulting with Federal Agencies (ESA Section 7.

National Oceanic and Atmospheric Administration, 2014d. Nihoa Millerbird Receiveds Hawaiian Name [Online]. Available: http://www.papahanaumokuakea.gov/news/millerbird_hawaiian_names.html.

National Oceanic and Atmospheric Administration, 2015. PMNM—Native Hawaiian Cultural Heritage—Cultural Research and Significance [Online]. Available: http://www.papahanaumokuakea.gov/heritage/welcome.html.

National Oceanic and Atmospheric Administration, United States Fish and Wildlife Services and Hawaii Department of Land and Natural Resources, 2008. Papahānaumokuākea Marine National Monument Management Plan [Online]. Available: http://www.papahanaumokuakea.gov/management/mp/vol1_mmp08.pdf

National Tropical Botanical Garden, 2015. *Pritchardia remota* [Online]. Available: http://ntbg.org/plants/plant_details.php?plantid=9497.

National Park Service, n.d. Papahānaumokuākea World Heritage Site [Online]. Available: www.papahanaumokuakea.gov. Retrieved 16 December 2014.

Native Plant Hawaii, 2009. *Sesbania tomentosa* (Ohai) [Online]. Available: http://nativeplants.hawaii.edu/plant/view/Sesbania_tomentosa.

Naughton, M., and E. Flint, 2004. Populations and conservation status of seabirds nesting in the Northwestern Hawaiian Islands. Paper read at Northwestern Hawaiian Islands 3rd Scientific Symposium, Honolulu.

Northwestern Hawaiian Island Multi-Agency Education Project, n.d [Online]. Available: http://www.hawaiianatolls.org/about/nihoa.php.

Northwestern Hawaiian Islands, n.d [Online]. Available: http://hawaii.gov/dlnr/exhibits/nwhi/NWHI_6.htm.

Ortega-Ortiz, C.D., F.R. Elorriaga-Verplancken, A. Olivos-Ortiz, M.A. Liñán-Cabello, and M.H. Vargas-Bravo, 2014. Insights into the Feeding Habits of False Killer Whales (*Pseudorca crassidens*) in the Mexican Central Pacific. *Aquatic Mammals*, *40*(4), 386-393.

Papahānaumokuākea Marine National Monument, 2011. Maritime Heritage Research, Education, and Management Plan [Online]. Available: http://www.papahanaumokuakea.gov/pdf/mh_plan.pdf.

Parker, D.M., G.H. Balazs, C.S. King, L. Katahira, and W. Gilmartin, 2009. Short-Range Movements of Hawksbill Turtles (*Eretmochelys imbricata*) from Nesting to Foraging Areas within the Hawaiian Islands. *Pacific Science*, *63*(3), 371-382.

Parker, D.M., W. Cooke, and G.H. Balazs, 2002. Dietary components of pelagic loggerhead turtles in the North Pacific Ocean. In*: Proceedings of the Twentieth Annual Symposium on Sea Turtle Biology and Conservation*, February 29–March 4, 2000, Orlando, FL. US Department of Commerce, NOAA Technical Memorandum NMFS-SEFSC. 417:148–151.

Parker, D.M., P.H. Dutton, and G.H. Balazs, 2011. Oceanic diet and distribution of haplotypes for the green turtle, *Chelonia mydas*, in the Central North Pacific. *Pacific Science*, *65*(4), 419-431.

Parks, S.E., J.D. Warren, K. Stamieszkin, C.A. Mayo, and D. Wiley, 2011. Dangerous dining: surface foraging of North Atlantic right whales increases risk of vessel collisions. *Biology Letters*, rsbl20110578.

Parrish F.A. and A.R. Baco, 2007. State of Deep Coral Ecosystems in the Alaska Region: Gulf of Alaska, Bering Sea and the Aleutian Islands. pp. 65-108. In: Lumsden, S.E., T.F. Hourigan, A.W. Bruckner and G. Dorr (eds.) The State of Deep Coral Ecosystems of the United States. NOAA Technical Memorandum CRCP-3. Silver Spring MD 365 pp.

Parrish, F.A., M.P. Craig, T.J. Ragen, G.J. Marshall, and B.M. Buhleier, 2000. Identifying Diurnal Foraging Habitat of Endangered Hawaiian Monk Seals Using a Seal-Mounted Video Camera. *Marine Mammal Science*, *16*(2), 392-412.

Parrish, F.A., G.J. Marshall, B. Buhleier, and G.A. Antonelis, 2008. Foraging interaction between monk seals and large predatory fish in the Northwestern Hawaiian Islands. *Endangered Species Research*, *4*(3), 299.

Parrish, F.A., G.J. Marshall, C. Littnan, M. Heithaus, S. Canja, B. Becker, and G.A. Antoneijs, 2005. Foraging of juvenile monk seals at French Frigate Shoals, Hawaii. *Marine Mammal Science*, *21*(1), 93-107.

Patenaude, N.J., W.J. Richardson, M.A. Smultea, W.R. Koski, G.W. Miller, B. Würsig, and C.R. Greene, 2002. Aircraft sound and disturbance to bowhead and beluga whales during spring migration in the Alaskan Beaufort Sea. *Marine Mammal Science*, *18*(2), 309-335.

Polovina, J.J., G.H. Balazs, E.A. Howell, D.M. Parker, M.P. Seki, and P.H. Dutton, 2004. Forage and migration habitat of loggerhead (*Caretta caretta*) and olive ridley (*Lepidochelys olivacea*) sea turtles in the central North Pacific Ocean. *Fisheries Oceanography*, *13*(1), 36-51.

Ragen, T.J. and D.M. Lavigne, 1999. The Hawaiian monk seal: Biology of an endangered species. pp. 224-245. In Twiss, Jr., J.R. and R.R. Reeves, Eds. *Conservation and Management of Marine Mammals*, Washington D.C.: Smithsonian Institution Press.

Rankin, S., and J. Barlow, 2007. Vocalizations of the sei whale *Balaenoptera borealis* off the Hawaiian Islands. *Bioacoustics*, *16*(2), 137-145.

Reeves, R.R., T.D. Smith, R.L. Webb, J. Robbins, and P.J. Clapham, 2002. Humpback and fin whaling in the Gulf of Maine from 1800 to 1918. *Marine Fisheries Review*, *64*(1), 1-12.

Reich, K.J., K.A. Bjorndal, and A.B. Bolten, 2007. The 'lost years' of green turtles: using stable isotopes to study cryptic lifestages. *Biology Letters*, *3*(6), 712-714.

Rice, D.W., 1989. Sperm whale, *Physeter macrocephalus* (Linnaeus, 1758). Pages 177-233 in S.H. Ridway, and S.R. Harrison, editors. Handbook of Marine Mammals Volume 4: River Dolphins and the Larger Toothed Whales, volume 4.

Rice, D.W., 1998. *Marine mammals of the world: systematics and distribution* (No. 4). Society for Marine Mammalogy.

Rice, M.R., and G.H. Balazs, 2008. Diving behavior of the Hawaiian green turtle (*Chelonia mydas*) during oceanic migrations. *Journal of Experimental Marine Biology and Ecology*, *356*(1), 121-127.

Richardson, W.J., C.R. Greene Jr., C.I. Malme, D.H. Thomson, 1995. *Marine Mammals and Noise*. Academic Press, San Diego, CA.

Richter, C., S. Dawson, and E. Slooten, 2006. Impacts of commercial whale watching on male sperm whales at Kaikoura, New Zealand. *Marine Mammal Science*, *22*(1), 46-63.

Roberts S., and M. Hirshfield, 2003. Deep sea corals: out of sight, but no longer out of mind. Oceana Rep, Washington DC, 16 pp.

Rowntree, V., J. Darling, G. Silber, M. Ferrari, 1980. Rare sighting of a right whale (*Eubalaena glacialis*) in Hawaii. *Canadian Journal of Zoology*, *58*(2), 309-312.

Sadove, S.S., and S.J. Morreale, 1990. Marine mammal and sea turtle encounters with marine debris in the New York Bight and the northeast Atlantic. In Shomura, R.S. and M.L. Godfrey (Eds.), *Proceedings of the 2nd International Conference on Marine Debris*, *vol. 1* (pp. 562-570). United States Department of Commerce, Honolulu, Hawaii, USA.

Salden, D.R. and J. Mickelsen, 1999. Rare sighting of a North Pacific right whale (*Eubalaena glacialis)* in Hawai'i. *Pacific Science* 53(4):341-345.

Scarff, J.E., 1986. Historic and present distribution of the right whale (*Eubalaena glacialis*) in the eastern North Pacific south of 50 N and east of 180 W. *Report of the International Whaling Commission (Special Issue 10)*, 43-63.

Scheidat, M., C. Castro, J. Gonzalez, and R. Williams, 2004. Behavioural responses of humpback whales (*Megaptera novaeangliae*) to whalewatching boats near Isla de la Plata, Machalilla National Park, Ecuador. *Journal of Cetacean Research and Management*, *6*(1), 63-68.

Schuyler, Q., B.D. Hardesty, C. Wilcox, and K. Townsend, 2014. Global Analysis of Anthropogenic Debris Ingestion by Sea Turtles. Conservation Biology, 28:129–139.

Sears, R. and W.F. Perrin, 2009. Blue whale *Balaenoptera musculus*. In Perrin, W.F., B. Wursig, and J.G.M. Thewissen (Eds.), *Encyclopedia of marine mammals (2nd Ed.) (*pp. 120-124). Accessed online via Elsevier.

Seminoff, J.A., T.T. Jones, A. Resendiz, W.J. Nichols, and M.Y. Chaloupka, 2003. Monitoring green turtles (*Chelonia mydas*) at a coastal foraging area in Baja California, Mexico: Multiple indices to describe population status. Journal of the Marine Biological Association of the United Kingdom 83:1355–1362.

Seminoff, J.A., S.R. Benson, K.E. Arthur, P.H. Dutton, R. Tapilatu, B.N. Popp, 2012. Stable isotope tracking of endangered sea turtles: validation with satellite telemetry and δ15N analysis of amino acids. *PLoS ONE*, 7(5): e37403

Smithsonian, n.d. Corals and Coral Reefs [Online]. Available: http://ocean.si.edu/corals-and-coral-reefs.

Smultea, M. A., J.J.R. Mobley, D. Fertl, G.L. Fulling, 2008. An unusual reaction and other observations of sperm whales near fixed-wing aircraft. *Gulf and Caribbean Research*, *20*, 75-80.

Stafford, K.M., 2003. Two types of blue whale calls recorded in the Gulf of Alaska. *Marine Mammal Science*, *19*(4), 682-693.

Stewart, B.S., G.A. Antonelis, J.D. Baker, and P.K. Yochem, 2006. Foraging biogeography of Hawaiian monk seals in the northwestern Hawaiian Islands. *Atoll Research Bulletin*, *543*(13), 1-145.

Swimmer, Y., R. Arauz, M. McCracken, L. McNaughton, J. Ballestero, M. Musyl, and R. Brill, 2006. Diving behavior and delayed mortality of olive ridley sea turtles *Lepidochelys olivacea* after their release from longline fishing gear. *Marine Ecology Progress Series*, *323*, 253-261.

Tava, R., and M. Keale, 1989. Niihau: The Traditions of a Hawaiian Island. Mutual Publishing, Honolulu

Teloni, V., J.P. Mark, M.J. Patrick, and M.T. Peter, 2008. Shallow food for deep divers: Dynamic foraging behavior of male sperm whales in a high latitude habitat. *Journal of Experimental Marine Biology and Ecology*, *354*(1), 119-131.

TenBruggencate, J., 2005. "Coral test could unravel Nihoa's mysterious past' in the Honolulu Advertiser, 29 August.

Thompson, P.O., and W.A. Friedl, 1982. A long term study of low frequency sounds from several species of whales off Oahu, Hawaii. Cetology, 45, 1-19.

Tiwari, M., G.H. Balazs, and S. Hargrove, 2010. Estimating carrying capacity at the green turtle nesting beach of East Island, French Frigate Shoals. *Marine Ecology Progress Series*, *419*,

U.S. Department of Commerce, The Under Secretary of Commerce for Oceans and Atmosphere, 2007. Papahānaumokuākea Marine National Monument: Application for Inclusion of a Property in the U.S. World Heritage Tentative List, 30 March.

U.S. Department of the Navy, 2005. Draft Overseas Environmental Impact Statement/ Environmental Impact Statement—East Coast Underwater Training 24 Range.

U.S. Department of the Navy, 2008. Final Environmental Impact Statement/Overseas Environmental Impact Statement—Hawaii Range Complex.

U.S. Environmental Protection Agency, 1999. Consideration of Cumulative Impacts in EPA Review of NEPA Documents. Office of Federal Activities (2252A). May.

U.S. Fish and Wildlife Service, 2012a. Endangered Species in the Pacific Islands Nihoa Finch/*Telespyza ultima* [Online]. Available: http://www.fws.gov/ pacificislands/fauna/nihoafinch.htm, September.

U.S. Fish and Wildlife Service, 2012b. Pacific Islands Fish and Wildlife Office—Pacific Region. Endangered Species in the Pacific Islands—Nihoa Millerbird *Acrocephalus familiaris kingi* [Online]. Available: http://www.fws.gov/ pacificislands/fauna/nihoamillerbird.html. Retrieved 16 December 2014.

U.S. Fish and Wildlife Service, 2013. National Wildlife Refuges of Papahānaumokuākea Marine National Monument [Online]. Available: http://www.papahanaumokuakea.gov/pdf/national_wildlife_refuges_of_pmnm_2013.pdf.

U.S. Fish and Wildlife Service, 2014. Endangered Species—Section 7 Consultation: A Brief Explanation [Online]. Retrieved 16 December 2014. Available: http://www.fws.gov/midwest/endangered/section7/section7.html 1/1.

Vanderlaan, A.S.M., and C.T. Taggart, 2007. Vessel collisions with whales: The probability of lethal injury based on vessel speed. Marine Mammal Science 23:144–156.

VanderWerf, E.A., 2012. Hawaiian Bird Conservation Action Plan: NWHI Passerines. Honolulu, Hawaii [Online]. Available: http://www.pacificrimconservation.com/PDF_Docs/Planning%20and%20Coordination/NWHI%20Passerines.pdf

Van Houtan, K.S., J.N. Kittinger, A.L. Lawrence, C. Yoshinaga, V.R. Born, and A. Fox, 2012. Hawksbill sea turtles in the northwestern Hawaiian Islands. *Chelonian Conservation and Biology*, *11*(1), 117-121.

Wade, P.R., A. Kennedy, R. LeDuc, J. Barlow, J. Carretta, K. Shelden, and P.J. Clapham, 2010. The world's smallest whale population? *Biology Letters*, rsbl20100477.

Wahlberg, M., 2002. The acoustic behaviour of diving sperm whales observed with a hydrophone array. *Journal of Experimental Marine Biology and Ecology*, *281*(1), 53-62.

Ware, C., A.S. Friedlaender, and D.P Nowacek, 2011. Shallow and deep lunge feeding of humpback whales in fjords of the West Antarctic Peninsula. *Marine Mammal Science*, *27*(3), 587-605.

Watling, L., P. Auster, I. Babb, C. Skinder, and B. Hecker, 2003. A geographic database of deepwater alcyonaceans of the northeastern U.S. continental shelf and slope. Version 1.0 CD-ROM. Nat. Undersea Res. Cent., Univ. Conn., Groton.

Watkins, W.A., J.E. George, M.A. Daher, K. Mullin, D.L. Martin, S.H. Haga, and N.A. DiMarzio, 2000. *Whale call data for the North Pacific November 1995 through July 1999: Occurrence of calling whales and source locations from SOSUS and other acoustic systems*. Technical Report WHOI-00-02. 160pp.

Watkins, W.A., M.A. Daher, K.M. Fristrup, T.J. Howald, and G. Notarbartolo di Sciara, 1993. Sperm whales tagged with transponders and tracked underwater by sonar. *Marine Mammal Science, 9* (1), 55–67.

Watkins, W.A. and W.E. Schevill, 1976. Right whale feeding and baleen rattle. *Journal of Mammalogy*, 58-66.

Watwood, S.L., P.J. Miller, M. Johnson, P.T. Madsen, and P.L. Tyack, 2006. Deep-diving foraging behaviour of sperm whales (*Physeter macrocephalus*). *Journal of Animal Ecology, 75*: 814–825.

Whitehead H., 2009. Sperm whale *Physeter macrocephalus*. In: Encyclopedia of marine mammals 2nd Ed. (Perrin W.F., Würsig B., Thewissen J.G.M., eds.) Academic Press, Amsterdam, 1091-1097.

Wise, J., 1924. Ka huakai i na mokupuni ma ka akau-komohana [A journey to the islands in the north-west]. Ka Nūpepa Kūʻokoa 62 (29), July 19.

Woodward, B.L., J.P. Winn, and F.E. Fish, 2006. Morphological specializations of baleen whales associated with hydrodynamic performance and ecological niche. *Journal of Morphology*, *267*(11), 1284-1294.

Work, T.M., and G.H. Balazs, 2010. Pathology and distribution of sea turtles landed as bycatch in the Hawaii-based North Pacific pelagic longline fishery. *Journal of Wildlife Diseases*, *46*(2), 422-432.

World Heritage Convention, 2015. UNESCO World Heritage Centre-Decision-34COM 8B.10—Mixed Properties-Papahanaumokuakea (United States of America). Available [Online]. http://whc.uncesco.org/en/decisions/3990.

Wursig, B., S.K. Lynn, T.A. Jefferson, and K.D. Mullin, 1998. Behaviour of cetaceans in the northern Gulf of Mexico relative to survey ships and aircraft. *Aquatic Mammals*, *24*, 41-50.

Wynne, K. and M. Schwartz, 1999. *Guide to Marine Mammals & Turtles of the U.S. Atlantic & Gulf of Mexico*. Rhode Island Sea Grant No NA86RG0076 from the NOAA NMFS, Office of Protected Resources.

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6.0 Agencies and Individuals Contacted

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6.0 AGENCIES AND INDIVIDUALS CONTACTED

NEPA regulations require that Federal, State, and local agencies with jurisdiction or special expertise regarding environmental impacts be consulted and involved in the NEPA process. Agencies involved include those with authority to issue permits, licenses, and other regulatory approvals. Other agencies include those responsible for protecting significant resources such as endangered species or wetlands. The agencies listed below were contacted during the preparation of this SEA.

Federal

Federal Aviation Administration
Honolulu Control Facility

U.S. Fish and Wildlife Service
Pacific Islands Office

National Marine Fisheries Service
Pacific Islands Office

United States Navy, Pacific Missile Range Facility
Kauai, HI

National Oceanic and Atmospheric Administration Office of National Marine Sanctuaries, Permit and Policy Office
Honolulu, HI

State

The Office of Hawaiian Affairs
Honolulu Headquarters

State Historic Preservation Division
Department of Land and Natural Resources

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Appendix A
Distribution List

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APPENDIX A
DISTRIBUTION LIST

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Honolulu, HI 96818

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Honolulu, HI 96850

National Marine Fisheries Service
Pacific Islands Office
1601 Kapiolani Blvd, Suite 1110
Honolulu, HI 96814-4700

State

The Office of Hawaiian Affairs
Honolulu Headquarters
711 Kapiolani Blvd, Suite 500
Honolulu, HI 96813

State Historic Preservation Division
Department of Land and Natural Resources
601 Kamokila Blvd, Suite 555
Kapolei, HI 96707

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4344 Hardy Street
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Appendix B
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APPENDIX B
CORRESPONDENCE

National Aeronautics and
Space Administration
Mission Support Directorate

NASA Management Office

4800 Oak Grove Drive
Pasadena, CA 91109-8099

Reply to Attn of AI020

February 27, 2015

Mr. Neil Okuna
Federal Aviation Administration
Honolulu Control Facility
760 Worchester Ave
Honolulu, HI 96818

SUBJECT: National Aeronautics and Space Administration Low-Density Supersonic Decelerator Test – Pacific Missile Range Facility Draft Supplemental Environmental Assessment

Dear Mr. Okuna:

The National Aeronautics and Space Administration (NASA) prepared a Final Environmental Assessment (EA) and issued a Finding of No Significant Impact (FONSI) in May 2013 which evaluated and addressed the potential environmental consequences of conducting the proposed launch, operation, and recovery of the Low Density Supersonic Decelerator (LDSD) Technology Demonstration Mission (TDM) test flights at the U.S. Navy's Pacific Missile Range Facility (PMRF) on Kauai, Hawaii. Based on information gleaned from the first test, NASA is preparing a Supplemental Environmental Assessment (SEA). Because the proposed launch requires routine coordination between PMRF and the Federal Aviation Administration (FAA) for established area airspace, NASA is providing the enclosed Draft SEA (DSEA).

NASA is proposing to use an additional 37,600 km^2 (10,950 nm^2) of splashdown area for future supersonic flight dynamic tests (SFDT) test flights. Of the approximately 37,600 km^2 (10,950 nm^2), approximately 28,730 km^2 (8,370 nm^2) is Open Ocean Area within Papahānaumokuākea Marine National Monument (PMNM) and the other approximately 8,875 km^2 (2,600 nm^2) of Open Ocean Area is north of PMNM. NASA submitted a Conservation and Management Permit requesting authorization for use of the 28,730 km^2 (8,370 nm^2) of Open Ocean Area within PMNM. If granted, the PMNM Conservation and Management Permit would authorize entry, splashdown, and recovery of expended flight hardware within PMNM.

This proposed test campaign would consist of launch, operation, and recovery of up to two missions per year for the next 5 years from a designated location on PMRF. The Test Vehicle with its small solid rocket motor would be launched on a high altitude balloon from PMRF. The majority of activities would use existing facilities and/or be on previously disturbed land.

The balloon, Test Vehicle, and parachute would be recovered. The DSEA identifies and evaluates the potential for environmental impacts to the Open Ocean Area of PMNM and Nihoa Island. Because of the established coordination process between PMRF and the FAA for area airspace, and adherence to applicable Department of Defense (DoD) directives and FAA regulations concerning issuance of Notices to Airmen (NOTAMs) and selection of launch areas and trajectories, the potential for any environmental impacts is minimal.

To ensure that any concerns you might have about our efforts to identify issues and assess potential environmental impacts are fully addressed, please review the DSEA and provide any written comments on the enclosed comment form by March 27, 2015. Comments can be e-mailed to sslaten@nasa.gov.

If you or any other staff have questions on the DSEA, please contact Steve Slaten, Jet Propulsion Laboratory Facilities and Environmental Manager at the following address or by calling (818) 393-6683, or by email at sslaten@nasa.gov.

Mr. Steven W. Slaten
NASA Management Office Environment and Facilities Manager
Jet Propulsion Laboratory
4800 Oak Grove Drive
MS 180-801
Pasadena, CA 91109

Sincerely,

Steve Slaten
Environmental and Facilities Manager
NASA Management Office

Enclosure: DSEA and Comment Form (Hard Copy and CD)

cc:
HDLNR\Mr. W. Aila
NMFS\Dr. S. Kolinski
NMS\Ms. T. Brown
OHA\Ms. C. Machado
USFWS\Dr. D. Polhemus

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March 9,2015

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Reply to Attn of: AI020

February 27, 2015

Dr. Steven Kolinski
National Marine Fisheries Service
Pacific Islands Region Office
1601 Kapiolani Blvd, Suite 1110
Honolulu, HI 96814-4700

SUBJECT: National Aeronautics and Space Administration Low-Density Supersonic Decelerator Test – Pacific Missile Range Facility Draft Supplemental Environmental Assessment

Dear Dr. Kolinski:

The National Aeronautics and Space Administration (NASA) prepared a Final Environmental Assessment (EA) and issued a Finding of No Significant Impact (FONSI) in May 2013 which evaluated and addressed the potential environmental consequences of conducting the proposed launch, operation, and recovery of the Low Density Supersonic Decelerator (LDSD) Technology Demonstration Mission (TDM) test flights at the U.S. Navy's Pacific Missile Range Facility (PMRF) on Kauai, Hawaii. Based on information gleaned from the first test, NASA is preparing a Supplemental Environmental Assessment (SEA). Because the proposed LDSD activities would occur in the Pacific Ocean, the enclosed Draft SEA (DSEA) is being distributed to your office for review and comment.

NASA is proposing to use an additional 37,600 km^2 (10,950 nm^2) of splashdown area for future supersonic flight dynamic tests (SFDT) test flights. Of the approximately 37,600 km^2 (10,950 nm^2), approximately 28,730 km^2 (8,370 nm^2) is Open Ocean Area within Papahānaumokuākea Marine National Monument (PMNM) and the other approximately 8,875 km^2 (2,600 nm^2) of Open Ocean Area is north of PMNM. NASA submitted a Conservation and Management Permit requesting authorization for use of the 28,730 km^2 (8,370 nm^2) of Open Ocean Area within PMNM. If granted, the PMNM Conservation and Management Permit would authorize entry, splashdown, and recovery of expended flight hardware within PMNM.

This proposed test campaign would consist of launch, operation, and recovery of up to two missions per year for the next 5 years from a designated location on PMRF. The Test Vehicle with its small solid rocket motor would be launched on a high altitude balloon from PMRF. The majority of activities would use existing facilities and/or be on previously disturbed land.

The balloon, Test Vehicle, and parachute would be recovered. The DSEA identifies and evaluates the potential for environmental impacts to the Open Ocean Area of PMNM and Nihoa Island. The affected area for any potential biological resource impacts includes the open ocean area within and outside of PMNM that could be affected by proposed activities, possible expended flight hardware, seaborne vessel and aircraft and over-flight of Nihoa Island.

No impacts on sensitive marine species protected by the Marine Mammal Protection Act are planned. No impacts on listed threatened or endangered marine species or critical habitat protected by the Endangered Species Act are planned. Balloon over-flight of Nihoa Island is not expected to affect marine species or the Hawaiian monk seal.

Although a direct hit from a LDSD balloon, Test Vehicle, or parachute would affect a sea turtle or marine mammal, or marine species at the surface, it is extremely unlikely that this would occur due to the relatively low density of marine species present, the limited number of test events, and the size of the ocean area that would be potentially affected. By the time the spent rocket motors impact in the open ocean, generally all of the propellants in them have burned. Any residual aluminum oxide, burned hydrocarbons, or propellant materials are not expected to present toxicity concerns. The Proposed Action would not result in any impacts on coral, degradation of water/sediment quality near the corals, or essential fish habitat.

NASA has determined that the proposed action would not jeopardize any listed threatened or endangered species or critical habitat. Also NASA has determined that the proposed action for the reasons mentioned above would be extremely unlikely to result in the take of a marine mammal protected under the Marine Mammal Protection Act. Therefore, an incidental take permit would not be required.

To ensure that any concerns you might have about our efforts to identify issues and assess potential environmental impacts are fully addressed, please review the DSEA and provide any written comments on the enclosed comment form by March 27, 2015. Comments can be e-mailed to sslaten@nasa.gov.

If you or any other staff have questions on the DSEA, please contact Steve Slaten, Jet Propulsion Laboratory Facilities and Environmental Manager at the following address or by calling (818) 393-6683, or by email at sslaten@nasa.gov.

Mr. Steven W. Slaten
NASA Management Office Environment and Facilities Manager
Jet Propulsion Laboratory
4800 Oak Grove Drive
MS 180-801
Pasadena, CA 91109

Sincerely,

Steve Slaten
Environmental and Facilities Manager
NASA Management Office

Enclosure: DSEA and Comment Form (hardcopy and CD)

cc:
FAA\Mr. N. Okuna
HDLNR\Mr. W. Aila
NMS\Ms. T. Brown
OHA\Ms. C. Machado
USFWS\Dr. D. Polhemus

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March 9,2015

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NASA Management Office

4800 Oak Grove Drive
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Reply to Attn of AI020

February 27, 2015

Ms. Colette Machado, Chairperson
The Office of Hawaiian Affairs, Honolulu Headquarters
711 Kapiolani Blvd., Suite 500
Honolulu, HI 96813

SUBJECT: National Aeronautics and Space Administration Low-Density Supersonic Decelerator Test – Pacific Missile Range Facility Draft Supplemental Environmental Assessment

Dear Ms. Machado:

The National Aeronautics and Space Administration (NASA) prepared a Final Environmental Assessment (EA) and issued a Finding of No Significant Impact (FONSI) in May 2013 which evaluated and addressed the potential environmental consequences of conducting the proposed launch, operation, and recovery of the Low Density Supersonic Decelerator (LDSD) Technology Demonstration Mission (TDM) test flights at the U.S. Navy's Pacific Missile Range Facility (PMRF) on Kauai, Hawaii. Based on information gleaned from the first test, NASA is preparing a Supplemental Environmental Assessment (SEA). Because the DSEA considers the potential for impacts on archaeological, historical, and traditional Native Hawaiian resources, and in accordance with the National Historic Preservation Act and its implementing regulations 36 Code of Federal Regulations (CFR) 800, NASA is providing the enclosed Draft SEA (DSEA) for your review.

NASA is proposing to use an additional 37,600 km^2 (10,950 nm^2) of splashdown area for future supersonic flight dynamic tests (SFDT) test flights. Of the approximately 37,600 km^2 (10,950 nm^2), approximately 28,730 km^2 (8,370 nm^2) is Open Ocean Area within Papahānaumokuākea Marine National Monument (PMNM), and the other approximately 8,875 km^2 (2,600 nm^2) of Open Ocean Area is north of PMNM. NASA submitted a Conservation and Management Permit requesting authorization for use of the 28,730 km^2 (8,370 nm^2) of Open Ocean Area within PMNM. If granted, the PMNM Conservation and Management Permit would authorize entry, splashdown, and recovery of expended flight hardware within PMNM.

This proposed test campaign would consist of launch, operation, and recovery of up to two missions per year for the next 5 years from a designated location on PMRF. The Test Vehicle with its small solid rocket motor would be launched on a high altitude balloon from PMRF. The majority of activities would use existing facilities and/or be on previously disturbed land. The Area of Potential Effects (APE) for cultural resources encompasses the over-flight of Nihoa Island.

Based on a review of cultural resources surveys, NASA has determined that no archaeological/traditional Native Hawaiian sites or historic properties will be affected by the proposed LDSD activities. There are also no ground disturbing activities associated with this Proposed Action.

To ensure that any concerns you might have about our efforts to identify issues and assess potential environmental impacts are fully addressed, please review the DSEA and provide any written comments on the enclosed comment form by March 27, 2015. Comments can be e-mailed to sslaten@nasa.gov.

If you or any other staff have questions on the DSEA, please contact Steve Slaten, Jet Propulsion Laboratory Facilities and Environmental Manager at the following address or by calling (818) 393-6683, or by email at sslaten@nasa.gov.

Mr. Steven W. Slaten
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Sincerely,

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Environmental and Facilities Manager
NASA Management Office

Enclosure: DSEA and Comment Form (hardcopy and CD)

cc:
FAA\Mr. N. Okuna
HDLNR\Mr. W. Aila
NMFS\Dr. S. Kolinski
NMS\Ms. T. Brown
USFWS\Dr. D. Polhemus

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March 9,2015

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NASA Management Office

4800 Oak Grove Drive
Pasadena, CA 91109-8099

Reply to Attn of AI020

February 27, 2015

Mr. William J. Aila, Jr.
State Historic Preservation Division
Department of Land and Natural Resources
601 Kamokila Boulevard, Suite 555
Kapolei, HI 96707

SUBJECT: National Aeronautics and Space Administration Low-Density Supersonic Decelerator Test – Pacific Missile Range Facility Draft Supplemental Environmental Assessment

Dear Mr. Aila:

The National Aeronautics and Space Administration (NASA) prepared a Final Environmental Assessment (EA) and issued a Finding of No Significant Impact (FONSI) in May 2013 which evaluated and addressed the potential environmental consequences of conducting the proposed launch, operation, and recovery of the Low Density Supersonic Decelerator (LDSD) Technology Demonstration Mission (TDM) test flights at the U.S. Navy's Pacific Missile Range Facility (PMRF) on Kauai, Hawaii. Based on information gleaned from the first test, NASA is preparing a Supplemental Environmental Assessment (SEA).

In accordance with Section 106 of the National Historic Preservation Act and its implementing regulations 36 CFR 800, NASA seeks your concurrence and comments on the proposed launch, operation, and recovery of the LDSD test campaign at PMRF on Nihoa Island and the Open Ocean Area. NASA is proposing to use an additional 37,600 km^2 (10,950 nm^2) of splashdown area for future supersonic flight dynamic tests (SFDT) test flights. Of the approximately 37,600 km^2 (10,950 nm^2), approximately 28,730 km^2 (8,370 nm^2) is Open Ocean Area within Papahānaumokuākea Marine National Monument (PMNM), and the other approximately 8,875 km^2 (2,600 nm^2) of Open Ocean Area is north of PMNM. NASA submitted a Conservation and Management Permit requesting authorization for use of the 28,730 km^2 (8,370 nm^2) of Open Ocean Area within PMNM. If granted, the PMNM Conservation and Management Permit would authorize entry, splashdown, and recovery of expended flight hardware within PMNM.

This proposed test campaign would consist of launch, operation, and recovery of up to two missions per year for the next 5 years from a designated location on PMRF. The Test Vehicle with its small solid rocket motor would be launched on a high altitude balloon from PMRF. The majority of activities would use existing facilities and/or be on

previously disturbed land. The 2013 Final LDSD was submitted to your office for review and comment that addressed the existing facilities and/or previously disturbed land.

NASA has prepared the attached Draft Supplemental Environmental Assessment (DSEA) in compliance with the National Environmental Policy Act (NEPA) of 1969, as amended (42 United States Code [U.S.C.] 4321 et seq.). The DSEA outlines the proposed action and its potential environmental effects. The proposed undertaking is similar to other launches by the Navy and other entities at PMRF.

The purpose of the SFDT campaign of LDSD is to demonstrate and evaluate development of new supersonic inflatable aerodynamic decelerator (SIAD) and supersonic ringsail (SSRS) parachute technologies. These tests would allow the SIAD and SSRS parachute to fly in the Earth's stratosphere at supersonic speed to simulate operation in the thin atmosphere of Mars or other similar planets.

The Area of Potential Effects (APE) encompasses the Open Ocean Area and possible balloon over-flight of Nihoa Island (please see attached figure). Based on a review of cultural resources surveys, NASA has determined that no archaeological/traditional Native Hawaiian sites or historic properties will be affected by the proposed LDSD activities. There are also no ground disturbing activities associated with this Proposed Action.

NASA's proposed LDSD mission will support ambitious new robotic missions to Mars and other planetary bodies and will lay the groundwork for even more complex human and science explorations in the future. NASA has continuously used a parachute-based deceleration system since the Viking Program, which put two landers on Mars in 1977. New technology beyond the current parachute-based deceleration systems is needed to slow even larger, heavier landers from the supersonic speeds of atmospheric entry to subsonic surface-approach speeds for these other planetary bodies. The LDSD will test new parachute technology to further space exploration.

NASA's LDSD DSEA addresses all of the reasonably foreseeable activities in the particular geographical areas affected by the Proposed Action and the No-action Alternative and focuses on those activities ready for Federal and resource agency decisions. NASA anticipates no land disturbance activities that might affect cultural resources and intends to carry out its activities much the same way PMRF regularly conducts launch tests. The Department of the Navy (DON) and PMRF previously conducted the Hawaii Range Complex Environmental Impact Statement/Overseas Environmental Impact Statement (HRC EIS/OEIS) (May 2008) outlining the use of the Hawaii Range, which was concurred on by your office.

Based on the analysis in the DSEA and coordination with the DON/PMRF, NASA has determined that there will be no historic properties affected by the proposed undertaking and seeks your concurrence. If NASA does not receive any further comment from your office on the proposed undertaking within 30 days, we will assume concurrence with our determination. The Draft SEA (DSEA) is enclosed for your review. Please provide any written comments on the DSEA by March 27, 2015, using the enclosed comment form. Comments can be e-mailed to sslaten@nasa.gov.

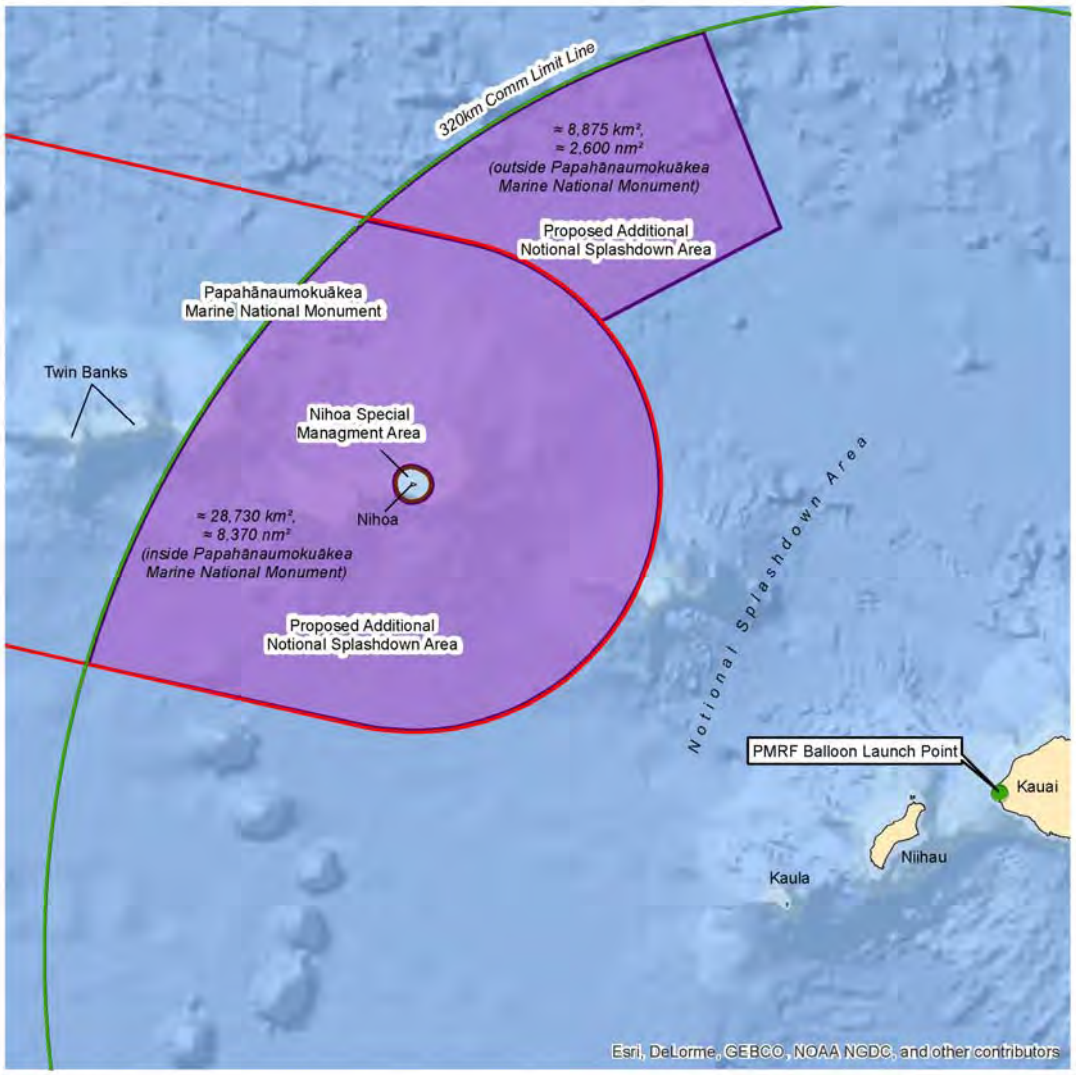
If you or any other staff have questions on the DSEA, please contact Steve Slaten, Jet Propulsion Laboratory Facilities and Environmental Manager at the following address or by calling (818) 393-6683, or by email at sslaten@nasa.gov.

Mr. Steven W. Slaten
NASA Management Office Environment and Facilities Manager
Jet Propulsion Laboratory
4800 Oak Grove Drive
MS 180-801
Pasadena, CA 91109

Sincerely,

Steve Slaten
Environmental and Facilities Manager
NASA Management Office

Enclosure: DSEA and Comment Form (hardcopy and CD)
cc:
FAA\Mr. N. Okuna
NMFS\Dr. S. Kolinski
NMS\Ms. T. Brown
OHA\Ms. C. Machado
USFWS\Dr. D. Polhemus



EXPLANATION

- PMRF Balloon Launch Point
- 320-km Communications Limit Line
- Proposed Additional Notional Splashdown Area
- Nihoa 3-nautical mile Special Management Area
- Papahānaumokuākea Marine National Monument

NORTH 0 12.5 25 50 Nautical Miles

Proposed Additional Splashdown Area

PMRF, Niihau, and Open Ocean

Figure 1-5

March 9,2015

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Recipient:
Mr. William Aila Jr.
State Historic Preservation Society
Dept. of Land& Nat. Resources
601 Kamokila Blvd, Ste. 555
KAPOLEI, HI 96707 US
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National Aeronautics and
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Mission Support Directorate

NASA Management Office

4800 Oak Grove Drive
Pasadena, CA 91109-8099

Reply to Attn of: AI020

February 27, 2015

Dr. Dan Polhemus
U.S. Fish and Wildlife Service
Pacific Islands Fish and Wildlife Office
P.O. Box 500888
Honolulu, HI 96850

SUBJECT: National Aeronautics and Space Administration Low-Density Supersonic Decelerator Test – Pacific Missile Range Facility Draft Supplemental Environmental Assessment

Dear Dr. Polhemus:

The National Aeronautics and Space Administration (NASA) prepared a Final Environmental Assessment (EA) and issued a Finding of No Significant Impact (FONSI) in May 2013 which evaluated and addressed the potential environmental consequences of conducting the proposed launch, operation, and recovery of the Low Density Supersonic Decelerator (LDSD) Technology Demonstration Mission (TDM) test flights at the U.S. Navy's Pacific Missile Range Facility (PMRF) on Kauai, Hawaii. Based on information gleaned from the first test, NASA is preparing a Supplemental Environmental Assessment (SEA). Because the proposed LDSD activities have the potential for over-flight of Nihoa Island, the enclosed Draft SEA (DSEA) is being distributed to your office for review and comment.

NASA is proposing to use an additional 37,600 km^2 (10,950 nm^2) of splashdown area for future supersonic flight dynamic tests (SFDT) test flights. Of the approximately 37,600 km^2 (10,950 nm^2), approximately 28,730 km^2 (8,370 nm^2) is Open Ocean Area within Papahānaumokuākea Marine National Monument (PMNM), and the other approximately 8,875 km^2 (2,600 nm^2) of Open Ocean Area is north of PMNM. NASA submitted a Conservation and Management Permit requesting authorization for use of the 28,730 km^2 (8,370 nm^2) of Open Ocean Area within PMNM. If granted, the PMNM Conservation and Management Permit would authorize entry, splashdown, and recovery of expended flight hardware within PMNM.

This proposed test campaign would consist of launch, operation, and recovery of up to two missions per year for the next 5 years from a designated location on PMRF. The Test Vehicle with its small solid rocket motor would be launched on a high altitude balloon from PMRF. The majority of activities would use existing facilities and/or be on previously disturbed land.

The DSEA identifies and evaluates the potential for environmental impacts to the Open Ocean and Nihoa Island. As described in the DSEA, the affected area for any potential biological resource impacts includes the area within the property boundary that could be affected by possible balloon over-flight of Nihoa Island, and areas of the Pacific Ocean.

The potential impacts of the proposed activities on Nihoa Island terrestrial and marine biological resources are expected to be minimal. Balloon over-flight of Nihoa Island is not expected to affect plant or wildlife species on the island. The activities would incorporate procedures to avoid threatened or endangered wildlife that are foraging, resting, or hauled out, such as the endangered Hawaiian monk seal. NASA has determined that the proposed action will not jeopardize any listed threatened or endangered species or critical habitat. In conjunction with the DSEA, NASA is currently preparing a Biological Evaluation for your review and concurrence.

To ensure that any concerns you might have about our efforts to identify issues and assess potential environmental impacts are fully addressed, please review the DSEA and provide any written comments on the enclosed comment form by March 27, 2015. Comments can be e-mailed to sslaten@nasa.gov.

If you or any other staff have questions on the DSEA, please contact Steve Slaten, Jet Propulsion Laboratory Facilities and Environmental Manager at the following address or by calling (818) 393-6683, or by email at sslaten@nasa.gov.

Mr. Steven W. Slaten
NASA Management Office Environment and Facilities Manager
Jet Propulsion Laboratory
4800 Oak Grove Drive
MS 180-801
Pasadena, CA 91109

Sincerely,

Steve Slaten
Environmental and Facilities Manager
NASA Management Office

Enclosure: DSEA and Comment Form (hardcopy and CD)

cc:
FAA\Mr. N. Okuna
HDLNR\Mr. W. Aila
NMFS\Dr. S. Kolinski
NMS\Ms. T. Brown
OHA\Ms. C. Machado

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March 9,2015

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Recipient:
Dr. Loyal Mehrhoff
US Fish & Wildlife Service
Pacific Islands Office
300 Ala Moana Blvd., RM 3-122
HONOLULU, HI 96850 US
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NASA Management Office

4800 Oak Grove Drive
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Reply to Attn of: AI020

February 27, 2015

Ms. Tia Brown
Permit and Policy Coordinator
NOAA Office of National Marine Sanctuaries
Papahānaumokuākea Marine National Monument
1845 Wasp Blvd. Building 176
Honolulu, HI 96818

SUBJECT: National Aeronautics and Space Administration Low-Density Supersonic Decelerator Test – Pacific Missile Range Facility Draft Supplemental Environmental Assessment

Dear Ms. Brown:

The National Aeronautics and Space Administration (NASA) prepared a Final Environmental Assessment (EA) and issued a Finding of No Significant Impact (FONSI) in May 2013 which evaluated and addressed the potential environmental consequences of conducting the proposed launch, operation, and recovery of the Low Density Supersonic Decelerator (LDSD) Technology Demonstration Mission (TDM) test flights at the U.S. Navy's Pacific Missile Range Facility (PMRF) on Kauai, Hawaii. Based on information gleaned from the first test, NASA is preparing a Supplemental Environmental Assessment (SEA). Because the proposed LDSD activities have the potential for over-flight of Nihoa Island, the enclosed Draft SEA (DSEA) is being distributed to your office for review and comment.

NASA is proposing to use an additional 37,600 km^2 (10,950 nm^2) of splashdown area for future supersonic flight dynamic tests (SFDT) test flights. Of the approximately 37,600 km^2 (10,950 nm^2), approximately 28,730 km^2 (8,370 nm^2) is Open Ocean Area within Papahānaumokuākea Marine National Monument (PMNM), and the other approximately 8,875 km^2 (2,600 nm^2) of Open Ocean Area is north of PMNM. NASA submitted a Conservation and Management Permit requesting authorization for use of the 28,730 km^2 (8,370 nm^2) of Open Ocean Area within PMNM. If granted, the PMNM Conservation and Management Permit would authorize entry, splashdown, and recovery of expended flight hardware within PMNM.

This proposed test campaign would consist of launch, operation, and recovery of up to two missions per year for the next 5 years from a designated location on PMRF. The Test Vehicle with its small solid rocket motor would be launched on a high altitude balloon from PMRF. The majority of activities would use existing facilities and/or be on previously disturbed land. The DSEA identifies and evaluates the potential for

environmental impacts to the Open Ocean (air quality, biological resource, and cultural resources) and Nihoa Island (biological resource, cultural resources, and health and safety).

No impacts on sensitive marine species protected by the Marine Mammal Protection Act are planned in the Open Ocean Area. No impacts on listed threatened or endangered marine species or critical habitat protected by the Endangered Species Act are planned in the Open Ocea Area. The potential impacts of the proposed activities on Nihoa Island terrestrial and marine biological resources are expected to be minimal. Balloon over-flight of Nihoa Island is not expected to affect plant or wildlife species on the island. The activities would incorporate procedures to avoid threatened or endangered wildlife that are foraging, resting, or hauled out, such as the endangered Hawaiian monk seal. NASA has determined that the proposed action will not jeopardize any listed threatened or endangered species or critical habitat.

To ensure that any concerns you might have about our efforts to identify issues and assess potential environmental impacts are fully addressed, please review the DSEA and provide any written comments on the enclosed comment form by March 27, 2015. Comments can be e-mailed to sslaten@nasa.gov.

If you or any other staff have questions on the DSEA, please contact Steve Slaten, Jet Propulsion Laboratory Facilities and Environmental Manager at the following address or by calling (818) 393-6683, or by email at sslaten@nasa.gov.

Mr. Steven W. Slaten
NASA Management Office Environment and Facilities Manager
Jet Propulsion Laboratory
4800 Oak Grove Drive
MS 180-801
Pasadena, CA 91109

Sincerely,

Steve Slaten
Environmental and Facilities Manager
NASA Management Office

Enclosure: DSEA and Comment Form (hardcopy and CD)
cc:
FAA\Mr. N. Okuna
HDLNR\Mr. W. Aila
NMFS\Dr. S. Kolinski
OHA\Ms. C. Machado
USFWS\Dr. D. Polhemus

March 9,2015

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		Weight:	3.0 lbs/1.4 kg

Recipient:
Ms. Tia Brown
NOAA Ofc of Natl Marine Sanctuaries
Permit & Policy Coodinator
1845 Wasp Blvd, Bldg 176
HONOLULU, HI 96818 US
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NASA Management Office
180-801
4800 Oak Grove Drive
Pasadena, CA 91109-8099

Reply to Attn of: AI020

DATE: February 27, 2015

SUBJECT: NASA Supplemental Environmental Assessment for the Low Density Supersonic Decelerator (LDSD) Project

To Whom It May Concern:

Please provide space in your library or offices for public access to the enclosed National Aeronautics and Space Administration Low Density Supersonic Decelerator Test – Pacific Missile Range Facility Draft Supplemental Environmental Assessment (DSEA). The DSEA will be available for public access and review through **March 27, 2015.**

The document and a blank comment form are also available on the internet at https://www.govsupport.us/nasaldsdsea

Anyone wishing to provide comments can do so in one of three ways:

1. E-mail comments to sslaten@nasa.gov.

2. Mail comments to:

Mr. Steven W. Slaten
NASA Management Office Environment and Facilities Manager
Jet Propulsion Laboratory
4800 Oak Grove Drive
MS 180-801
Pasadena, CA 91109

Comments should be received no later than **March 27, 2015.** Questions and comments regarding the DSEA, or requests for additional copies, can be sent to sslaten@nasa.gov.

Steve Slaten
Environmental and Facilities Manager
NASA Management Office

Enclosures: One hardcopy and 1 CD of DSEA and Comment Form

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March 9,2015

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Hawaii & Pacific Section Doc. Unit
Hawaii State
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March 9,2015

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4344 Hardy Street
LIHUE, HI 96766 US

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Suite 120
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March 9,2015

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WAIMEA, HI 96796 US

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Suite 120
HUNTSVILLE, AL 35806 US

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National Aeronautics and
Space Administration
Mission Support Directorate

NASA Management Office
180-801
4800 Oak Grove Drive
Pasadena, CA 91109-8099

Reply to Attn of: AI020

DATE: February 27, 2015

SUBJECT: NASA Draft Supplemental Environmental Assessment for the Low Density Supersonic Decelerator (LDSD) Project

The National Aeronautics and Space Administration (NASA) prepared a Final Environmental Assessment (EA) and issued a Finding of No Significant Impact (FONSI) in May 2013 which evaluated and addressed the potential environmental consequences of conducting the proposed launch, operation, and recovery of the Low Density Supersonic Decelerator (LDSD) Technology Demonstration Mission (TDM) test flights at the U.S. Navy's Pacific Missile Range Facility (PMRF) on Kauai, Hawaii. Based on information gleaned from the first test, NASA is preparing a Supplemental Environmental Assessment (SEA), in accordance with the following statutes, regulations, and procedures:

- National Environmental Policy Act (NEPA) of 1969, as amended (42 United States Code [U.S.C.] 4321 et seq.);
- Council on Environmental Quality (CEQ) Regulations for Implementing the Procedural Provisions of NEPA (40 Code of Federal Regulations [CFR] Parts 1500-1508);
- NASA NEPA Implementing Regulation (Subpart 1216.3);
- NASA Procedural Requirement 8580.1, NASA National Environmental Policy Act Management Requirements;
- Executive Order (EO) 12114, Environmental Effects Abroad of Major Federal Actions;
- Presidential Proclamation, 8031 Establishment of the Northwestern Hawaiian Islands Marine National Monument; and
- 50 CFR Part 404, Northwestern Hawaiian Islands Marine National Monument.

The NASA LDSD SEA analyzes potential environmental consequences (environmental impacts) of changes planned for future campaigns. These changes consist of two alternatives. Alternative 1 consists of using an additional open ocean splashdown area within and outside of Papahānaumokuākea Marine National Monument (PMNM), and Alternative 2 consists of adding additional launch years to the 2013 Final EA. For Alternative 1 (preferred alternative), these changes consist of (1) permit authorization (issuance of which is contingent upon final approval of this SEA and associated FONSI) for flight hardware to potentially fly over, splashdown, and be recovered (except the balloon flight train, which would rapidly sink in the open ocean) within the easternmost part of PMNM; and (2) perform up to two LDSD TDM test flights annually over the next 5 years, starting in June 2015 and ending in August 2019. For Alternative 2, these changes consist of additional testing of up to two missions per year over the next 4 years (June 2016–August 2019) from a designated location on

PMRF using the flight trajectory outlined in the 2013 LDSD Final EA. This document and a blank comment form are also available online at:
http://sites.wff.nasa.gov/code250/docs/NASA_LDSD_DSEA.pdf.

Please provide your written comments on this Draft SEA (DSEA) by March 27, 2015, using the enclosed comment form. Comments may be submitted contact Steve Slaten, Jet Propulsion Laboratory Facilities and Environmental Manager at the following address or by calling (818) 393-6683, or by email at sslaten@nasa.gov.

Mr. Steven W. Slaten
NASA Management Office Environment and Facilities Manager
Jet Propulsion Laboratory
4800 Oak Grove Drive
MS 180-801
Pasadena, CA 91109

Steve Slaten
Environmental and Facilities Manager
NASA Management Office

Enclosures: One hardcopy and 1 CD of DSEA and Comment Form

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March 9,2015

Dear Customer:

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		Weight:	3.0 lbs/1.4 kg

Recipient:
Attn: John Burger, BS395
Commanding Officer
PMRF, Bldg 374
Nohili Road
KEKAHA, HI 96752 US
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Silbert, Shari A. (WFF-200.C)[LJT AND ASSOCIATES, INC.]

From: John Nakagawa <JNakagaw@dbedt.hawaii.gov>
Sent: Monday, March 09, 2015 3:52 PM
To: Silbert, Shari A. (WFF-200.C)[LJT AND ASSOCIATES, INC.]
Cc: Bundick, Joshua A. (WFF-2500); Hommon, Rebecca M CIV CNRH, N00L
Subject: Re: Hawaii CZP Process
Attachments: PMRF_low_density_supersonic_decelerator_13-001.pdf; Navy CZM DeMinimis List 2009.pdf

Ms. Silbert,

Previously, on January 7, 2013, NASA in coordination with the Navy (PMRF) determined that the Low-Density Supersonic Deceleration (LDSD) Test program at PMRF is covered by the Navy CZMA De Minimis List, which was approved by the Hawaii CZM Program on July 9, 2009. The proposal included the launch, operation, and recovery of up to four missions originating from PMRF. The NASA determination and the approved Navy CZMA De Minimis List are attached for your reference. We recommend that you consult the Navy regarding the continued applicability of the Navy CZMA De Minimis List for the LDSD Test program.

Thank you for consulting the Hawaii CZM Program. Please contact me if you have any questions.

John Nakagawa
Hawaii Coastal Zone Management Program
(808) 587-2878

From: "Silbert, Shari A. (WFF-200.C)[LJT AND ASSOCIATES, INC.]" <shari.a.silbert@nasa.gov>
To: "jnakagaw@dbedt.hawaii.gov" <jnakagaw@dbedt.hawaii.gov>
Cc: "Bundick, Joshua A. (WFF-2500)" <joshua.a.bundick@nasa.gov>
Date: 03/09/2015 07:30 AM
Subject: Hawaii CZP Process

Dear Mr. Nakagawa,

In May 2013, the National Aeronautics and Space Administration (NASA) prepared a Final Environmental Assessment (EA) and issued a Finding of No Significant Impact (FONSI) which evaluated and addressed the potential environmental consequences of conducting the proposed launch, operation, and recovery of the Low Density Supersonic Decelerator (LDSD) Technology Demonstration Mission (TDM) test flights at the U.S. Navy's Pacific Missile Range Facility (PMRF) on Kauai, Hawaii.

The 2013 Final EA addressed the first demonstration test that was successfully conducted in June 2014, as well as the campaigns planned in 2015 consisting of up to three additional demonstration tests. Based on information gleaned from the first test, NASA is preparing a Supplemental Environmental Assessment (SEA) to evaluate the potential environmental consequences of changes planned for future campaigns. The

1

2015 Draft LDSD SEA is currently available for public comment (Project website: http://sites.wff.nasa.gov/code250/NASA_LDSD_DSEA.html).

In addition to supplementing the EA, NASA has applied for a Conservation and Management Permit with the Papahānaumokuākea Marine National Monument to potentially splashdown and recover expended flight hardware into the southeastern portion of the Monument excluding Nihoa Island and the 3-nautical mile Special Management Area surrounding the island.

We would like to discuss with your office, at your earliest convenience, the potential changes to this mission with regards to the Hawai'i Coastal Zone Management Program and whether a Federal Consistency Determination is required, separate from that held by the U.S. Navy, Hawai'i Region.

Thank you.

Shari A. Silbert
LJT & Associates, Inc.
Environmental Scientist
NASA Wallops Flight Facility
Wallops Island, VA 23337
ph (757) 824-2327
fx (757) 824-1819
Shari.A.Silbert@nasa.gov
www.nasa.gov/wallops
https://www.facebook.com/WallopsFarmersMarket

"Take this for what it's worth, step lightly on the earth." – Thompson Twins in "Fool's Gold"

"The contents of this message do not reflect any position of the National Aeronautics and Space Administration or Goddard Space Flight Center."

NASA LDSD Notification of de minimis Determination
Slaten, Steven W. (HQ-LP040)
to:
jnakagaw@dbedt.hawaii.gov
01/07/2013 07:21 AM
Cc:
"Phillips, John M", "Slaten, Steven W. (HQ-LP040)"
Hide Details
From: "Slaten, Steven W. (HQ-LP040)" <sslaten@nasa.gov>
To: "jnakagaw@dbedt.hawaii.gov" <jnakagaw@dbedt.hawaii.gov>,
Cc: "Phillips, John M" <j.m.phillips@jpl.nasa.gov>, "Slaten, Steven W. (HQ-LP040)" <sslaten@nasa.gov>

SUBJECT: Notification of *de minimis* Determination – *National Aeronautics and Space Administration Low-Density Supersonic Decelerator Test Pacific Missile Range Facility Environmental Assessment*

Dear Mr. Nakagawa:

This correspondence is notification of a *de minimis* determination for the following National Aeronautics and Space Administration (NASA) project: *Low-Density Supersonic Deceleration (LDSD) Test* baselined to be performed at the Pacific Missile Range Facility (PMRF), Kauai, Hawaii. The project includes possible over-flight of Niihau and landing and recovery of the balloon, Test Vehicle, and parachute in the Open Ocean Area. A brief description of the project and supporting information regarding the *de minimis* determination follow.

Project Description

The NASA Jet Propulsion Laboratory is proposing to conduct supersonic flight dynamic tests (SFDT) for NASA's LDSD Project from the Department of the Navy's PMRF. These proposed tests would consist of launch, operation, and recovery of up to four missions from a designated location on PMRF. The purpose of the SFDT is to demonstrate and evaluate development of new supersonic inflatable aerodynamic decelerator (SIAD) and supersonic ringsail (SSRS) parachute technologies. These tests would allow the SIAD and SSRS parachute to be tested in the Earth's stratosphere at supersonic speed to simulate operation in the thin atmosphere of Mars. The Test Vehicle with its small solid rocket motor would be launched on a high altitude balloon from PMRF.

The LDSD test series is needed to demonstrate the ability to slow larger, heavier landers from the supersonic speeds of atmospheric entry to subsonic surface approach speeds. Successful completion of the test series will allow NASA to support ambitious new robotic missions to Mars, and other planetary bodies, and will lay the groundwork for future, even more complex, human and science explorations.

***De Minimis* Determination**

In accordance with Department of Commerce, National Oceanic and Atmospheric Administration, Coastal Zone Management (CZM) Act Federal Consistency Regulation 15 Part CFR Part 930.33(3) and application of the corresponding mitigation and conditions approved by the Hawaii Department of Business, Economic Development & Tourism on 2 April 2007 (revised 9 July 2009), NASA in coordination with the Navy (PMRF) has determined that this project falls within the scope of U.S. Navy *de minimis* category Number 12 (Military Testing and Training) and would not be subject to further review by the Hawaii Coastal Zone Management Program. The applicable *de minimis* Project

Mitigation/General Conditions are listed below:

Mitigation/Condition #9: Project-related vehicles would be fueled in areas away from the coastal waters/open ocean surrounding PMRF. PMRF has well established procedures and facilities for handling, storing, managing, and transporting hazardous substances, as well as resources for responding to spills, fires, and other hazardous conditions that could result from project activities. Unexpected releases of hazardous or nonhazardous materials would be handled in accordance with existing PMRF Standard Operating Procedures.

Mitigation/Condition #13: There are no protected plant species identified by the Endangered Species Act that would be affected by proposed LDSD activities. Personnel would be instructed to avoid contact with monk seals, sea turtles, or sea turtle nests that might occur within the adjacent area. If turtle nests are unexpectedly discovered, NASA personnel would contact the PMRF Environmental Office, which would consult with the appropriate agencies.

Mitigation/Condition #14: The National Environmental Policy Act (NEPA) process will be completed in accordance with Council on Environmental Quality and Department of Defense mandates, regulations, and implementing guidance.

Mitigation/Condition #15: The proposed LDSD launch testing process would comply with the Navy Occupational Safety and Health Program Manual, Navy Operations Instruction 5100.23E, and the PMRF Range Safety Operation Plan, which is generated by PMRF Range Safety personnel prior to range operations.

Mitigation/Condition #16: Submittal of this documentation satisfies the requirement set forth in Mitigation/Condition #16 to notify the Hawaii CZM Program of *de minimis* list usage for projects requiring an EA.

If you have questions, please contact Mark Phillips, LDSD Project NEPA Lead, at the Jet Propulsion Laboratory, Attention: Mark Phillips (4800 Oak Grove Drive – M/S 301-370, Pasadena, CA 91109) by calling 818-354-1181, or by email at j.m.phillips@jpl.nasa.gov.

Thank You,

Steve Slaten
Facilities and Environmental Manager
NASA Management Office
Jet Propulsion Laboratory
818-393-6683

LINDA LINGLE
GOVERNOR
THEODORE E. LIU
DIRECTOR
MARK K. ANDERSON
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OFFICE OF PLANNING

DEPARTMENT OF BUSINESS,
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OFFICE OF PLANNING
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Telephone: (808) 587-2846
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Ref. No. P-12644

July 9, 2009

Lieutenant Commander E. J. D'Andrea
Assistant Regional Engineer
Department of the Navy
Commander
Navy Region Hawaii
850 Ticonderoga Street, Suite 110
Pearl Harbor, Hawaii 96860-5101

Attention: Mr. Brian Yamada

Dear Lt. Commander D'Andrea:

Subject: Hawaii Coastal Zone Management (CZM) Program Federal Consistency Concurrence with Modifications to the Department of the Navy De Minimis Activities in Hawaii under the Coastal Zone Management Act (CZMA)

The Hawaii CZM Program has completed the federal consistency review of the proposed modifications to the list of Department of the Navy de minimis activities under the CZMA, including changes to various activity categories, adding new activity categories, and expanding the coverage to Marine Corps Base Hawaii Kaneohe Bay and Camp Smith. The CZM Program conducted a thorough review of the request and a public notice of the CZM review was published in the State of Hawaii Office of Environmental Quality Control's publication, *The Environmental Notice*, on June 23, 2009. The public was provided an opportunity to participate in the review through July 7, 2009. There were no public comments received.

We concur that the activities identified on the modified list entitled, "Navy/Marine Corps De Minimis Activities Under CZMA" are expected to have insignificant direct or indirect (cumulative and secondary) coastal effects, and should not be subject to further review by the Hawaii CZM Program on the basis and condition that the listed activities are subject to and bound by full compliance with the corresponding "Project Mitigation / General Conditions."

The Hawaii CZM Program reserves the right to review, amend, suspend, and/or revoke the "Navy/Marine Corps De Minimis Activities Under CZMA" list whenever it finds that a listed activity or activities will have reasonably foreseeable coastal effects. CZM consistency

concurrence does not convey approval with any other regulations administered by any State or County agency.

Modifying and expanding the list of Navy de minimis activities under the CZMA was a cooperative effort between our Office and Mr. Brian Yamada from the Department of the Navy, who interned with the Hawaii CZM Program in September 2008. We appreciate the efforts of Mr. Yamada in working with our CZM staff. The de minimis activities list will result in more efficient compliance with CZMA federal consistency requirements for both the Navy and the Hawaii CZM Program.

If you have any questions, please call John Nakagawa of our CZM Program at 587-2878.

Sincerely,

Abbey Seth Mayer
Director

c: U.S. Army Corps of Engineers, Regulatory Branch (w/ copy of de minimis list)
Ms. Rebecca Hommon, Region Counsel, Navy Region Hawaii

JDN/do
Disk #12

DEPARTMENT OF THE NAVY
COMMANDER
NAVY REGION HAWAII
850 TICONDEROGA ST STE 110
PEARL HARBOR, HAWAII 96860-5101

5090
Ser N4/ 04163
01 JUN 2009

CERTIFIED MAIL NO. 7007 2560 0002 0326 9580

Mr. Abbey Mayer
Office of Planning
Department of Business, Economic
Development and Tourism
P. O. Box 2359
Honolulu HI 96804

RECEIVED
JUN - 5 2009
OFFICE OF PLANNING

Dear Mr. Mayer:

SUBJECT: REQUEST FOR CONCURRENCE WITH MODIFICATIONS TO THE DEPARTMENT OF THE NAVY DE MINIMIS ACTIVITIES UNDER THE COASTAL ZONE MANAGEMENT ACT (CZMA)

This letter is to request your concurrence with the attached list of Navy/Marine Corps de minimis activities under the CZMA. The attached de minimis list will amend the current de minimis list which was established on April 2, 2007. The new de minimis list will include the Marine Corps, and will cover areas in the Pearl Harbor Naval complex, Naval Magazine Lualualei, Naval Communications and Telecommunications Area Master Station Pacific, Pacific Missile Range Facility on Kauai, Kaneohe Marine Corps Base Hawaii, Camp Smith and all associated installations/facilities/equipment located outside of those Navy/Marine Corps properties.

The Navy and Marine Corps have determined that the listed Proposed Actions have insignificant direct or indirect (cumulative and secondary) coastal effects and should therefore be categorized as de minimis in accordance with the Department of Commerce, National Oceanic and Atmospheric Administration, CZMA Federal Consistency Regulations 15 CFR part 930.33 (3). With the corresponding mitigation and conditions applied, these actions would be exempt from a negative determination or a consistency determination from the State of Hawaii.

Should you have any questions, please contact Mr. Brian Yamada at 472-1449, by facsimile transmission at 474-5419, or by email at brian.yamada@navy.mil.

Sincerely,

E. J. D'ANDREA
Lieutenant Commander, CEC, U. S. Navy
Assistant Regional Engineer
By direction of the
Commander

Enclosure: 1.Navy De minimis Activities Under CZMA

Navy/Marine Corps De Minimis Activities Under CZMA

***covering areas in Pearl Harbor Naval Complex, Naval Magazine Lualualei, Naval Communications and Telecommunications Area Master Station (NCTAMS) Pacific, Pacific Missile Range Facility (PMRF), Kaneohe Marine Corps Base Hawaii, Camp Smith, and all associated installations/facilities/equipment located outside of these Navy/Marine Corps properties**

No.	Proposed Action	Description	Mitigation / Conditions
1	New Construction	Construction of new facilities and structures wholly within Navy/Marine Corps controlled areas (including land and water) that is similar to present use and, when completed, the use or operation of which complies with existing regulatory requirements.	1, 3, 6, 8, 9, 10, 11, 13, 14, 16
2	Utility Line Activities	Acquisition, installation, operation, construction, maintenance, or repair of utility or communication systems that use rights of way, easements, distribution systems, or facilities on Navy/Marine Corps controlled property. This also includes the associated excavation, backfill, or bedding for the utility lines, provided there is no change in preconstruction contours.	1, 10, 11, 12, 14, 16
3	Repair and Maintenance	Routine repair and maintenance of buildings, ancillary facilities, piers, wharves, dry docks, vessels, or equipment associated with existing operations and activities.	12, 14, 16
4	Aids to Navigation	Includes buoys, beacons, signs, etc. placed within Navy/Marine Corps controlled coasts and navigable waters as guides to mark safe water.	2, 5, 14, 16
5	Structures in Fleeting and Anchorage Areas	The installation of structures, buoys, floats and other devices placed within anchorage or fleeting areas to facilitate moorage of vessels within Navy/Marine Corps controlled property.	2, 5, 14, 16
6	Oil Spill and Hazardous Waste Cleanup	Activities required for the containment, stabilization, removal and cleanup of oil and hazardous or toxic waste materials on Navy/Marine Corps controlled property.	1, 6, 14, 16
7	Maintenance Dredging	Excavation and removal of accumulated sediment for maintenance to previously authorized depths.	2, 3, 4, 5, 7, 8, 9, 13, 14, 16
8	New Dredging	Excavation and removal of material from the ocean floor not to exceed 100 cubic yards below the plane of the ordinary high water mark or the mean high water mark from navigable waters of the US and; excavation and removal of material from the ocean floor within Navy/Marine Corps controlled property. This does not include dredging or degradation through coral reefs.	2, 3, 4, 5, 7, 8, 9, 13, 14, 16
9	Scientific Measuring Devices	The installation of devices which record scientific data (staff gages, tide gages, water recording devices, water quality testing and improvement devices and similar structures) on Navy/Marine Corps controlled property. Devices must not transmit acoustics (certain frequencies) that will adversely affect marine life.	1, 2, 14, 16
10	Studies and Data Collection and Survey Activities	Studies, data and information-gathering, and surveys that involve no permanent physical change to the environment. Includes topographic surveys, wetlands mapping, surveys for evaluating environmental damage, engineering efforts to support environmental analyses, core sampling, soil survey sampling, and historic resources surveys.	2, 3, 6, 8, 9, 11, 12, 13, 14, 16
11	Demolition	Demolition and disposal involving buildings or structures when done in accordance with applicable regulations and within Navy/Marine Corps controlled properties.	1, 11, 12, 14, 16
12	Military Testing and Training	Routine testing and evaluation of military equipment on or over military, or an established range, restricted area or operating area or training conducted on or over military land or water areas in which the impact is not significant.	9, 13, 14, 15, 16
13	Real Estate/Property Transfer	Real estate acquisitions or outleases of land involving new ingrants/outgrants and/or 50 acres or more where existing land use will change.	14, 16

ENCLOSURE(/)

14	Mission Changes	Mission changes, base closures/relocations/consolidations, and deployments that would cause long term population increases or decreases in affected areas.	14, 16
15	Limitation of Access to Property	Permanent closure or limitation of access to any areas that were open previously to public use, such as roads or recreational purposes (provided the access is not required by established agreements with State of Hawaii, private industry, etc.)	14, 16
16	Environmental Management Activities	Environmental management activities within Navy/Marine Corps controlled areas including, but not limited to, activities such as vegetation and mangrove removal, ditch clearing, sediment removal, invasive species removal, construction related to protecting endangered species and wildlife, and actions prescribed by the Integrated Natural Resources Management Plan (INRMP)	2, 13, 14, 16
17	Towers	Installation, operation, and maintenance of towers (such as communication towers, cellular phone antennas, wind-energy towers) within Navy/Marine Corps controlled areas.	1, 2, 6, 8,9 , 12, 13, 14, 16
18	Alternative Energy Research	Installation, operation, replacement, and removal of alternative energy research structures/equipment taking place within Navy/Marine Corps controlled areas.	1, 2, 3, 5, 6, 12, 13, 14, 16
19	Army Corps Nation Wide Permits	Work subject to an Army Corps of Engineers Nationwide permit (which are applicable to Hawaii)	16

Project Mitigation / General Conditions

1) Navy/Marine Corps controlled property refers to land areas, rights of way, easements, roads, safety zones, danger zones, ocean and naval defensive sea areas under active Navy/Marine Corps control.
2) If any listed species enters the area during conduct of construction activities, all activities should cease until the animal(s) voluntarily depart the area.
3) Turbidity and siltation from project related work shall be minimized and contained to within the vicinity of the site through appropriate use of effective silt containment devices and the curtailment of work during adverse tidal and weather conditions.
4) Dredging/filling in the marine/aquatic environment shall be scheduled to avoid coral spawning and recruitment periods.
5) All project-related materials and equipment (dredges, barges, backhoes, etc.) to be placed in the water shall be cleaned of pollutants prior to use.
6) No project-related materials (fill, revetment rock, pipe, etc.) should be stockpiled in the water (intertidal zones, reef flats, stream channels, wetlands, etc.).
7) All debris removed from the marine/aquatic environment shall be disposed of at an upland site or EPA approved ocean disposal site, and Best Management Practices shall be followed.
8) No contamination (trash or debris disposal, alien species introductions, etc.) of adjacent marine/aquatic environments (reef flats, channels, open ocean, stream channels, wetlands, etc.) shall result from project-related activities.
9) Fueling of project-related vehicles and equipment should take place away from the water and a contingency plan to control petroleum products accidentally spilled during the project shall be developed. Absorbent pads and containment booms shall be stored on-site, if appropriate, to facilitate clean-up of accidental petroleum releases.
10) Any under-layer fills used in the project shall be protected from erosion with stones (or core-loc units) as soon after placement as practicable.
11) Any soil exposed near water as part of the project shall be protected from erosion (with plastic sheeting, filter fabric, etc.) after exposure and stabilized as soon as practicable (with vegetation matting, hydroseeding, etc.).
12) Section 106, of the National Historic Preservation Act (NHPA), consultation requirements must be met. Also, follow guidelines in the area-specific Integrated Cultural Resources Management Plan (ICRMP) if applicable.
13) Navy/Marine Corps shall evaluate the possible impact of the action on species and habitats protected under the Endangered Species Act (ESA). If the Navy/Marine Corps determines that no such species or habitats will be affected by the action, neither U.S. Fish and Wildlife (FWS) Service nor National Oceanic and Atmospheric Administration (NOAA) concurrence is required. Should it be determined by the Navy/Marine Corps, FWS, or NOAA that the action may affect any such species or habitat, informal or formal consultation will be initiated by the Navy/Marine Corps as required by section 7 (Interagency Cooperation) of the ESA.
14) The National Environmental Policy Act (NEPA) review process will be completed.
15) The training, testing and evaluation will be conducted in accordance with applicable standard operating procedures protective of the environment.
16) Navy or Marine Corps staff shall notify State CZM of de minimis list usage for projects which require an Environmental Assessment (EA). Notification can be sent via email: to JNakagaw@dbedt.hawaii.gov

From: Richard Hall - NOAA Federal [mailto:richard.hall@noaa.gov]
Sent: Friday, March 27, 2015 3:07 PM
To: Slaten, Steven W. (HQ-AI020)
Cc: Silbert, Shari A. (WFF-200.C)[LJT AND ASSOCIATES, INC.]; Gerry Davis - NOAA Federal; Danielle Jayewardene - NOAA Affiliate; Justin Rivera - NOAA Affiliate; Tia Brown - NOAA Federal; Pua Borges-Smith - NOAA Affiliate
Subject: EFH Consultation for the LDSD Project

Dr. Slaten,

I work for NOAA Fisheries Pacific Islands Regional Office, and I am writing you regarding NASA's responsibility to consult with our agency under the Essential Fish Habitat (EFH) provision of the Magnuson-Stevens Fishery Conservation and Management Act for the Low Density Supersonic Decelerator that NASA is testing to develop technology to land equipment on Mars. Section 1855(b)2 of the Magnuson-Stevens Act requires federal agencies to consult with NMFS, with respect to "any action authorized, funded, or undertaken, or proposed to authorized, funded, or undertaken, by such agency that may adversely affect EFH" identified by the Act.

NASA performed test of the LDSD in 2013 at the U.S. Navy's Pacific Missile Range Facility on Kauai, Hawaii. Because of the potential for adverse effects to the marine environment for those test, NASA requested an EFH consultation with NMFS. The results of our consultation for the 2013 LDSD tests was that the proposed tests would not adversely affect EFH, and our agency provided our response to NASA in an e-mail from Dr. Steve Kolinski on April 3, 2013 (attached).

During the tests in 2013, NASA determined that there was a possibility that some of the equipment being tested could land in the Papahanaumokuakea Marine National Monument (Monument) which is due west of Kauai. Because of this possibility, NASA has applied for a permit to access the Monument in case equipment from the tests returned inside its boundaries. Each application for access to the Monument goes through a series of reviews, among which is an EFH review.

I am writing you to let you know that another EFH review will not be necessary for the LDSD project, since the scope of work has not changed significantly from the review that was done in 2013. However, if the project scope should change in the future, another EFH review will be required to ensure that those changes do not adversely affect EFH.

This concludes your responsibilities under the Magnuson-Stevens Act with regards to those provisions pertaining to Essential Fish Habitat. If you have any questions, comments, or concerns you may feel free to contact me at your convenience.

--
Richard Hall
Fishery Policy Analyst
Pacific Islands Regional Office
NOAA Inouye Regional Center
1845 Wasp Blvd., Building 176
Honolulu, HI 96818
808-725-5018

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Pacific Islands Fish and Wildlife Office
300 Ala Moana Boulevard, Room 3-122
Honolulu, Hawai'i 96850

In Reply Refer To
2015-I-0209

APR 0 6 2015

Joshua A. Bundick
Environmental Planning
National Aeronautics and Space Administration
Goddard Space Flight Center
Wallops Flight Facility
Wallops Island, VA 23337

Subject: Informal Consultation for the Proposed Low Density Supersonic Decelerators Technology Demonstration Mission, Kaua'i

Dear Mr. Joshua Bundick:

The U.S. Fish and Wildlife Service (Service) received your email on March 6, 2015, requesting our concurrence with your determination that the proposed Low Density Supersonic Decelerator (LDSD) Technology Demonstration Mission may affect, but is not likely to adversely affect listed species or their designated critical habitats. At issue are the potential effects of the proposed project on the following endangered species:

Species List for Pacific Missile Range Facility and Mākaha Range, Kaua'i

Common Name	Scientific Name	Status
Honu'ea or Hawksbill sea turtle	*Eretmochelys imbricata*	Endangered
Honu or green sea turtle	*Chelonia mydas*	Threatened
'Ope'ape'a or Hawaiian hoary bat	*Lasiurus cinereus semotus*	Endangered
Nēnē or Hawaiian goose	*Branta sandvicensis*	Endangered
Ae'o or Hawaiian stilt	*Himantopus mexicanus knudseni*	Endangered
'Alae 'ula or Hawaiian gallinule	*Gallinula chloropus sandvicensis*	Endangered
'Alae ke'oke'o or Hawaiian coot	*Fulica alai*	Endangered
Koloa maoli or Hawaiian duck	*Anas wyvilliana*	Endangered
'Ua'u or Hawaiian petrel	*Pterodroma sandwichensis*	Endangered
'A'o or Newell's shearwater	*Puffinus auricularis newelli*	Threatened
Band-rumped storm-petrel	*Oceanodroma castro*	Candidate
Short-tailed albatross	*Phoebastria albatrus*	Endangered
Hawaiian picture-wing fly	*Drosophila substenoptera*	Endangered
Hawaiian picture-wing fly	*Drosophila obscura*	Endangered
Dwarf ihiau	*Wilkesia hobdyi*	Endangered

Spermolepis hawaiiensis	*Spermolepis hawaiiensis*	Endangered
Mā'oli'oli	*Schiedea apokremnos*	Endangered
Nā pali beach hedyotis	*Hedyotis st.-johnii*	Endangered
Designated Critical Habitat		
Lau 'ehu	*Panicum niihauense*	Currently unoccupied

Species List for Ni'ihau

Common Name	**Scientific Name**	**Status**
Honu 'ea or Hawksbill sea turtle	*Eretmochelys imbricata*	Endangered
Honu or green sea turtle	*Chelonia mydas*	Threatened
Ae'o or Hawaiian stilt	*Himantopus mexicanus knudseni*	Endangered
'Alae 'ula or Hawaiian gallinule	*Gallinula chloropus sandvicensis*	Endangered
'Alae ke'oke'o or Hawaiian coot	*Fulica alai*	Endangered
Koloa maoli or Hawaiian duck	*Anas wyvilliana*	Endangered
'Ua'u or Hawaiian petrel	*Pterodroma sandwichensis*	Endangered
'A'o or Newell's shearwater	*Puffinus auricularis newelli*	Threatened
Band-rumped storm-petrel	*Oceanodroma castro*	Candidate
'Ōlulu	*Brighamia insignis*	Endangered
'Āwikiwiki	*Canavalia pubescens*	Endangered
Pu'uka'a	*Cyperus trachysanthos*	Endangered
Ihi'ihi	*Marsilea villosa*	Endangered
Lau'ehu	*Panicum niihauense*	Endangered
Wāhane	*Pritchardia aylmer-robinsonii*	Endangered
'Ōhai	*Sesbania tomentosa*	Endangered
Vigna o-wahuensis	*Vigna o-wahuensis*	Endangered
Designated Critical Habitat		
Niihau 1–*Brighamia insignis*–a	*Brighamia insignis*	Occupied

Species List for Nihoa Island, Papahānaumokuākea.

Common Name	**Scientific Name**	**Status**
Honu 'ea or Hawksbill sea turtle	*Eretmochelys imbricata*	Endangered
Honu or green sea turtle	*Chelonia mydas*	Threatened
Ulūlu or Nihoa millerbird	*Acrocephalus familiaris kingi*	Endangered
'Ekupu'u or Nihoa finch	*Telespyza ultima*	Endangered
Amaranthus brownii	*Amaranthus brownii*	Endangered
Loulu	*Pritchardia remota*	Endangered
Schiedea verticillata	*Schiedea verticillata*	Endangered
'Ōhai	*Sesbania tomentosa*	Endangered
Pōpolo	*Solanum nelsonii*	Candidate
'Ihi	*Portulaca villosa*	Candidate
Designated Critical Habitat		
Nihoa 1–*Amaranthus brownii*		Occupied
Nihoa 2–*Pritchardia remota*		Occupied
Nihoa 3–*Schiedea verticillata*		Occupied
Nihoa 4–*Sesbania tomentosa*		Occupied

The findings and recommendations in this consultation are based on (1) your email dated March 6, 2015; (2) the Biological Evaluation dated March 2015; (3) the draft Supplemental Environmental Assessment dated February 2015; and (4) other information available to us. A complete administrative record is on file in our office. This response is in accordance with the section 7 of the Endangered Species Act of 1973 (Act), as amended (16 U.S.C. 1531 *et seq.*).

Project Description

The National Aeronautics and Space Administration's (NASA) Low Density Supersonic Decelerators (LDSD) Technology Demonstration Missions (TDMs) are used to bridge the gap between laboratory development and demonstration in space. NASA proposes to fund and conduct up to two Supersonic Flight Dynamics Tests (SFDT) each summer (June through August) from 2015 through 2019, from the U.S. Navy's Pacific Missile Range Facility (PMRF) on the island of Kaua'i and over (during flight) and within (in the case of an off-nominal landing) the islands of Ni'ihau and Nihoa. The primary focus of the LDSD Project's campaign in Hawai'i is to validate a 30 meter [m; 100 feet (ft)] diameter Supersonic Ring Sail (SSRS) parachute behind a 6 m (20 ft) attached torus Supersonic Inflatable Aerodynamic Decelerator (SIAD). In accordance with the authorities granted to them under Presidential Proclamation 8031 and 50 CFR Part 404, you are requesting, along with the State of Hawai'i, for a permit to enter the Papahānaumokuākea Marine National Monument (PMNM). We understand NASA has assumed the role as Lead Agency (50 CFR § 402.07) to fulfill the ESA obligations of all three federal action agencies.

Each SFDT flight would consist of releasing from PMRF a 34 million cubic foot (1 million cubic meter [m^3]) helium-filled scientific balloon that carries a Test Vehicle (TV) to a minimum desired float altitude of 120,000 ft (37,600 m). At float altitude, the balloon fully inflates to approximately 400 ft (122 m) tall and 450 ft (137 m) in diameter. The TV is then released, initiating the mission sequence. Once the TV is dropped, a signal is sent that separates the flight train from the balloon and, in the process rips the balloon to allow for its descent. After the TV drops, small solid-fueled rocket motors ignite and stabilize the TV prior to the main motor ignition. The main motor is a Star 48B, a long nozzle solid-fueled rocket engine. The Star 48B ignites, propelling the TV upwards to an altitude of approximately 180,000 ft (55,000 m) at a speed of approximately Mach 4. The TV then deploys a torus (doughnut-shaped) tube called the SIAD to slow its velocity to approximately Mach 2. The TV then deploys the 100-ft (30-m) diameter SSRS parachute, which carrier the TV safely to a controlled oceanic impact in a pre-coordinated operational area off the west coast of Kaua'i.

Pre-launch activities to measure wind conditions (speed and direction), telemetry, command systems, radar tracking, and other systems would be conducted. These activities will utilize latex meterological (MET) balloons and Super Loki sounding rocket-deployed Rocket Balloon Instruments (ROBINs). It is assumed that a portion of the MET balloons used in support of SFDT launch operations would land in small shreds or deflated and fully intact. Battery operated (9 volt) radiosondes are not recovered from the ocean, however, are packaged in floating polystyrene containers with waterproof pre-paid labels for return to NASA's scientific balloon contactor. Super Loki first stage motors, Dart second stage motors, and ROBIN spheres would land in the Pacific Ocean west of Kaua'i. The balloon flight train connects the TV to the

balloon, and consists of a burst parachute (a safety instrument), sensors, connections, and Kevlar® cabling. This flight train system would be non-recoverable and instead would sink rapidly in to the ocean floor.

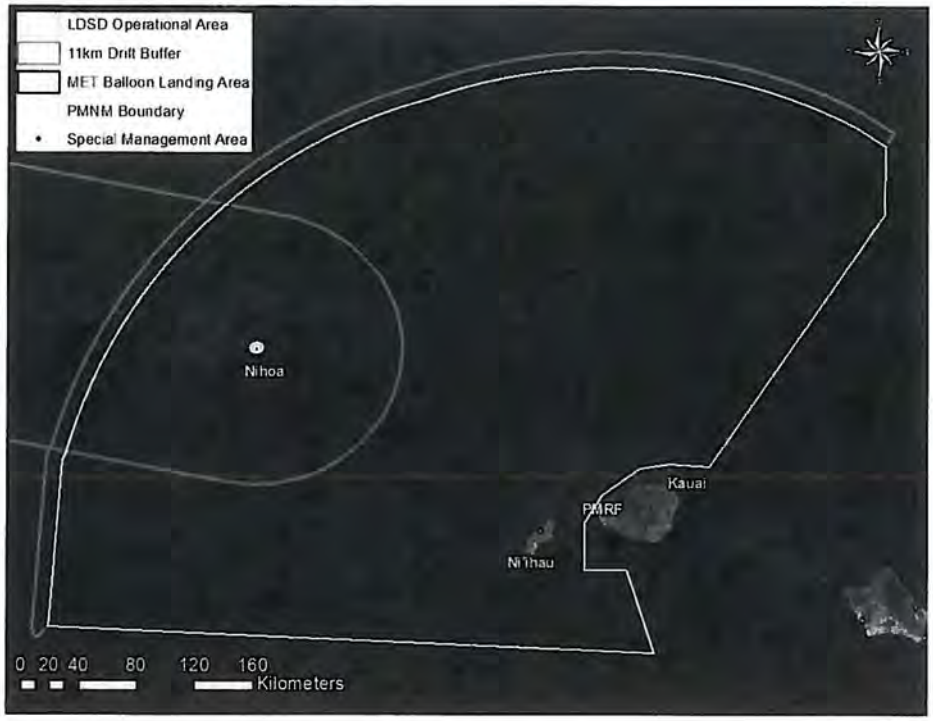
NASA proposes to recover the floating expended flight hardware including the scientific balloon, the TV, the flight imagery recorder, and the SIAD. Accurate tracking information is captured and analyzed in real-time starting at launch of the scientific balloon, during execution of the SFDT, and through splash down. To recover floating expended flight hardware, NASA would deploy three recovery vessels to anchor at positions selected to minimize the recovery operations timeline. The maximum cruise speed of the three vessels would be 22 kilometers per hour [km/hr; 12 knots (kt)] with an average cruising speed of 10 kt. Up to two U.S. Navy aircrafts would be flown to perform safety surveillance of the operational area and to assist with locating expended flight hardware for recovery. During the 2014 campaign, it took the respective vessels approximately 5 hours to reach and recover the supersonic parachute, 6.5 hours to reach and recover the balloon carcass, and 4 hours to reach and recover the TV. Swimmers with snorkling gear, may enter the water to assist in recovery of the floating hardware. The proposed LDSD project is limited by the 315 km (170 nautical mile) arc centered at Mākaha Ridge, Kaua'i, therefore swimmers wound not enter the water within the Special Preservation Area of the Midway Atoll Special Management Area.

Action Area

The proposed SFDTs would include the airspace, land, water column, and seabed within which the balloon and TV could fly and expended flight hardware could land and ultimately come to rest. The proposed action area also accounts for where the flight and deposition of meteorological support equipment (i.e. MET balloons, Super Loki rockets, ROBIN spheres) could occur. It should be noted that under nominal flight conditions, the action area would not include the terrestrial or marine areas comprising Ni'ihau, Nihoa Island, and the Special Management Area within 5.6 km (3.0 nm) surrounding Nihoa Island.

As the action area would include a portion of the PMNM, on January 27, 2015, NASA submitted to the PMNM permit coordinator an application seeking authorization to allow for access to PMNM waters. NASA is seeking this authorization via the established permitting process defined in Presidential Proclamation 8031 and codifying regulations in 50 CFR Part 404. The permit application seeks the ability to potentially drop and recover floating expended flight hardware within the boundary of PMNM, but outside of the Special Management Area surrounding Nihoa Island. This permit would also allow NASA to enter the PMNM for recovery purposes if the flight hardware is dropped outside the PMNM but carried into the PMNM by ocean currents. You anticipate the expended hardware would not be deposited on Nihoa Island or within the SMA and propose to exclude this within your action area by: (1) initiating the testing in such a manner that expended flight hardware would be recovered before drifting into the excluded area or (2) ensuring the flight system to fly over the excluded area at an altitude of approximately 120,000 feet and initiating the test well outside the 2-nautical mile SMA.

Figure 1: LDSD SFDT Action Area



Effects of the action

Sea turtles (Honu 'ea and Honu)

The potential for exposing nesting or basking sea turtles to the TV-generated sonic boom would be unlikely as both flight and re-entry (during which there would be the most focused energy) would occur over the open ocean. Between Kaua'i, Ni'ihau, and Nihoa, the probability of sonic boom sound energy propagating to nesting or basking beaches would be greatest at Nihoa. Should a hauled out sea turtle be exposed to a sonic boom, it is unlikely to evoke much, if any, of a physiological or behavioral response at the levels and frequencies that would be propagated to the ground. Behaviorally, the majority of energy in a sonic boom is less than 100 Hz. Early research on the hearing of green sea turtles by Ridgway et al. (1969) identified their maximum hearing sensitivity to be at higher frequencies, namely between 300 and 400 Hz. Consequently, while the potential for a sea turtle detecting the audible stimulus, should it be exposed to it, cannot be completely ruled out, it may be concluded that the resultant behavioral effect, if one even were to occur, would be minor to non-existent.

Sea turtles may be within the vicinity of the proposed project if there were a catastrophic failure and potential for flight hardware to land within terrestrial areas. However, the vast majority of nesting occurs outside the action area. Moreover, nesting and basking beaches would only be overflown (imparting no stressors on the species) under nominal circumstances. When considered within the context of the infrequent nature of the action, and the low density of individuals within the action area, the probability of a direct or proximate strike from catastrophic failure would be very low.

While theoretically possible that a sea turtles on Kaua'i or Ni'ihau could become entangled in cordage on a radiosonde MET balloon or expended flight hardware when traveling between the beach and the marine environment, it would be highly unlikely due to the low numbers of sea turtles observed on either Kaua'i or Ni'ihau (radiosondes would not reach Nihoa), the infrequent nature of the action, and the fact that SFDTs (and resultant terminations) would only occur in the open ocean. It would only be in the case of a catastrophic failure that SFDT hardware would land within terrestrial areas, and, in such a case, the hardware would be removed immediately. Likewise, if a radiosonde balloon were identified on PMRF or Ni'ihau beaches, it would be recovered immediately.

'Ōpe'ape'a

The potential for exposing 'ōpe'ape'a to the TV-generated sonic boom would be unlikely as both flight and re-entry (during which there would be the most focused energy) would occur over the open ocean. Coupled with the low intensity of the sonic boom, even if directly under the re-entering TV, the potential for 'ōpe'ape'a, to modify their behavior in response to the brief acoustic stimulus would be highly unlikely.

No records exist of 'ōpe'ape'a becoming entangled in small items such as the MET balloons and the likelihood of encountering a small latex balloon and becoming entangled would be highly improbable.

Project related fixed-wing surveillance and recovery aircraft flying at altitudes greater than 1,500 ft (457 m) AGL would generally be expected to cause minimal, if any, response from 'ōpe'ape'a on the ground. Additionally, 'ōpe'ape'a forage primarily just before or after sunset. As the LDSD balloon launch and initiation of aircraft surveillance would occur near dawn, the probability of an aircraft encountering a flying 'ōpe'ape'a is extremely low.

Hawaiian picture-wing flies

The potential for exposing Hawaiian picture-wing flies to the TV-generated sonic boom would be unlikely as both flight and re-entry (during which there would be the most focused energy) would occur over the open ocean. Coupled with the low intensity of the sonic boom, even if directly under the re-entering TV, the potential for Hawaiian picture-wing flies to modify their behavior in response to the brief acoustic stimulus would be highly unlikely.

Hawaiian birds: (nēnē, ae'o, 'alae 'ula, 'alae ke'oke'o, koloa maoli, 'ua'u, 'a'o, band-rumped storm-petrel, short-tailed albatross, ulūlu, and 'ekupu'u)

The flight of the TV would generate sonic booms that could propagate to the ground on Nihoa Island or within the oceanic portion of the action area. However, due to their weak nature, these sonic booms would not be expected to damage eggs (Ting et al. 2002), but they could potentially be heard by avian species. Again, due to their weak nature and infrequent occurrence, the resultant effect would at most be a change to an alert posture, though it would be short in duration and would not have a measurable effect on the birds' fitness. Similarly, birds nesting within the action area on Kaua'i or Ni'ihau/Lehua Islet would not likely be exposed to sonic booms as TV supersonic flight and re-entry would occur over the open ocean.

Should the descending flight hardware land within an area inhabited by Hawaiian birds, it could result in injury or mortality. Should descending flight hardware land in close proximity to individuals, it could startle them, potentially disrupting breeding, foraging, or resting behaviors. Similar, although more intense, disturbance could also result from recovery activities that required multiple persons to enter Nihoa Island. The potential for a direct or proximate strike would be very low due to the infrequent nature of the action; the low probability of the SFDT entering the PMNM; and the categorical avoidance of intentionally terminating a flight over Nihoa Island and its surrounding SMA, should the balloon and TV even float that far to the west of Kaua'i.

The probability of the balloon or TV landing in a terrestrial area on Nihoa would be very low and only in the event of a catastrophic flight termination. Furthermore, in the unlikely event that a landing on Nihoa was to occur, the flight hardware would be recovered rapidly, negating the potential for individuals to be exposed to this stressor. Although meteorological equipment (e.g., latex balloons) could land within terrestrial areas of the action area (i.e., Kaua'i), it would be highly unlikely for listed passerine species to be within those areas of PMRF, and there would be no probability of interaction with those items. Seabirds have also been reported as becoming entangled in marine debris. It is most likely that seabirds become entangled accidentally when seeking natural prey items in the entangling debris. However, in consideration of the infrequency of the proposed action, the low density of individuals within the action area, the eventual degradation and fouling of the balloons (causing the items to sink), and the fact that the majority of buoyant items would be recovered, the probability of entangling a listed or candidate species would be very low.

The infrequency of project related fixed-wing surveillance and recovery aircraft flying in addition to the low density of individuals within the action area, and the fact that the majority of aircraft operations would be over the open ocean, the probability of an aircraft encountering a bird in flight is extremely low.

With the exception of seabirds, no other ESA-listed or candidate species within USFWS jurisdiction would be exposed to potential stressors imparted by recovery vessels. In the case of seabirds, it is expected that project recovery vessels would at most evoke a brief startle reaction. However, due to the infrequent nature of the action and low density of individuals within the oceanic portion of the action area, effects would be negligible.

Hawaiian plants: (dwarf iliau, *Spermolepis hawaiiensis*, māʻoliʻoli, nā pali beach hedyotis, ʻōlulu, ʻāwikiwiki, puʻukaʻa, ihiʻihi, lauʻehu, wāhane, ʻōhai, *Vigna o-wahuensis*, *Amaranthus brownii*, loulu, *Schiedea verticillata*, ʻōhai, pōpolo, and ʻihi)
The primary stressor the proposed action could impact upon the listed plants within the action area would be the inadvertent crushing or burial of plants by descending SFDT flight hardware. Similarly, the TV's hot rocket motor, if coming into contact with dried plant material, could either singe or burn vegetation. Recovery operations could also result in trampling or burial of individual plants. To reduce the potential for environmental impact to Nihoa Island, one of two scenarios would occur: the LDSD Program would initiate the SFDT in such a manner that expended flight hardware would be recovered before entering Nihoa; or the flight system would overfly the island of Nihoa, and the TV would be dropped more than 5.5 km (3 nm) from Nihoa Island. It would be only in the condition of a catastrophic failure that flight hardware would land within Nihoa or the 5.5 km (3 nm) buffer around it. Additionally, under the assumption that all possible trajectories were allowed to fly, it is estimated that the balloon has approximately a 0.4 percent chance of reaching float altitude within PMNM and a 20 percent chance of entering PMNM after reaching float altitude. In consideration of these facts, the probability of exposing an individual plant to either project-inducted stressor is so low as to be discountable. Likewise, listed plant species on Kauaʻi or Niʻihau would be unaffected by the proposed action unless there were a catastrophic failure of the balloon flight system during its initial ascent phase.

Designated critical habitats: (lauʻehu, Niʻihau 1–*Brighamia insignis*–a, Nihoa 1–*Amaranthus brownii*, Nihoa 2–*Pritchardia remota*, Nihoa 3–*Schiedea verticillata*, and Nihoa 4–*Sesbania tomentosa*)
Potential stressors on designated critical habitat for either plant species within the action area would be limited to physical damage by the descending flight hardware in the event of a failure. The resultant effect on substrate would be an indentation, or "divot." Recovery operations could also result in small-scale land disturbance. However, as discussed above, the potential for landing on Nihoa, Niʻihau, or Kauaʻi and, therefore, potentially affecting designated critical habitat, would be very low and would only occur in the event of a catastrophic failure.

Conservation Measures
The following measures identified in your letter will be implemented at the project sites to avoid and minimize effects to ESA species and their designated critical habitats. These conservation measures are considered part of the project description. Any changes to, modifications of, or failure to implement these conservation measures may result in the need to reinitiate this consultation.

There would be only a remote likelihood of the TV or balloon striking or landing near a listed terrestrial species as flight hardware would nominally land in the ocean. Only on the case of a catastrophic failure would the hardware land within terrestrial areas. Although MET balloons could land within terrestrial areas on Kauaʻi or Niʻihau, due to their small size they would not possess enough kinetic energy to inflict injurious effects on species in the unlikely event they were to land on them.

- To ensure that flight hardware does not land within the terrestrial or marine areas comprising Ni'ihau, Nihoa Island, and the SMA within 5.6 km (3.0 nm) surrounding Nihoa Island, one of two scenarios would occur: the LDSD Project would initiate the SFDT in such a manner that expended flight hardware would be recovered or sink before drifting into either area or the flight system would overfly these areas and the TV would be dropped outside either area. Therefore, with the exception of an in-flight system failure, expended flight hardware would not be deposited on Ni'ihau, Nihoa Island, or within the Special Management Area surrounding Nihoa Island.

- All major flight hardware components will be tracked during flight until splashdown, at which point surface vessels (i.e., propeller-driven ships) will be deployed to recover the balloon and TV.

- NASA will continually monitor the effects of its ongoing actions on listed species and will submit annual reports on the outcomes of the project to the Service by December 31 of each year between the years 2015 and 2019. Annual reports will include the following: (a) the dates of all SFDT launches; (b) locations (GPS coordinates) of all SFDT flight terminations and resultant recoveries; (c) any available information on the fate of expended flight hardware after flight termination, including sink rate, evidence that components failed to sink, or evidence that components later reappeared on the surface; and (d) information on attempts to recover hardware after flight termination.

Summary

By implementing the above conservation measures, the proposed project will avoid potential adverse effects to all ESA listed and candidate species and designated critical habitats listed above. Therefore, we concur that the proposed project may affect, but is not likely to adversely affect all listed and candidate species and designated critical habitats within the proposed action area. Unless the project description changes, or new information reveals that the proposed project may affect listed species in a manner or to an extent not considered, or a new species or critical habitat is designated that may be affected by the proposed action, no further action pursuant to section 7 of the ESA is necessary.

If it is determined that the proposed project may affect federally listed species, we recommend you contact our office early in the planning process so that we may assist you with the ESA compliance. If the proposed project is funded, authorized, or permitted by a Federal agency, then that agency should consult with us pursuant to section 7(a)(2) of the ESA. If no Federal agency is involved with the proposed project, the applicant should apply for an incidental take permit under section 10(a)(1)(a) of the ESA. A section 10 permit application must include a habitat conservation plan that identifies the effects of the action on listed species and their habitats, and defines measures to minimize and mitigate those adverse effects.

If you have any questions or concerns regarding this consultation, please contact Jiny Kim, Fish and Wildlife Biologist (phone: 808-792-9400, email: jiny_kim@fws.gov).

Sincerely,

Aaron Nadig
Island Team Manager
O'ahu, Kaua'i, Northwestern Hawaiian Islands, and American Samoa

References:

Ridgway, S. H., Wever, E. G., McCormick, J. G., Palin, J., & Anderson, J. H. (1969). Hearing in the giant sea turtle, *Chelonia mydas*. *Proceedings of the National Academy of Sciences, 64*(3), 884-890.

Ting, C., Garrelick, J., & Bowles, A. (2002). An analysis of the response of Sooty Tern eggs to sonic boom overpressures. *The Journal of the Acoustical Society of America, 111*(1), 562-568.

Appendix C
PMNM Conservation and Management Permit Application

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Papahānaumokuākea Marine National Monument

CONSERVATION AND MANAGEMENT Permit Application

NOTE: ***This Permit Application (and associated Instructions) are to propose activities to be conducted in the Papahānaumokuākea Marine National Monument. The Co-Trustees are required to determine that issuing the requested permit is compatible with the findings of Presidential Proclamation 8031. Within this Application, provide all information that you believe will assist the Co-Trustees in determining how your proposed activities are compatible with the conservation and management of the natural, historic, and cultural resources of the Papahānaumokuākea Marine National Monument (Monument).***

ADDITIONAL IMPORTANT INFORMATION:

- Any or all of the information within this application may be posted to the Monument website informing the public on projects proposed to occur in the Monument.

- In addition to the permit application, the Applicant must either download the Monument Compliance Information Sheet from the Monument website OR request a hard copy from the Monument Permit Coordinator (contact information below). The Monument Compliance Information Sheet must be submitted to the Monument Permit Coordinator after initial application consultation.

- Issuance of a Monument permit is dependent upon the completion and review of the application and Compliance Information Sheet.

INCOMPLETE APPLICATIONS WILL NOT BE CONSIDERED

Send Permit Applications to:
NOAA/Inouye Regional Center
NOS/ONMS/PMNM/Attn: Permit Coordinator
1845 Wasp Blvd, Building 176
Honolulu, HI 96818
nwhipermit@noaa.gov
PHONE: (808) 725-5800 FAX: (808) 455-3093

SUBMITTAL VIA ELECTRONIC MAIL IS PREFERRED BUT NOT REQUIRED. FOR ADDITIONAL SUBMITTAL INSTRUCTIONS, SEE THE LAST PAGE.

Papahānaumokuākea Marine National Monument
Permit Application Cover Sheet

This Permit Application Cover Sheet is intended to provide summary information and status to the public on permit applications for activities proposed to be conducted in the Papahānaumokuākea Marine National Monument. While a permit application has been received, it has not been fully reviewed nor approved by the Monument Management Board to date. The Monument permit process also ensures that all environmental reviews are conducted prior to the issuance of a Monument permit.

Summary Information

Applicant Name: David Wilcox
Affiliation: National Aeronautics and Space Administration (NASA) Goddard Space Flight Center (GSFC)/Wallops Flight Facility (WFF) Range and Mission Management Office (RMMO), Low Density Supersonic Decelerators (LDSD) Project, Project Manager (GS15)

Permit Category: Conservation and Management
Proposed Activity Dates: every June 1 through August 31, 2015 - 2019

Proposed Method of Entry (Vessel/Plane): up to 3 commercial vessels & 2 Navy aircraft

Proposed Locations: within a 320 kilometer (approximately 200 mile) arc centered on Makaha Ridge, Kauai

Estimated number of individuals (including Applicant) to be covered under this permit: 35
Estimated number of days in the Monument: 8

Description of proposed activities: (complete these sentences):

a.) The proposed activity would…
allow for PMNM access to recover decelerator technologies flight hardware in the event the decelerator enters and lands in PMNM waters. This activity supports full scale testing of decelerator technologies at representative conditions to those found on the planet Mars. The decelerator technologies developed as part of the Low Density Supersonic Decelerator (LDSD) project could enable the following on future missions to Mars:

- Placement of more mass on the Martian surface in a single landing
- Make more of the Martian surface accessible for exploration
- Increase landing accuracy on the Martian surface

The focus of the LDSD project's campaign is to validate a 100 feet (ft.) diameter Supersonic Ring Sail (SSRS) parachute behind a 19 ft. 8 inches (in.) attached torus Supersonic Inflatable Aerodynamic Decelerator (SIAD).

b.) To accomplish this activity we would ….

The LDSD Project seeks, as a contingency condition, to potentially drop and recover floating expended flight hardware from up to two scheduled SFDTs in 2015 (with the possibility for up to 2 additional flights per summer [June through August] through 2019) in the Open Ocean area within the boundary of PMNM, but outside of the 3 NM Special Management Area surrounding Nihoa Island. This operations area would not include the 170 acres of Nihoa Island and the Special Management Area within the 3 NM surrounding Nihoa Island. In order to circumvent this area, one of two scenarios would occur: (1) the LDSD Program would initiate the Supersonic Flight Dynamic Test (SFDT) in such a manner that expended flight hardware would be recovered or sink before drifting into the Special Management Area or (2) the flight system would overfly Nihoa and the Special Management Area and the Test Vehicle would be dropped outside the Special Management Area surrounding Nihoa Island. Therefore, expended flight hardware would not be deposited on Nihoa Island or within the Special Management Area surrounding the Island. Enclosure 1A highlights the area within PMNM in which the LDSD Project is requesting permission to potentially drop and recover floating expended flight hardware within the boundary of PMNM during the months of June, July, and August 2015 through 2019. This overlay of the hardware splashdown area was derived from negotiations between LDSD Project, U.S. Navy (USN) Range Management, and the Federal Aviation Administration (FAA) within the 170 NM arc defining the TV to PMRF telecommunications limit plus and additional 6 NM buffer to account for a conservative estimate of the distance the floating hardware could drift with surface currents for the 12 hours it would take for recovery vessels to reach them.

In accordance in with the National Environmental Policy Act (NEPA), in May 2013 NASA prepared an Environmental Assessment (EA) for the proposed LDSD Technology Demonstration Mission (TDM) (http://www.govsupport.us/nasaldsdea/default.aspx). Based on the EA, NASA issued a Finding of No Significant Impact (FONSI) on 29 May 2013. Section 2.6.2 of the May 2013 LDSD EA, details the site selection process for the LDSD Project. NASA began evaluating sites for the LDSD Program in 2011; originally analyzing twelve global candidate test sites. The USN Pacific Missile Range Facility (PMRF) in Kauai, Hawaii was considered the most viable launch range and, therefore, was selected as the host test range for the execution of the SFDT portion of the LDSD Project. Additionally, please refer to the enclosed PMNM Advisory Council White Paper for more details (Enclosure 1).

Each nominal SFDT flight would consist of releasing from PMRF a 34 million cubic foot (mcf) scientific balloon that carries the TV to the minimum desired float altitude of 120,000 ft (Figure 1 of Enclosure 1). At float altitude, the balloon fully inflates to approximately 400 ft tall and 450 ft in diameter. The TV is then released, initiating the

mission sequence. Once the TV is dropped, a signal is sent that separates the flight train from the balloon and in the process, ripping the balloon to allow descent. After the TV drops, small solid-fueled rocket motors ignite and stabilize the TV prior to the main motor ignition. The main motor is an Orbital Alliant Techsystems, Incorporated manufactured Star 48B, a long nozzle solid-fueled rocket engine. The Star 48B ignites propelling the TV upwards to an altitude of approximately 180,000 ft at a speed of approximately Mach 4. The TV then deploys a torus (doughnut-shaped) tube called the Supersonic Inflatable Aerodynamic Decelerator (SIAD) to slow its velocity to approximately Mach 2. The TV then deploys the 100-ft diameter supersonic parachute, which carries the TV safely to a controlled oceanic impact in a pre-coordinated operational area off the west coast of the Island of Kauai, Hawaii.

Almost all expended flight hardware is then recovered from the ocean, with the exception of the balloon flight train (Enclosure 2, "Balloon Flight Train Assembly, Summary"). This flight train connects the TV to the balloon. The flight train, that separates from the balloon and the TV, weighs approximately 830 pounds; is approximately 990 feet long; and consists of a burst parachute (a safety instrument), sensors, connections, and Kevlar® cabling. This system would sink rapidly in the ocean and would be almost impossible to locate.

The balloon system carries approximately 250 pounds of 0.3 to 0.5 mm steel shot ballast (roughly the diameter of beach sand) that would be slowly and completely released during the ascent phase. Ballast released during ascent would travel in the upper atmospheric winds and be dispersed over hundreds of miles. It is, therefore, highly unlikely that ballast material would enter PMNM. If, in the unlikely event that all ballast is not released during ascent, the leak proof container would be recovered with the balloon system.

Whether the SFDT is nominal or off nominal, the intention is to drop the TV and scientific balloon within an approximately 170 NM arc centered on the PMRF instrumentation site located on Makaha Ridge, Kauai. This arc distance is defined by the TV to PMRF telecommunications limitation. A 6 NM buffer would be added to telecommunications limit (resulting in a 176 NM arc) to account for a conservative estimate of the distance the floating hardware could drift with surface currents for the 12 hours it would take for recovery vessels to reach them.

c.) This activity would help the Monument by …

In the event the LDSD enters and lands in the Monument, recovery activities would ensure protection of Monument resources. In addition, NASA is willing to discuss potential avenues to partner with the Monument in support of outreach and/or education activities that would mutually benefit both the Monument's and NASA's mission goals.

Other information or background:

The focus of the successful 2014 LDSD Project campaign was to validate the SFDT test architecture itself. The SFDT executed on 28 June 2014 from the USN's PMRF was accomplished within existing constraints outlined in the LDSD project's EA and USN's Range Safety Operational Plan (RSOP). However, there were several lessons learned during this first campaign.

Although the initial two week launch window opened on 2 June 2014, the LDSD project experienced daily upper wind conditions that preempted all launch attempts during window. The LDSD project and USN Range Management scheduled a second launch window at the end of June 2014 requiring redeployment of project personnel and support assets. The first day of the second launch window opened on 28 June 2014 and provided a valid opportunity for launch. The predicted scientific balloon trajectory was along a path north of Niihau Island (Figure 3 of Enclosure 1). The trajectories north of Niihau provide much less time at float and thereby less time for reaction to unknowns. The LDSD project accepted the risks associated with this northern trajectory and moved forward with a launch attempt. The LDSD project and USN Range Safety identified a nominal TV drop location from the scientific balloon for the execution of the SFDT. After numerous decision meetings, all Go / No Go criteria were green and the scientific balloon was released from the launch site at PMRF.

The combined flight system (TV and scientific balloon) is continually tracked by PMRF ground instrumentation providing positional data to the USN Range Safety Organization. The present position of the flight system along with individual impact dispersions (which is a variable circle with a maximum radius of 14 NM) for the scientific balloon, detached flight train on recovery parachute, and TV are overlaid onto a display system. The impact dispersions are compared to restrictions imposed on the LDSD project due to Niihau and Kauai Islands (public safety criteria), FAA boundaries (public safety criteria), and PMNM (environmental safety criteria).

The 2014 SFDT was nominal except for slightly higher upper air winds speeds than predicted and the scientific balloon's ascent being slightly slower than predicted. The combination of the northern trajectory, higher than predicted winds, and slower than predicted ascent shortened the available decision window for initiation of the SFDT. Had there been any significant delay in the mission countdown (e.g. non-participating vessels in the range, hardware issue, etc.), then the USN Range Safety Organization would have issued a mission termination order, resulting in an immediate drop of the TV into the ocean in order to prevent the trajectory from crossing into PMNM.

The LDSD project demonstrated the ability to accurately predict the scientific balloon's climb out trajectory and to recover all floating expended flight hardware (see Figures 4 and 5 of Enclosure 1). The hard lessons learned from the 2014 campaign was that there is the possibility of going weeks without acceptable conditions for launch. The northern trajectories represents significant risk of early termination unless mitigated. One potential path of mitigating the risk is seeking a PMNM entry permit for the SFTD campaigns.

Section A - Applicant Information

1. Applicant

Name (last, first, middle initial): Wilcox, David A.

Title: NASA GSFC/WFF LDSD Project Manager

1a. Intended field Principal Investigator (See instructions for more information):

Mr. Eric Littleton
LDSD Project Recovery Director
NASA Wallops Flight Facility
34200 Fulton Street
Wallops Island, VA 23337
office (757) 824-2049
cell (410) 430-3310
eric.a.littleton@nasa.gov

2. Mailing address (street/P.O. box, city, state, country, zip):

34200 Street, Wallops Island, Virginia 23337

Phone: (757) 824-1314

Fax:

Email: David.A.Wilcox@nasa.gov

For students, major professor's name, telephone and email address:

3. Affiliation (institution/agency/organization directly related to the proposed project):

NASA GSFC/WFF, Range and Mission Mangement Office

4. Additional persons to be covered by permit. List all personnel roles and names (if known at time of application) here (e.g. John Doe, Research Diver; Jane Doe, Field Technician):

Each of the three vessels listed below either already has a PMNM-approved VMS system installed and operational or has a system on order that will be installed and operational prior to entering the Monument:

Vessel Kahana
4 – 6 Ship Crew from Hawaii Resources Group
3 – 4 Explosive Ordnance Disposal (EOD) Technicians from Naval Station Pearl Harbor
2 – 3 Flight Hardware Subject Matter Experts from NASA Jet Propulsion Laboratory
Total not to exceed 11 passengers
VMS System:
Sailor Inmarsat 150 communication unit
Sailor 3026D VMS Gold tracking unit
(already installed and operational)

Vessel Honua
4 – 6 Ship Crew from Hawaii Resources Group
VMS System:
Sailor Inmarsat 150 communication unit
Sailor VMS 3027D Gold tracking unit
(on order)

Vessel Manao II
3 Ship Crew from Hawaii Resources Group
VMS System:
Sailor Inmarsat 150 communication unit
Sailor VMS 3027D Gold tracking unit
(on order)

Section B: Project Information

5a. Project location(s):

		Ocean Based	
☒ Nihoa Island	☐ Land-based	☐ Shallow water	☒ Deep water
☐ Necker Island (Mokumanamana)	☐ Land-based	☐ Shallow water	☐ Deep water
☐ French Frigate Shoals	☐ Land-based	☐ Shallow water	☐ Deep water
☐ Gardner Pinnacles	☐ Land-based	☐ Shallow water	☐ Deep water
☐ Maro Reef			
☐ Laysan Island	☐ Land-based	☐ Shallow water	☐ Deep water
☐ Lisianski Island, Neva Shoal	☐ Land-based	☐ Shallow water	☐ Deep water
☐ Pearl and Hermes Atoll	☐ Land-based	☐ Shallow water	☐ Deep water
☐ Midway Atoll	☐ Land-based	☐ Shallow water	☐ Deep water
☐ Kure Atoll	☐ Land-based	☐ Shallow water	☐ Deep water
☐ Other			

☐ Remaining ashore on any island or atoll (with the exception of Midway & Kure Atolls and Field Camp staff on other islands/atolls) between sunset and sunrise.

NOTE: There is a fee schedule for people visiting Midway Atoll National Wildlife Refuge via vessel and aircraft.

Location Description:
Project could occur within a 320 km arc centered at Makaha Ridge, Kauai, excluding all State waters.

5b. Check all applicable regulated activities proposed to be conducted in the Monument:

☐ Removing, moving, taking, harvesting, possessing, injuring, disturbing, or damaging any living or nonliving Monument resource
☐ Drilling into, dredging, or otherwise altering the submerged lands other than by anchoring a vessel; or constructing, placing, or abandoning any structure, material, or other matter on the submerged lands
☐ Anchoring a vessel
☐ Deserting a vessel aground, at anchor, or adrift
☒ Discharging or depositing any material or matter into the Monument
☐ Touching coral, living or dead
☐ Possessing fishing gear except when stowed and not available for immediate use during passage without interruption through the Monument
☐ Attracting any living Monument resource
☐ Sustenance fishing (Federal waters only, outside of Special Preservation Areas, Ecological Reserves and Special Management Areas)
☐ Subsistence fishing (State waters only)
☒ Swimming, snorkeling, or closed or open circuit SCUBA diving within any Special Preservation Area or Midway Atoll Special Management Area

6. Purpose/Need/Scope ***State purpose of proposed activities:***
In the event the TV and/or scientific balloon lands or drifts into the PMNM boundary as a result of the SFDT, NASA is requesting access to PMNM to recover floating expended flight hardware (see Enclosure 2 for description of flight hardware not to be recovered and Enclosure 3 for descriptions of flight hardware to be recovered). The LDSD Project seeks to potentially drop and recover floating expended flight hardware from up to two scheduled SFDTs in 2015 (with the potential for up to 2 additional flights per sum [June to August] through 2019) in the Open Ocean area within the boundary of PMNM, but outside of the 3 NM Special Management Area surrounding Nihoa Island. Enclosure 1A highlights the area within PMNM in which the LDSD project is requesting permission to operate. This overlay of the hardware splashdown area was derived from negotiations between LDSD Project, U.S. Navy (USN) Range Management, and the Federal Aviation Administration (FAA) within the 170 NM arc defining the TV to PMRF telecommunications limit plus and additional 6 NM buffer to account for a conservative estimate of the distance the floating hardware could drift with surface currents for the 12 hours it would take for recovery vessels to reach them.

The purpose of the LDSD Project is to support full-scale testing of decelerator technologies at representative conditions to those found on the planet Mars. The decelerator technologies developed as part of the LDSD project could enable the following on future missions to Mars:

- Placement of more mass on the Martian surface in a single landing
- Make more of the Martian surface accessible for exploration
- Increase landing accuracy on the Martian surface

The focus of the LDSD project's campaign is to validate a 100 ft. diameter supersonic parachute behind a 19 ft. 8 in. attached torus-shaped SIAD. The validation of the supersonic parachute requires execution of a SFDT from the USN PMRF in a pre-coordinated operational area off the west coast of the Island of Kauai, Hawaii.

Each nominal SFDT would consist of releasing from PMRF a 34 mcf scientific balloon that carries a TV to the minimum desired float altitude of 120,000 ft. (Figure 1 of Enclosure 1). At float altitude, the balloon fully inflates to approximately 400 ft. tall and 450 ft. in diameter. The TV is then released, initiating the mission sequence. Separate sets of solid-fueled rocket motors first stabilize the TV, and then propel the TV upwards to an altitude of approximately 180,000 ft. at a speed of approximately Mach 4. The TV then deploys a doughnut-shaped tube called the SIAD to slow its velocity to approximately Mach 2. The TV then deploys the 100 ft. diameter supersonic parachute, which carries the TV safely to a controlled oceanic impact, while the balloon and balloon flight train separate and splashdown.

*Considering the purpose of the proposed activities, do you intend to film / photograph federally protected species? Yes ☐ No ☒

For a list of terrestrial species protected under the Endangered Species Act visit:
http://www.fws.gov/endangered/
For a list of marine species protected under the Endangered Species Act visit:
http://www.nmfs.noaa.gov/pr/species/esa/
For information about species protected under the Marine Mammal Protection Act visit:
http://www.nmfs.noaa.gov/pr/laws/mmpa/

7. Answer the Findings below by providing information that you believe will assist the Co-Trustees in determining how your proposed activities are compatible with the conservation and management of the natural, historic, and cultural resources of the Monument:

The Findings are as follows:

a. How can the activity be conducted with adequate safeguards for the cultural, natural and historic resources and ecological integrity of the Monument?

The proposed activities would be carried out with strict safeguards for the natural, cultural and historic resources of the Monument as required by Presidential Proclamation 8031, other applicable laws, and agency policies and standard operating procedures. Early and ongoing coordination of proposed activities would occur between NASA, the USN, Monument managers and all other relevant partners. NASA will ensure full participation in all pre-access permit and cultural briefings required each year prior to access to the Monument as well as strict adherence to all relevant Monument Best Management Practices (BMPs).

The notional predicted trajectories of the balloon from PMRF include possible over-flight of Nihoa Island, the Special Management Area around Nihoa Island, and the eastern-most part of PMNM. Although, fine control of the balloon's altitude is possible by releasing ballast material or venting helium, trajectory control (i.e., steering) cannot be achieved; the balloon system would follow the prevailing wind patterns encountered during its flight. These wind patterns were part of the computational algorithms used during the Monte Carlo simulations utilized to project flight trajectories.

The Monte Carlo method is a problem solving technique which approximates the probability of certain outcomes by running multiple trial runs, called simulations, using random variables. Monte Carlo simulations were employed to take an identified set of variables (e.g., wind patterns) representing real world conditions that could affect the LDSD flight and used computational algorithms to find potential outcomes (i.e., flight trajectories) of “what-if” scenarios. These scenarios were not screened against the safety and mission success criteria, so several of these trajectories would not be executed under the project’s established Go/No Go criteria (e.g., safety restrictions,

proper weather conditions, operational status of all LDSD subsystems, telemetry checks, and readiness of recovery systems).

Under the assumption that all possible trajectories were allowed to fly, NASA estimates the balloon system has approximately a 0.4% chance of reaching float altitude within PMNM and a 20% chance of overflying PMNM after reaching float altitude (e.g., 110,000 ft). These probabilities are reduced when NASA and the U.S. Navy apply the project's established Go/No Go criteria. These Go/No Go test rules eliminate trajectories that are predicted to fly out directly over large populated areas or follow a trajectory outside boundaries set by NASA, the U.S. Navy, and the FAA.

NASA has a vested interested in recovering the floating expended flight hardware including the scientific balloon, the TV, the flight imagery recorder, and the SIAD. Enclosure 3, "Flight Hardware to be Recovered" gives a detailed description of each of these systems. High speed and high resolution memory data storage devices for each flight are onboard the TV and must be recovered. Part of the flight reconstruction process is physical examination of the actual decelerators, so those too must be recovered. Therefore, accurate tracking information is captured and analyzed in real-time starting at launch of the scientific balloon, during execution of the SFDT, through splash down.

The recovery concept of operations has been demonstrated. During the 2014 campaign, the NASA and USN team demonstrated the ability to precisely predict and track the scientific balloon, TV, and other associated flight hardware through splash down. Lessons learned from the 2014 campaign will be leveraged in the remaining demonstration tests to improve the project's prediction, tracking, and recovery performance. The process improvements being implemented for the 2015 through 2019 campaigns represent the adequate safeguards being submitted for consideration.

Almost all expended flight hardware is recovered from the ocean, with the exception of the balloon flight train (Enclosure 2, "Balloon Flight Train Assembly, Summary"). This flight train connects the TV to the balloon. Once the TV is dropped, a signal is sent that separates the flight train from the balloon and in the process, ripping the balloon to allow descent. The flight train weighs approximately 830 pounds; is approximately 990 feet long; and consists of a burst parachute (a safety instrument), sensors, connections, and Kevlar® cabling. This system would sink rapidly in the ocean and would be almost impossible to locate.

In August 2014, NASA, in consultation with the National Science Foundation and the National Marine Fisheries Service, finalized an Initial Environmental Evaluation/Environmental Assessment of Southern Hemisphere Ultra Long Duration Ballooning Operations Expansion (accessible online at http://sites.wff.nasa.gov/code250/docs/ULDB/ULDB%20Southern%20Hemi%20IEE-EA%20FINAL.pdf) which found no significant impact to environmental resources from

scientific balloons designed to sink after performing in the southern hemisphere (between the 29°S and 65°S latitude bands).

b. How will the activity be conducted in a manner compatible with the management direction of this proclamation, considering the extent to which the conduct of the activity may diminish or enhance Monument cultural, natural and historic resources, qualities, and ecological integrity, any indirect, secondary, or cumulative effects of the activity, and the duration of such effects?

As assessed in the 2013 LDSD EA, NASA does not anticipate direct, indirect, secondary, or cumulative effects (either beneficial or detrimental) to Monument cultural, natural, and historic resources, qualities, or ecological integrity. Section 4.3.2.5 of the EA stated that "…activities would not result in any direct impacts on the coral or degradation of water/sediment quality in the vicinity of the corals. PMRF strictly controls launches and does not permit an exercise to proceed until the range is determined clear after consideration of inputs from ships' sensors, visual surveillance of the range from aircraft and range safety boats, radar data, acoustic information from a comprehensive system of sensors, and surveillance from shore. Implementation of these controls minimizes the potential for cumulative impacts to marine species. No substantial adverse cumulative impacts are anticipated from the planned LDSD launches. Implementation of the Proposed Action in conjunction with other past, present, and reasonably foreseeable future actions will not result in cumulative effects on cultural resources within the Open Ocean Area. Any submerged features that might be within this area are at considerable depth, and the potential for disturbance is extremely remote."

In addition, NASA is willing to discuss potential avenues to partner with the Monument in support of outreach and/or education activities that would mutually benefit both the Monument's and NASA's mission goals. NASA staff have reached out to NOAA ONMS staff in efforts to begin discussions regarding potential support for education and/or outreach activities and hope to continue discussions with the broader Monument managing agencies.

c. Is there a practicable alternative to conducting the activity within the Monument? If not, explain why your activities must be conducted in the Monument.
There is no practicable alternative to allowing for this proposed action to occur within the Monument. Once at float altitude, there are common wind conditions that could push the scientific balloon into PMNM before attaining the altitude needed to execute an SFDT. Allowing Monument access to the LDSD project team would ensure timely and safe recovery of any floating flight hardware that entered the Monument as well as would allow NASA to conduct a full-test of the decelerator technologies under development.

As previously mentioned, there are common wind conditions that could push the scientific balloon into PMNM before attaining the altitude needed to execute an SFDT. Allowing balloon flights over the Monument would give the LDSD Project additional flight

opportunities based on predicted balloon trajectories and avoid terminating a healthy flight vehicle in the event that contingencies preclude a timely TV drop (e.g., non-participating vessels in the range, stratospheric wind speeds are under predicted). Additionally, the TV is notionally launched in a northeasterly to easterly direction from the scientific balloon which may put mission-critical cameras at risk of pointing into the sun. The TV's on-board high-speed and high-resolution cameras are used to measure parachute shape versus flight time. The proposed splashdown area within the Monument would allow the TV to be launched in a more eastward or potentially southeastwardly direction such that the cameras' field of view would not be exposed to sun glare. Without the option of splashdown and recovery in the Monument, the probability that the SFDT would fail to meet mission objectives, due to an absence of proper imaging, is higher.

d. How does the end value of the activity outweigh its adverse impacts on Monument cultural, natural and historic resources, qualities, and ecological integrity?

NASA does not anticipate adverse impacts on Monument cultural, natural, or historic resources, qualities, or ecological integrity. On the contrary, NASA's ability to quickly and safely recover floating flight hardware after splashdown would ensure minimal if any impact to Monument resources and could be considered an appropriate management action to safeguard Monument resources in the event of a landing within PMNM boundaries. In addition, participants will ensure that all Monument BMPs are followed to ensure safety and protection of Monument natural and cultural resources. NASA will also work with the USN to establish appropriate mission rules of engagement to further ensure safety and protection of Monument natural and cultural resources.

In addition, as expressed by the Space Studies Board's Committee on the Planetary Science Decadal Survey in "Vision and Voyages for Planetary Science in the Decade 2013-2022", a technology development program is considered one of the highest priority activities for the upcoming decade in support of the Mars Exploration Program. The report emphasized the need for a focused technology program that includes the development of new and improved capabilities for entry, descent, and landing in a variety of surfaces and atmospheres including Venus and Mars. The Space Studies Board further elaborates that the continued success of NASA planetary exploration is dependent on a "robust, stable technology development program" emphasizing key investment technologies that do not currently exist. (Space Studies Board, 2011; http://www.nap.edu/openbook.php?record_id=13329).

e. Explain how the duration of the activity is no longer than necessary to achieve its stated purpose.

NASA would only enter the Monument to recover floating expended flight hardware as demonstrated in the 2014 SFDT mission (see Figures 4 and 5 of Enclosure 1). NASA would deploy three recovery vessels to anchor at Test Support Positions (TSPs) selected to minimize the recovery operations timeline. Immediately upon splashdown of

the floating expended flight hardware, the vessels would be directed to the different floating hardware locations to begin recovery. Swimmers, with snorkeling gear, may enter the water to assist in recovery of the floating hardware. As the LDSD project is limited by the 170 NM arc from Makaha Ridge, Kauai, swimmers would not enter the water within a Special Preservation Area or the Midway Atoll Special Management Area. During the 2014 mission, it took the respective vessels approximately 5 hours to reach and recover the parachute, 6.5 hours to reach and recover the balloon carcass, and 4 hours to reach and recover the TV.

f. Provide information demonstrating that you are qualified to conduct and complete the activity and mitigate any potential impacts resulting from its conduct.

NASA, in partnership with the USN, demonstrated the ability to conduct and complete the SFDT during the successful LDSD 2014 campaign at PMRF.

g. Provide information demonstrating that you have adequate financial resources available to conduct and complete the activity and mitigate any potential impacts resulting from its conduct.

NASA, as with all Federal agencies, is subject to appropriations from Congress and both the mission and the recovery operations for the 2015 have been fully funded. Appropriations would occur annually prior to the 2016 through 2019 LDSD campaigns. Additionally, given NASA's strong commitment to stewardship, the Agency would advocate for any necessary mitigation funding from impacts resulting from the LDSD Program.

h. Explain how your methods and procedures are appropriate to achieve the proposed activity's goals in relation to their impacts to Monument cultural, natural and historic resources, qualities, and ecological integrity.

NASA will make every effort to limit the time spent within the Monument. Analogous to the 2014 demonstration mission, NASA would deploy three recovery vessels to anchor at TSPs, selected to minimize the recovery operations timeline. Immediately upon splashdown of the scientific balloon and TV, the vessels would be directed to the different floating hardware locations to begin recovery. During the 2014 mission, it took the respective vessels approximately 5 hours to reach and recover the parachute, 6.5 hours to reach and recover the balloon and flight train, and 4 hours to reach and recover the TV.

i. Has your vessel been outfitted with a mobile transceiver unit approved by OLE and complies with the requirements of Presidential Proclamation 8031?
Yes

j. Demonstrate that there are no other factors that would make the issuance of a permit for the activity inappropriate.

No other forseeable factors exist that would make the issuance of a permit for this activity inappopriate.

8. Procedures/Methods:
Sections 2.2, 2.3, and 2.4 of the May 2013 NASA LDSD Technology Demonstration Mission EA, (http://www.govsupport.us/nasaldsdea/default.aspx) detail the procedures and methods used for the LDSD missions. Prior to launch, the LDSD Project and USN Range Management conduct a series of launch decision meetings to determine whether a launch attempt can be made within a pre-determined set of public safety (e.g., non-participant vessel risks), environmental safety (e.g., potential to encroach on the PMNM), and mission success criteria (e.g., weather/winds conditions, critical hardware success). Each of these criteria imposes separate restrictions on the impact dispersion of both the scientific balloon and the TV. When the separate dispersion patterns are combined, the resulting pattern serves as the primary aid for these decision meetings.

If all range safety criteria are met, the SFDT is allowed to proceed and the 3 vessels are sent to their respective TSPs. Each SFDT consists of a 34 mcf scientific balloon that carries the SFDT TV to the minimum desired float altitude of 120,000 ft then releases the TV to initiate the mission sequence. Once the TV is dropped, a signal is sent that separates the flight train from the balloon and in the process, ripping the balloon to allow descent. After the TV drops, small solid-fueled rocket motors ignite and stabilize the TV prior to the main motor ignition. The main motor is an Orbital Alliant Techsystems, Incorporated manufactured Star 48B, a long nozzle solid-fueled rocket engine. The Star 48B ignites propelling the TV upwards to an altitude of approximately 180,000 ft at a speed of approximately Mach 4. The TV then deploys a doughnut-shaped tube called the SIAD to slow its velocity to approximately Mach 2. The TV then deploys a 100-ft diameter supersonic parachute, which carries the TV safely to a controlled oceanic impact. After splashdown, the three vessels transit to the locations of the floating expended flight hardware (balloon and TV) for recovery. The flight train, that separates from the balloon and the TV, would sink rapidly in the ocean and would be almost impossible to locate.

All launch activities would occur during daylight and all trajectories would direct splashdown into deep water, beyond 3 nautical miles of any island (vessels may be transiting to TSPs overnight). No Monument staff or volunteers would be required by NASA or its affiliate contractors, in conducting the mission.

NOTE: If land or marine archeological activities are involved, contact the Monument Permit Coordinator at the address on the general application form before proceeding.

9a. Collection of specimens - collecting activities (would apply to any activity): organisms or objects (List of species, if applicable, attach additional sheets if necessary):

Common name:

Scientific name:

& size of specimens:

Collection location:

☐ Whole Organism ☐ Partial Organism

9b. What will be done with the specimens after the project has ended?

9c. Will the organisms be kept alive after collection? ☐ Yes ☐ No

• General site/location for collections:

• Is it an open or closed system? ☐ Open ☐ Closed

• Is there an outfall? ☐ Yes ☐ No

• Will these organisms be housed with other organisms? If so, what are the other organisms?

• Will organisms be released?

10. If applicable, how will the collected samples or specimens be transported out of the Monument?

11. Describe collaborative activities to share samples, reduce duplicative sampling, or duplicative research:

12. List all specialized gear and materials to be used in this activity:

Sections 2.2.2 and 2.2.3 of the 2013 LDSD EA and Enclosure 5 "Equipment and Materials Description" detail the balloon launch platform and the SFDT Test Vehicle. The following is a breakdown of main components on each system:

5,100-pound, 34 mcf scientific balloon flight train assembly composed of thin sheets (0.8 mil) of polyethylene film (much like a typical trash bag) sealed together with enclosed polyester fibers.

830-pound balloon flight train including:

- Kevlar cable ladder made of ½" Zylon/PBO Synthetic
- FAA Air Traffic Control Radar Beacon System
- Micro Instrumentation Package (including global positioning system, uplink and downlink telemetry (TM), line of sight ultra-high frequency (UHF) transceiver and an Iridium unit for over the horizon commanding and TM)
- 90-pound, 72-foot balloon burst parachute and cabling
- Ballast (very fine fine steel shot [0.3 to 0.5 mm] - released during balloon ascent)
- Small, self-contained pyrotechnic device for balloon termination - ignited in flight, spent prior to landing

6,600-pound Test Vehicle (15 feet in diameter by 7 feet in height)

- TV core structure is constructed of composite sandwich panel, with carbon facesheets and closed-cell (foam) to provide bouyancy
- Orbital Alliant Techsystems, Incorporated manufactured Star 48B, a long nozzle solid-fueled rocket engine - ignited in flight, spent prior to landing
- Heat shield segments
- C-band beacon for radar tracking
- Two TM downlink systems operating in the S-band frequency range of 2,200-2,300 megahertz (MHz).
  - Frequency Modulation (FM) transmitter and two circularly polarized slot antennas
  - National Television System Committee (NTSC) standard video FM transmitter and two circularly polarized slot antennas
- Small solid-fueled rocket motors that ignite and stabilize the TV prior to the main motor ignition - ignited in flight, spent prior to landing
- 20-foot diameter silicone-coated Kevlar® or silicone-coated Technora® Supersonic Inflatable Aerodynamic Decelerator (SIAD) uses automotive gas generators (air bag propellant) and a custom designed gas diffuser for inflation
- 100-foot diameter Supersonic Ringsail (SSRS) parachute with a mortar fired pilot ballute (to provide extraction force for the main parachute deployment) and rigging (deployment bags, braided riser bridle, and bridle rigidizers)
- Flight image recorder and Go-Pro® cameras
- Electronics control platform with two subsystems battery packs:
  - Electrical power susbsystem contains 5 battery packs in parallel consisting of 11 lithium manganese dioxide (M62) cells in series per pack
  - Drop subsystem contains a 24 cell nickel cadmium (NiCad) "D" pack

13. List all Hazardous Materials you propose to take to and use within the Monument:
Refer to Enclosure 5. "Equipment and Materials Descriptions" for full descriptions of each hazardous system and corresponding safety data sheets.
All hazardous materials are fully integrated into either the balloon system or the TV. Immediately post-landing, vessels will transit from test support locations beyond the launch hazard arc to intercept and salvage the floating systems - balloon and TV. Whether or not either of these systems enter PMNM, they will be recovered as quickly as possible. Under nominal conditions, all pyrotechnic systems are fired during flight and land spent (as part of the balloon system or TV) in the ocean.

14. Describe any fixed installations and instrumentation proposed to be set in the Monument:
NA

15. Provide a time line for sample analysis, data analysis, write-up and publication of information:
Feb – Web Video – China Lake Rocket Sled testing
Feb/March – media day at JPL (include press release and video file)
April 1 – image release
April – feature story
May – web video
May – press release
May - Image release
June 1 – televised news briefing, video file, press release, web video, press kit
June 2 – commentary, press release
June 3 – media telecon, web video, video file and press release
June 4 – web video
June 17 – web video
D=0: Day of Test (to be determined in June, July, or August)
D+2 days: Flash Report on estimated trajectory conditions
D+30 days: Status Update on Trajectory Reconstruction
D+60 days: Test Summary Report Issued
D+90 - D+365 days: Publication and Presentation of Conference Papers

16. List all Applicant's publications directly related to the proposed project:
May 2013. National Aeronautics and Space Administration Low Density Supersonic Decelerator Technology Demonstration Mission Pacific Missile Range Facility, Environmental Assessment (http://www.govsupport.us/nasaldsdea/default.aspx)

June 2013. Low Density Supersonic Decelerators Fact Sheet (JPL 400-1530) (http://www.nasa.gov/pdf/737628main_Final_LDSD_Fact_Sheet_3-26-13.pdf)

May 2014. Low-Density Supersonic Decelerator (LDSD) Press Kit (http://www.jpl.nasa.gov/news/press_kits/ldsd.pdf)

June 2014. NASA's Low-Density Supersonic Decelerator Set to Lift Off. NASA Jet Propulsion Laboratory News (http://www.jpl.nasa.gov/news/news.php?release=2014-207)
June 2014. NASA's Low-Density Supersonic Decelerator Lifts Off. NASA Jet Propulsion Laboratory News (http://www.jpl.nasa.gov/news/news.php?release=2014-208)

June 2014. First LDSD Test Flight a Success. NASA Jet Propulsion Laboratory News (http://www.jpl.nasa.gov/news/news.php?release=2014-210)

August 2014. High-Def Video of NASA's 'Flying Saucer' Test. NASA Jet Propulsion Laboratory Videos (http://www.jpl.nasa.gov/video/details.php?id=1321)

August 2014. Fishing LDSD out of the Water. NASA Jet Propulsion Laboratory Images (http://www.jpl.nasa.gov/spaceimages/details.php?id=PIA18465)

November 2014. NASA Saucer Named 'Best of What's New'. NASA Jet Propulsion Laboratory News (http://www.jpl.nasa.gov/news/news.php?feature=4385)

With knowledge of the penalties for false or incomplete statements, as provided by 18 U.S.C. 1001, and for perjury, as provided by 18 U.S.C. 1621, I hereby certify to the best of my abilities under penalty of perjury of that the information I have provided on this application form is true and correct. I agree that the Co-Trustees may post this application in its entirety on the Internet. I understand that the Co-Trustees will consider deleting all information that I have identified as "confidential" prior to posting the application.

_____ _____

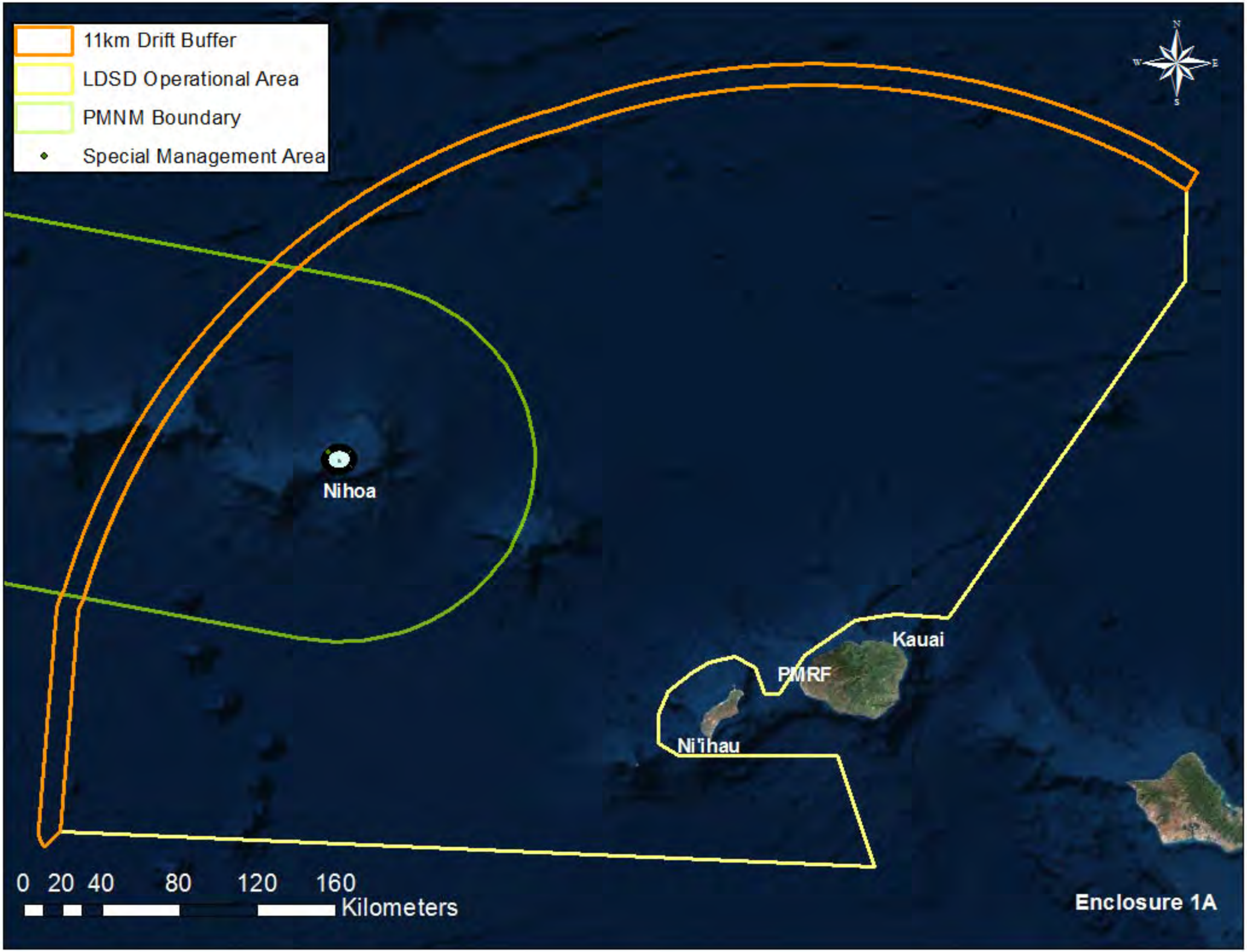
Signature Date

SEND ONE SIGNED APPLICATION VIA MAIL TO THE MONUMENT OFFICE BELOW:

NOAA/Inouye Regional Center
NOS/ONMS/PMNM/Attn: Permit Coordinator
1845 Wasp Blvd, Building 176
Honolulu, HI 96818
FAX: (808) 455-3093

DID YOU INCLUDE THESE?
☒ Applicant CV/Resume/Biography
☒ Intended field Principal Investigator CV/Resume/Biography
☒ Electronic and Hard Copy of Application with Signature

☐ Statement of information you wish to be kept confidential
☒ Material Safety Data Sheets for Hazardous Materials


11km Drift Buffer
LDSD Operational Area
PMNM Boundary
Special Management Area
N
W
E
S
Nihoa
Kauai
PMRF
Ni'ihau
0 20 40 80 120 160
Kilometers
Enclosure 1A

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Appendix D
LDSD Technology Demonstration Mission Biological Evaluation Submitted to NMFS

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National Aeronautics and
Space Administration

Goddard Space Flight Center
Wallops Flight Facility
Wallops Island, VA 23337

Reply to Attn of: 250.W

February 20, 2015

Ms. Ann Garrett
Acting Assistant Regional Administrator
Protected Resources Division
NMFS Pacific Islands Regional Office
1845 Wasp Boulevard, Building 176
Honolulu, Hawaii 96818

Dear Ms. Garrett:

The National Aeronautics and Space Administration (NASA) proposes to fund the 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 Kaua'i, Hawai'i. NASA would perform up to two LDSD Supersonic Flight Dynamics Tests annually over the next 5 years, starting in June 2015 and ending in August 2019. Enclosed is a Biological Evaluation (BE) to initiate informal consultation under Section 7(a)(2) of the Endangered Species Act (ESA).

Please note that the BE also considers the connected actions of the National Oceanic and Atmospheric Administration and the U.S. Fish and Wildlife Service. In accordance with the authorities granted to them under Presidential Proclamation 8031 and 50 CFR Part 404, NASA has requested that they, along with the State of Hawai'i, issue the LDSD Project a permit to enter the Papahānaumokuākea Marine National Monument. If NASA's permit application were to be approved, their action of issuing the permit would be subject to ESA consultation requirements. As such, NASA has assumed the role as Lead Agency (50 CFR § 402.07) and prepared this BE to fulfill the ESA obligations of all three federal action agencies.

As described in the enclosed BE, the proposed action may affect, but is not likely to adversely affect, the following ESA-listed marine species under your agency's jurisdiction:

North Pacific right whale (*Eubalaena japonica)*
Blue whale (*Balaenoptera musculus*)
Fin whale (*Balaenoptera physalus)*
Sei whale (*Balaenoptera borealis)*
Humpback whale (*Megaptera novaeangliae)*
False killer whale – Main Hawai'ian Insular (*Pseudorca crassidens*)
Sperm whale (*Physeter macrocephalus*)
Hawai'ian monk seal (*Neomonachus schauinslandi*)
Green sea turtle (*Chelonia mydas)*

Hawksbill sea turtle (*Eretmochelys imbricate)*
North Pacific loggerhead sea turtle (*Caretta caretta)*
Olive Ridley sea turtle (*Lepidochelys olivacea)*
Leatherback sea turtle (*Dermochelys coriacea).*

Designated and proposed critical habitat for the Hawai‘ian monk seal occurs within the action area. The proposed action may affect, but is not likely to adversely affect, designated monk seal critical habitat. Similarly, the proposed action is not likely to adversely modify Hawai‘ian monk seal critical habitat proposed for designation. We request your concurrence with our determinations, and hereby request informal consultation under Section 7 of the ESA.

We look forward to hearing from you. If you have any questions in the meantime, please contact me at (757) 824-2319 or Joshua.A.Bundick@nasa.gov.

Sincerely,

Joshua A. Bundick
Lead, Environmental Planning

Enclosure

cc:
250/Mr. T. Meyer
840/Mr. D. Wilcox
HQ/Ms. T. Norwood
JPL/Ms. V. Ryan
LJT/Mr. S. Combs
LJT/Ms. S. Silbert
NMFS PMNM/Ms. T. Brown
NMFS PRD/Mr. P. Opay
PMRF/Mr. J. Burger

BIOLOGICAL EVALUATION

LOW DENSITY SUPERSONIC DECELERATORS TECHNOLOGY DEMONSTRATION MISSION

Prepared for:

Low Density Supersonic Decelerators Project

Jet Propulsion Laboratory

Pasadena, CA

Prepared by:

Wallops Flight Facility Environmental Office

NASA Wallops Flight Facility

Wallops Island, VA

Submitted to:

National Marine Fisheries Service

Pacific Islands Regional Office Protected Resources Division

Honolulu, HI

February 2015

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1.0 Background/History

This Biological Evaluation (BE) has been prepared to address the effects of the National Aeronautics and Space Administration's (NASA) Low Density Supersonic Decelerators (LDSD) Technology Demonstration Mission (TDM) on species listed as endangered or threatened under the Endangered Species Act (ESA) of 1973, or their designated critical habitat. Section 7 of the ESA assures that, through consultation (or conferencing for proposed species) 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.

The primary action considered herein is NASA's funding of up to two Supersonic Flight Dynamics Tests (SFDT) per summer (June through August) from 2015 through 2019, from the U.S. Navy's (USN's) Pacific Missile Range Facility (PMRF) on Kaua'i, Hawai'i. Also considered in this BE are the connected actions of the National Oceanic and Atmospheric Administration (NOAA) and the USFWS. In accordance with the authorities granted to them under Presidential Proclamation 8031 and 50 CFR Part 404, NASA has requested that they, along with the State of Hawai'i, issue the LDSD Project a permit to enter the Papahānaumokuākea Marine National Monument (PMNM). If NASA's permit application were to be approved, their action of issuing the permit would be subject to ESA consultation requirements. As such, NASA has assumed the role as Lead Agency (50 CFR § 402.07) and prepared this BE to fulfill the ESA obligations of all three federal action agencies.

Because the action would occur over (during flight) and within (upon landing) the open ocean, it has the potential to impact ESA-listed marine species that may occur in the area, shown in **Table 1**.

Table 1: Summary of Species & Critical Habitat Potentially within the LDSD Action Area

Common Name	Scientific Name	ESA Status
Cetaceans		
North Pacific right whale	*Eubalaena japonica*	Endangered
Blue whale	*Balaenoptera musculus*	Endangered
Fin whale	*Balaenoptera physalus*	Endangered
Sei whale	*Balaenoptera borealis*	Endangered
Humpback whale	*Megaptera novaeangliae*	Endangered
False killer whale (MHI Insular)	*Pseudorca crasidens*	Endangered
Sperm whale	*Physeter macrocephalus*	Endangered
Pinnipeds		
Hawai'ian Monk Seal	*Neomonachus schauinslandi*	Endangered
Hawai'ian Monk Seal Critical Habitat	N/A	Designated & Proposed
Sea Turtles		
Green sea turtle	*Chelonia mydas*	Threatened
Hawksbill sea turtle	*Eretmochelys imbricate*	Endangered
North Pacific loggerhead sea turtle	*Caretta caretta*	Endangered
Olive ridley sea turtle	*Lepidochelys olivacea*	Threatened
Leatherback sea turtle	*Dermochelys coriaacea*	Endangered

Early coordination and pre-consultation with NMFS was conducted during a series of document reviews and telephone conversations including:

- December 2012 and March 2013: NASA completed the *Low Density Supersonic Decelerator Technology Demonstration Mission Pacific Missile Range Facility Final Environmental Assessment* ("LDSD EA;" **NASA 2013**) and issued a Finding of No Significant Impact on May 10, 2013. During the preparation of the LDSD EA, NMFS was provided copies of both the Coordinating Draft and Public Draft EA. Although it appears that NMFS reviewed the EA, no ESA consultation was conducted (**P. Opay, NMFS, personal communication, 2015**).

- January 20, 2015: NASA participated in a telephone conversation with Mr. Patrick Opay, NMFS Pacific Islands Region, Office of Protected Resources, to discuss the previous coordination on the 2013 LDSD EA and steps forward for completing ESA consultation for future tests. It was mutually agreed upon that NASA would prepare a BE and submit it to NMFS, and, pending NASA's determinations of effect, request either a Letter of Concurrence (informal consultation) or enter into formal consultation, should conditions warrant.

- January 28, 2015: NASA and NMFS held a brief teleconference to discuss the status of the BE and to confirm the necessity of NASA's providing a summary (rather than a detailed assessment) of the environmental baseline within the action area.

1.1 *Purpose of the Proposed Action*

NASA's TDMs are used to bridge the gap between need and means, between scientific and engineering challenges and the technological innovations needed to overcome them, and between laboratory development and demonstration in space.

Once a technology is proven in the laboratory environment, the program becomes a bridge from ground to flight testing. System-level technology solutions are given the opportunity to operate in the actual space environment, where they gain operational heritage, reduce risks to future missions by eliminating the need to fly unproven hardware, and continue NASA's long history as a technological innovator. These cutting-edge technologies allow future NASA missions to pursue bolder and more sophisticated science, enable safe and rewarding human missions beyond low-Earth orbit, and enable entirely new approaches to United States space operations.

NASA seeks to use atmospheric drag as a solution to the limitations of parachute-only deceleration systems in thin exoatmospheric environments, saving rocket engines and fuel for final maneuvers and landing procedures. The heavier planetary landers of tomorrow, however, would require much larger drag devices than those currently employed to slow them. The next-generation drag devices would also need to be deployed at higher supersonic speeds to safely land vehicle, crew, and cargo. NASA's LDSD TDM, led by the California Institute of Technology's Jet Propulsion Laboratory (JPL) in Pasadena, California, would conduct full-scale, stratospheric tests of these technologies in the Earth's stratosphere (which mimics Mars's thin atmosphere), to prove their value for future missions to Mars and potentially other solar system bodies.

NASA's Space Technology Mission Directorate (STMD) established the LDSD Project as a test architecture for the development and full-scale testing of decelerator technologies at representative conditions to those found on the planet Mars. The current decelerator technologies were developed in the 1970s as part of NASA's Viking Program, which sent two probes to the Martian surface. Since these early Mars landers, the main focus on technology development has been on the landing phase of planetary missions. The decelerator technologies that could be developed through the LDSD project enable the following on future missions to Mars:

- Placement of more mass on the Martian surface in a single landing
- Making more of the Martian surface accessible for exploration
- Increasing landing accuracy on the Martian surface

The primary focus of the LDSD Project's campaign in Hawai‘i is to validate a 30 meter (m; 100 feet [ft]) diameter Supersonic Ring Sail (SSRS) parachute behind a 6 m (20 ft) attached torus Supersonic Inflatable Aerodynamic Decelerator (SIAD).

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2.0 Description of the Action and Action Area

The LDSD Project seeks to conduct up to two SFDT campaigns in the summer of 2015, with the possibility for up to two additional flights per summer (i.e., June through August) through year 2019, from the USN's PMRF on Kaua'i, Hawai'i.

2.1 *Supersonic Flight Dynamics Test Overview*

Each SFDT flight (**Figure 1**) would consist of releasing from PMRF a 34 million cubic foot (1 million cubic meter [m^3]) helium-filled scientific balloon that carries a Test Vehicle (TV) to a minimum desired float altitude of 37,600 m (120,000 ft). At float altitude, the balloon fully inflates to approximately 122 m (400 ft) tall and 137 m (450 ft) in diameter. The TV is then released, initiating the mission sequence. Once the TV is dropped, a signal is sent that separates the flight train from the balloon and, in the process, rips the balloon to allow for its descent. After the TV drops, small solid-fueled rocket motors ignite and stabilize the TV prior to the main motor ignition. The main motor is a Star 48B, a long nozzle solid-fueled rocket engine. The Star 48B ignites, propelling the TV upwards to an altitude of approximately 55,000 m (180,000 ft) at a speed of approximately Mach 4. The TV then deploys a torus (doughnut-shaped) tube called the SIAD to slow its velocity to approximately Mach 2. The TV then deploys the 30-m (100-ft) diameter SSRS parachute, which carries the TV safely to a controlled oceanic impact in a pre-coordinated operational area off the west coast of Kaua'i.

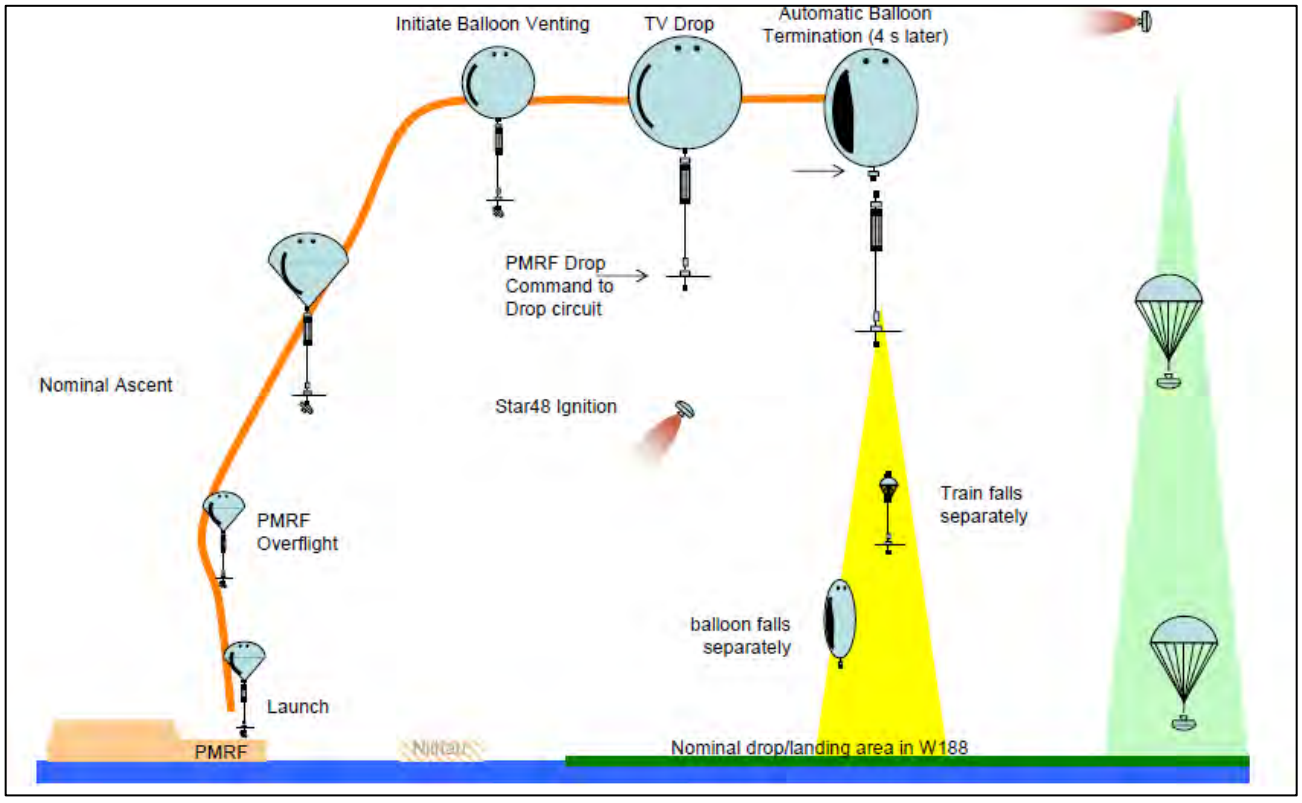


Figure 1: Supersonic Flight Dynamics Test Sequence

2.2 *Pre-launch Activities*

Launch decisions for the SFDT are tied directly to suitability of winds from ground level to a height of approximately 55,000 m (180,000 ft). Meteorological (MET) soundings are used to gauge mid- and upper level wind conditions. Two sizes of latex MET balloons ("2,000 grams" [g] and "30 g"), would be released to measure lower- and mid-level wind conditions from ground up to a height of approximately 33,500 m (110,000 ft) while Super Loki sounding rocket-deployed Rocket Balloon Instruments (ROBINs) are used to calculate upper level wind conditions to a height of approximately 90,000 m (295,000 ft). Each is described in more detail below.

2.2.1 Latex Meteorological Balloons

Radiosondes

During each LDSD campaign, a dress rehearsal is held prior to the first launch attempt of the campaign. This dress rehearsal is used to ensure that all telemetry, command systems, radar tracking, and other systems are functioning properly before the launch attempt. One 2,000 g MET balloon would be released as part of the dress rehearsal. Two 2,000 g MET balloons would be released the day of launch (one 1.5 hours prior to launch and the other 1.5 hours after launch). Each 2,000 g MET balloon would be equipped with a radiosonde that contains instruments capable of making direct in-situ measurements of air temperature, humidity, and pressure (**Figure 2**). These observed data are transmitted immediately to the ground station by a radio transmitter located within the instrument package.

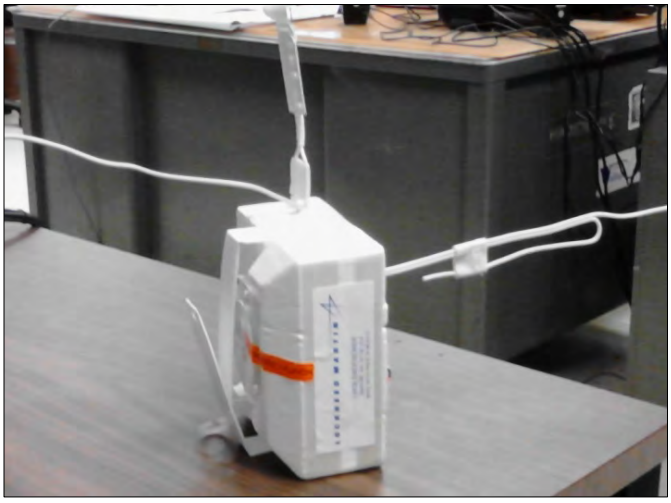


Figure 2: Polystyrene Radiosonde Box with Internal Electronics

The 2,000 g MET balloons are inflated with helium gas and free-fly from the release point on PMRF to a bursting elevation of approximately 35,000 m (115,000 ft). Parachutes then deploy and prevailing winds carry the instrument package over the Pacific. Battery operated (9 volt) radiosondes are not recovered from the ocean. However, they are packed in floating polystyrene containers with waterproof pre-paid labels for return to NASA's scientific balloon contractor. Over the remaining five-year time frame of the LDSD Project, a maximum of 25 radiosonde balloons would be released, burst, and descend to the Pacific Ocean. Based on wind conditions, these radiosonde balloons should land in the Pacific Ocean approximately 16 to 32 kilometers (km; 9 to 17 nautical miles [nm]) downrange or between Kaua'i and Ni'ihau (**D. Gregory, NASA Balloon Program Office, personal communication, 2015**).

Pilot Balloons

Pilot balloons (30 g MET balloons) are launched to determine wind speed and wind direction (**Figure 3**). They are filled with helium, released to free-fly, and visually tracked with optical instrumentation. Using height and angular direction information from a theodolite to the balloon, wind direction or horizontal movement of the balloon is tracked, calculated, and graphed. For 30 g latex pilot balloons, wind speed and direction can be tracked at altitudes up to 4,500 m (14,800 ft). These balloons do not carry instrumentation on them, rather, they are only balloons.

Starting 25 days before each of the up to two, 10-day launch windows (two work weeks), 30 g latex MET balloons would be released at the rate of one every 30 minutes for two hours before and two hours after sunrise every day. Each balloon would be filled with approximately 0.16 m^3 (5.7 cubic feet [ft^3]) of gaseous helium to a diameter of 64 centimeters (cm; 25 inches [in]). As the balloon rises in altitude, the gaseous helium expands until the balloon bursts completely at about 102 cm (40 in) in diameter.

Figure 3: 30 gram Pilot Balloon and Observation Equipment

If an LDSD launch attempt is not made until the last day of each window, a maximum of 630 pilot balloons could be released per year. For the entire five-year Project, a maximum of 3,150 pilot latex balloons could be released, burst, and land in the Pacific Ocean. Based on wind conditions, approximately 30 to 40 percent of these pilot balloons, equating to between 945 and 1,260 balloons during the remaining five-year term of the LDSD Project, would land in the Pacific Ocean approximately 8 km (4 nm) downrange from Kaua‘i (**D. Gregory, NASA Balloon Program Office, personal communication, 2015**).

2.2.2 Super Loki Sounding Rockets

The Super Loki is a two-stage rocket system used to obtain density, temperature, ozone, and wind data at altitudes ranging from 85,000 to 110,000 m (279,000 to 361,000 ft) to ground level. The first stage is a solid propellant rocket, 0.1 m (0.3 ft) in diameter and 2.0 m (6.6 ft) long. The second stage is an inert instrumented Dart, 0.054 m (0.177 ft) in diameter and 1.26 m (4.13 ft) long. Both stages consist of an aluminum case with an internally burning cast-in-the-case solid propellant. The propellant fuel is a

polysulfide polymer and the oxidizer is ammonium perchlorate. The entire rocket is approximately 3.25 m (10.7 ft) long and weighs approximately 30 kilograms (kg; 66 pounds [lb]) with propellants. After ignition, the first stage travels approximately 18,000 m (59,000 ft) in altitude before expending its fuel. The spent first stage rocket then separates from the Dart and follows a trajectory to an ocean impact approximately 5 km (3 nm) downrange. After separation, the second stage Dart ignites and reaches an altitude of approximately 80,000 m (262,000 ft), at which point the motor expends its fuel, the payload is released, and the Dart follows a ballistic trajectory to an ocean impact approximately 31 km (17 nm) downrange.

Each Super Loki rocket would deploy a ROBIN, (a metalized 0.5-mil thick Mylar sphere, 1.0 m [3.3 ft] in diameter, inflated to 12 hectopascal pressure), to a height of approximately 89,900 m (295,000 ft) (**Figure 4**). Since the ROBIN sphere's mass and spherical diameter is known, as the sphere falls from this initial deployment height to a minimum height of approximately 30,500 m (100,000 ft), where the higher external pressure causes the sphere to collapse, radar tracking information can be used to calculate wind direction, wind velocity, temperature, density, and pressure.

Figure 4: ROBIN Sphere Pre- (left) and Post- (right) Inflation

Super Loki MET rockets would be launched in conjunction with the 2,000 g radiosonde balloons. Therefore, over the remaining five-year time frame of the LDSD Project, a maximum of 25 Super Loki first stage motors, 25 Dart second stage motors, and 25 ROBIN spheres would land in the Pacific Ocean west of Kaua'i.

2.3 *Post-launch Activities*

2.3.1 Recovery

NASA has a vested interested in recovering the floating expended flight hardware including the scientific balloon, the TV, the flight imagery recorder, and the SIAD. High speed and high resolution memory data storage devices for each flight are onboard the TV and must be recovered. Part of the flight reconstruction process is physical examination of the actual decelerators, so those too must be recovered. Therefore, accurate tracking information is captured and analyzed in real-time starting at launch of the scientific balloon, during execution of the SFDT, through splash down.

The recovery concept of operations has been demonstrated (**Figures 5 and 6**). During the 2014 campaign, the NASA and USN team demonstrated the ability to precisely predict and track the scientific balloon, TV, and other associated flight hardware through splashdown.

To recover floating expended flight hardware, NASA would deploy three recovery vessels to anchor at positions selected to minimize the recovery operations timeline. The maximum cruise speed of the three vessels would be 22 km per hr [km/hr; 12 knots (kt)] with an average cruising speed of 10 kt. Up to two USN aircraft (either G-2/3 and/or C-12/26) would be flown to perform safety surveillance of the operational area and to assist with locating expended flight hardware for recovery. These aircraft would fly at altitudes between 460 and 7,300 m (1,500 and 24,000 ft) above the ocean surface and would help direct the vessels to the different recovery positions immediately upon splashdown of the floating expended flight hardware. During the 2014 mission, it took the respective vessels approximately 5 hours to reach and recover the supersonic parachute, 6.5 hours to reach and recover the balloon carcass (**Figure 5**), and 4 hours to reach and recover the TV (**Figure 6**). Swimmers, with snorkeling gear, may enter the water to assist in recovery of the floating hardware. As the LDSD project is limited by the 315 km (170 nm) arc centered at Mākaha Ridge, Kauaʻi, swimmers would not enter the water within a Special Preservation Area or the Midway Atoll Special Management Area.

Figure 5: Scientific Balloon Recovery Operations on 2014 SFDT

Figure 6: TV Recovery Operations on 2014 SFDT

2.3.2 Items Not Recovered

Nearly all LDSD expended flight hardware (i.e., TV, balloon) would be recovered from the open ocean, with the exception of the balloon flight train (items 2-17 depicted in **Figure 7**). This flight train connects the TV to the balloon, and consists of a burst parachute (a safety instrument), sensors, connections, and Kevlar® cabling. This system would sink rapidly in the ocean, as described in more detail below.

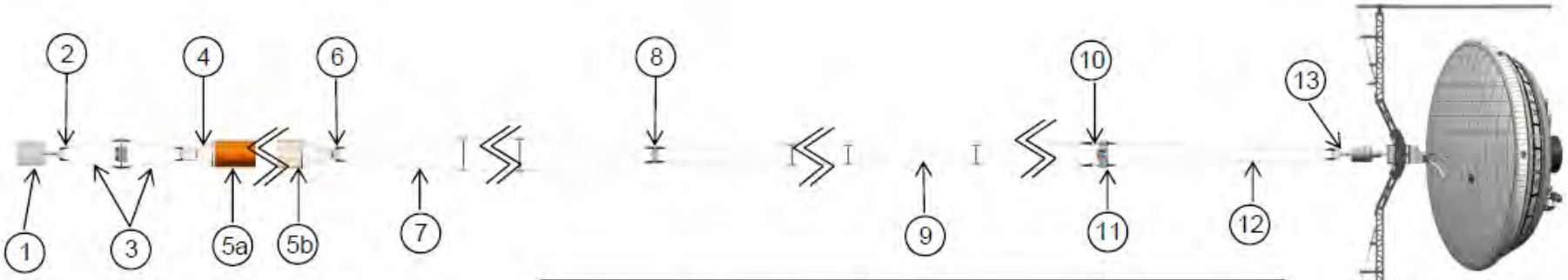
2.3.2.1 Detailed Description of Flight Train

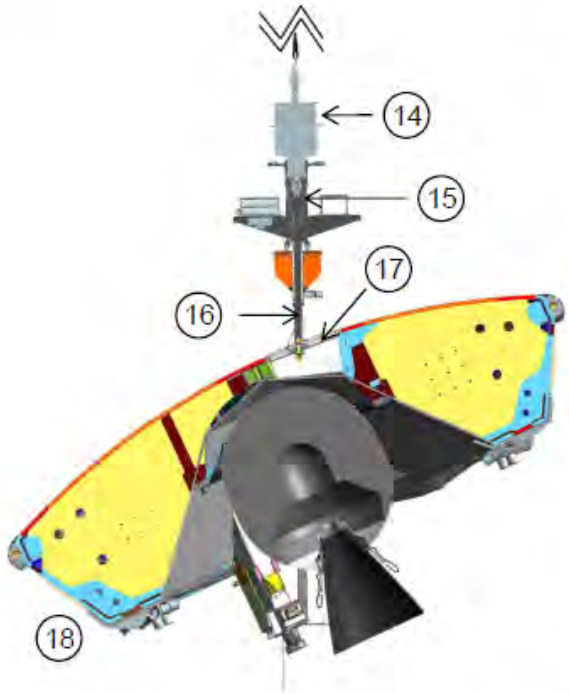
The balloon flight train weighs approximately 375 kg (827 lb) and is approximately 300 m (1,000 ft) long from the connection to the balloon through the connection to the TV. Stainless steel connectors, an electronic balloon burst detector for sensing a sudden drop in balloon altitude, a Micro Instrumentation Package (comprised of global positioning system, uplink and downlink telemetry, line of sight ultra-high frequency transceiver and an Iridium unit for over the horizon commanding and telemetry, electronic controlling units for venting the balloon, and small electrically-actuated charges for separating the balloon flight train from the balloon), and 1.5 m (5 ft) of Kevlar® line, connect the balloon to a 22 m (72 ft) diameter (canopy) nylon parachute. Parachute suspension cables connect to interface rings at both the top and bottom of the parachute. Three sections of Kevlar® cable "ladders" interspaced with aluminum anchor plates connect the parachute to the TV's rotator, electronics deck, and release hardware. Each strand of Kevlar® is approximately 1.27 cm (0.5 in) diameter with 0.5 m (1.6 ft) long strands attached perpendicularly between two parallel strands. The three ladder sections are 21, 39, and 4.5 m (69, 128, and 15 ft) long. The TV's electronics deck carries the leak-proof ballast hopper containing approximately 110 kg (243 lb) of 0.3 to 0.5 millimeter (mm; 0.01 to 0.02 inch) steel shot ballast (roughly the diameter of beach sand), and controls the slow, complete release of ballast during the ascent phase of LDSD. The TV release hardware contains additional small, electrically-actuated charges for separation of the TV from the balloon flight train.

2.3.2.2 Materials of Interest in Flight Train

Pyrotechnics

During each SFDT, two distinct separation events must occur: 1) release of the TV and 2) release of the balloon flight train with burst parachute. To enable such separations, the LDSD system contains a series of small explosive charges that are used to sever mechanical connections. To provide perspective on size, the largest charge currently employed is just less than 180 milligrams (0.0004 lb).





Train item no.	Assembly	Description
1	Balloon Train	Balloon B 36.73-3H-02
2	Balloon Train	Balloon Interface Hardware
3	Balloon Train	CLS1 12 Metric Ton Kevlar Rope (2 Top)
4	Balloon Train	Cable Loop Terminate Fitt. Standard
5a	Balloon Train	Parachute 72' Canopy
5b	Balloon Train	Parachute Suspension Lines
6	Balloon Train	Bottom Harness Interface
7	Balloon Train	CLS2 12-Metric Ton Kevlar Rope (70 ft. Lg)
8	Balloon Train	LDSD Tower Anchor Plate
9	Balloon Train	CLS3 12-Metric Ton Kevlar Rope (128 ft. Lg)
10	Balloon Train	Connector Rope
11	Balloon Train	Release Plate
12	Balloon Train	CLS4 12-Metric Ton Kevlar Rope (15 ft Lg)
13	Balloon Train	Upper Rotator Hardware
14	Balloon Train	NASA Rotator
15	Balloon Train	Bottom Universal Hardware
16	Balloon Train	Gondola (with Ballast)
17	Test Vehicle	Balloon Fitting
18	Test Vehicle	TV (CSA)

Figure 7: Balloon Flight Train

Each separation event uses two charges. Under normal flight conditions, all charges would be expended during flight. In an off-nominal flight condition (anomaly event), the charges for separation would not be expended; however, upon water impact, all unexpended charges would short out in the "safe" position, effectively eliminating the possibility of an in-water ignition.

Electrical System Components

Small electrical systems are required on the flight train to enable the separation functions described above and to power scientific instruments and flight tracking systems. The entire flight train contains approximately 23 kg (50 lb) of lithium sulfur dioxide ($LiSO_2$) batteries (comparable to approximately 710 "CR-V3" lithium cells typically used in consumer photographic and electronic devices: **Energizer Holdings, Incorporated n.d.**).

Very small quantities of lead-containing solder are used on other parts of the LDSD electrical systems. Although the majority of electrical systems are connected with crimps, some soldered connections are still employed, including those in the battery packs. Approximately 100 g (0.22 lb) of solder would be used on a balloon's entire electrical system, with 40 percent (40 g [0.09 lb]) of this solder consisting of lead. This quantity of lead is slightly more than what is contained in one 12-gauge shotgun shell used for small-game hunting. Therefore, in summary, there would be approximately 40 g (0.09 lb) of lead on each SFDT flight.

2.3.2.3 Estimated Flight Train Sink Rate

To estimate the sink rate of the unrecoverable flight train once in the water, a conservative assessment was performed that included the following assumptions:

- The parachute remained 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 density of seawater remained constant at a value expected at 6,000 m (19,685 ft) depth (1.05 g per cubic cm [65.5 lb per cubic ft]), increasing both the drag and the buoyant forces acting upon the entire system, when, in actuality, the density of seawater would be less at shallower depths; and

- The effect of horizontal currents (which would generate a negligible amount of lift) on the system's descent were zero, given that the effects would likely be outweighed by the previous two assumptions.

Based on this assessment, and assuming 170 kg (375 lb) of buoyant force, the flight train would sink at a rate between about 0.10 and 0.12 m per second (0.33 to 0.39 ft per second), equating to approximately 375 to 420 m (1,230 to 1,380 ft) per hour (**Figure 8**).

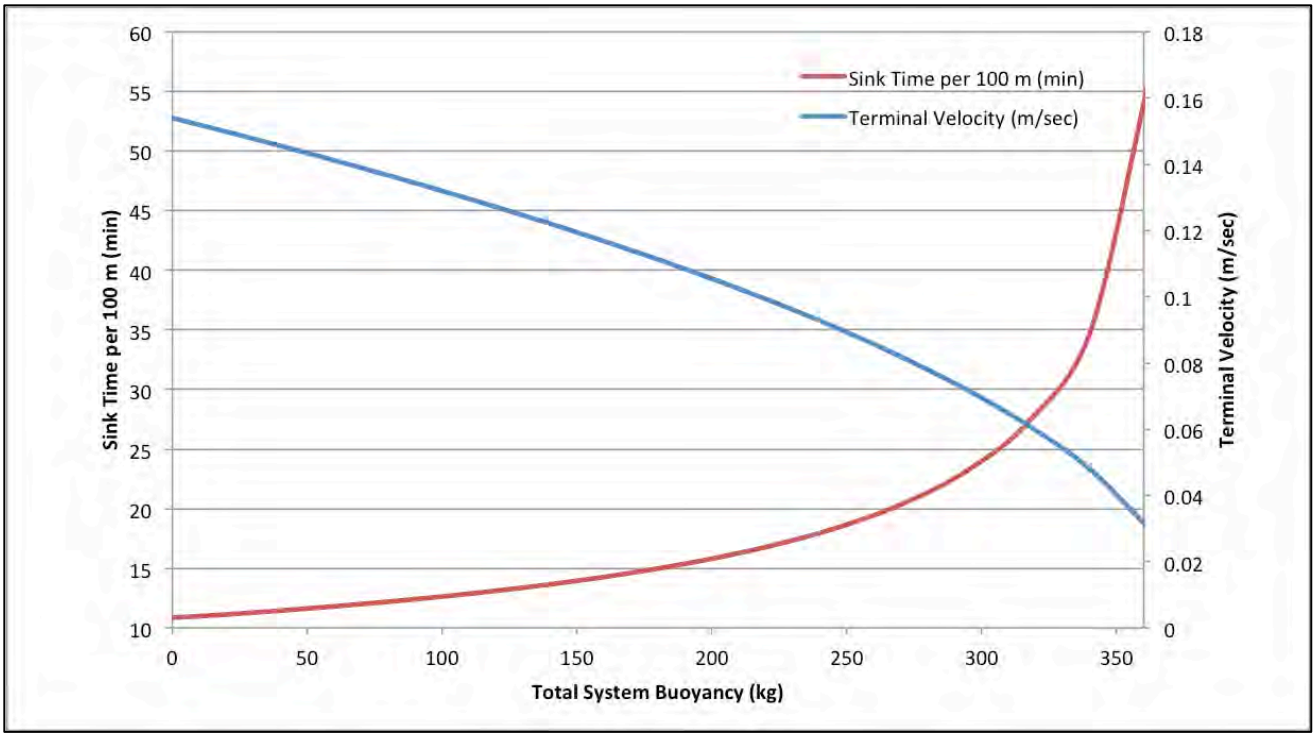


Figure 8: Estimated Sink Rates of Unrecoverable Flight Train

The time required to reach the ocean floor would depend on the depth of the ultimate landing location. However, based on the most commonly encountered depth "bins" within the action area (3,000 to 5,000 m [9,800 to 16,400 ft]: **IOC et al. 2003**), the descending flight train assembly would likely take between approximately 7.5 and 12.5 hours to reach such depths.

2.3.3 Fate of Unrecovered Materials

2.3.3.1 Meteorological Equipment

Latex Balloons

When a latex balloon is released, the helium gas inside it expands as the balloon rises. Depending on the weight of the balloon and the thickness of the latex, the helium will expand the latex until the balloon bursts. Commonly cited research (**Burchette 1989**) asserts that nearly all latex balloons at burst altitude rupture into small, ribbon-like fragments. However, **Foley** (**1990**) demonstrated that 80 percent of latex balloons studied burst into 2 to 3 mm shreds but, of those, 60 percent (48 percent of the total) remained intact (all or most parts still connected together) and 20 percent burst without shredding at all. Similarly, more recent research (**Irwin 2012**) noted that only 12 percent of balloons in a trial burst into small pieces and 81 percent were recovered with half the balloon mass intact. As such, from these studies, it is assumed that a portion of the MET balloons used in support of SFDT launch operations would land in the Pacific Ocean in small shreds, but most would likely land deflated and fully intact. These balloon pieces would be positively buoyant, float on the surface, and begin to photo-oxidize due to ultraviolet light

exposure. However, degradation would occur at a slower rate than on land due to less heat buildup and the biofouling. Numerous studies show that latex in water will degrade, losing tensile strength and integrity, though this process can require multiple months of exposure time (**Pegram & 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 & Andrady 1991; Lobelle & Cunliffe 2011**), or descending farther to rest on the seafloor (**Thompson et al. 2004**).

Polystyrene Radiosonde Box

Foamed polystyrene is a lightweight, positively buoyant polymer that is degraded by exposure to sunlight, high temperatures, moisture, abrasion, and fouling by microorganisms. According to weathering studies in the marine environment (**Andrady 1990**), foamed polystyrene sheets rapidly undergo yellowing, algal fouling, and embrittlement of the exposed surface. Over a twelve-month exposure period evaluated by **Andrady (1990)**, a surface layer of up to half the original thickness became brittle enough to crumble on handling. As the polystyrene became more brittle, wind and rain exposure scoured the surface, sloughing off fragments and decreasing the thickness of the material. **Andrady** (**1990**) also determined that the tensile strength of the remaining (non-yellowed) material decreases with the duration of exposure, as the deeper layers become accessible to the free radicals generated during the photoreaction. Foamed polystyrene degraded more quickly in seawater than on land, losing over 60 percent of tensile strength in 4 months and rapidly fragmenting.

As such, it is expected that the radiosonde boxes would remain afloat for a period time following oceanic impact, likely less than a year, during which a combination of fouling (**Wahl 1989**) and photodegradation would cause the material to break into smaller pieces and eventually sink into the water column. As each box would have "return to sender" information on it, the possibility exists for an inestimable portion of these items to be recovered prior to their ultimate degradation and/or descent below the water's surface.

Super Loki Rockets

Comprised of aluminum, these negatively buoyant items would sink and slowly corrode on the ocean floor. Small amounts of residual unconsumed solid propellant could be present inside them. However, effects on water quality would be negligible due to the extremely small amount of residual fuel and the effective dilution and buffering capacity of the ocean.

Corrosion of hardware and spent rocket stages into toxic concentrations of metal ions would be localized and temporary because corrosion rates of aluminum are very slow in seawater (**Godard 1960; Ezuber et al. 2008**) and do not change with immersion depth (**Vargel 2004**). Miscellaneous materials such as battery electrolytes are in such small quantities that only temporary, highly localized effects on water quality would be expected.

ROBIN Spheres

The degradation mechanisms for the plastic component (polyethylene terephthalate) of the Mylar ROBIN spheres would be similar to other polymers previously discussed. Studies have demonstrated (**Edge et al. 1991**; **Allen et al. 1994**) that the breakdown of these films is enhanced by increasing temperature, relative humidity, and ultraviolet (UV) irradiation, with high humidity causing the greatest degradation. However, due to the aluminized outer surface, photo-oxidation of the plastic material would be substantially reduced. As such, it is expected that biofouling (**Wahl 1989**) would occur before notable loss of structural integrity, with these items descending to the ocean floor where they would likely remain for many years.

2.3.3.2 Flight Train

Nylon Burst Parachute

The parachute's primary material, nylon, is in the family of high molecular weight polymers known as polyamides (**Hegde et al. 2004**), which are not easily degraded by abiotic (physical or chemical) or biotic processes (**Haines & Alexander 1974**). More specifically, LDSD parachutes are made of "ripstop" nylon that is woven with a double or extra-thick thread at regular intervals, creating a pattern of small squares. This structure keeps small tears from spreading (**Hall 2015**).

Photo-oxidative degradation, the process of decomposition of the material by light (most effectively by near-UV and UV wavelengths), would be the most effective source of damage exerted on the nylon parachute. Once initiated by exposure to sunlight, the degradation can continue thermo-oxidatively for some time without the need for further UV exposure as long as oxygen is available (**Andrady 2011**). However, upon entering the water column, the entire balloon flight train system would rapidly sink below the depths to which UV radiation in clear Pacific Ocean waters has been reported to penetrate (50 to 60 m [160 to 200 ft]: **Ahmad et al. 2003**), eventually resting on the ocean floor where exposure to UV light would also not occur (**Gregory & Andrady 2003**), making photo-oxidation improbable. Once on the ocean floor, the relatively constant temperatures (lacking diurnal cycling) and the 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 that 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 (which could cause a "mass" release of particles), 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 & Silver 1988**). Sinking rates of marine snow are estimated to range from 1 to 368 m (3 to 1,200 ft) per day (**Alldredge & 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 more than decades.

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 (**Derraik 2002**) to even thousands of years (**Barnes et al. 2009**), particularly in deep, cold, dark oceans (**Barnes et al. 2009; Bergmann & Klages 2012)**.

Because of the expected rapid descent toward the light-deficient ocean floor (**Wahl 1989**), fouling of a nylon burst 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**; **Moret-Ferguson et al. 2010**), though at the cost of replacing existing species and leading to non-natural alterations of community composition (**Bergmann & Klages 2012**). The epibionts of benthic polymer (i.e., plastic) debris are not as well-known as those of pelagic items. Accounts are limited (e.g., **Hollström 1975**), but indicate a hard ground biota dominated by broyzoans.

Kevlar® Ladder

Kevlar® is a negatively buoyant material that is highly resistant to mechanical degradation by abrasion or stretching (**Terry & Slater 1999**). Although studies have shown immersion in seawater causes fibers to swell and consequently lose tensile strength (**Fowler & Reiniger 1979; Riewald et al. 1986; Gopalan et al. 1989**), it is not expected that the material would be exposed to extreme mechanical loading once on the seafloor. As such, the material is expected to remain intact for the foreseeable future.

Metallic Components

Once the balloon flight train system is in contact with seawater, structural metallic components (i.e., aluminum and steel alloys) would corrode. Likewise, based on research conducted by **Rosak (1985)**, the $LiSO_2$ batteries would corrode, releasing their electrolytes (e.g., SO_2, acetonitrile, and lithium salt) into the water column and expose the internal lithium metal strips to seawater.

As corrosion rates in seawater are from the cumulative effect of multiple site-specific factors, including temperature, pH, dissolved oxygen, currents, and extent of biofouling (**Guedes Soares et al. 2011**), absolute corrosion rates of metallic balloon flight train hardware cannot be accurately estimated. However, some general observations can be made about the fate of these materials. When comparing potential corrosion rates of the balloon flight train system metals, due to the relatively high dissolved oxygen concentrations of the Pacific Ocean water at depth (**Joos et al. 2003**), ferrous materials would undergo corrosion more rapidly (**Melchers 2005**) than the aluminum components, which tend to form a protective oxide coating that can preserve the material (**Reinhart 1969**). Similarly, items containing lead (e.g., solder), a metal often regarded as highly resistant to corrosion in the marine environment (**Tylecote 1977**), would form a protective inorganic coating on their surfaces, slowing dissolution. Finally, given lithium metal's highly reactive nature in water, some of the corroded $LiSO_2$ batteries (i.e., those not fully discharged) could exhibit characteristic, short-duration lithium-water exothermic burning and popping, forming lithium chloride and releasing hydrogen gas (**Rosak 1985**). In the instance of fully discharged batteries, they would be unreactive due to the lithium metal being converted to a lithium oxide (**Aral & Vecchio-Sadus 2008**).

2.4 *Measures to Reduce Potential for Adverse Effects on Listed Species*

To reduce the potential for adverse effects on listed species, NASA has included the following measures as integral components of its proposed action.

2.4.1 Recovery of Expended Flight Hardware

As discussed in Section 2.3.1 of this BE, NASA requires that all major flight hardware components be tracked during flight until splashdown, at which point surface vessels (i.e., propeller-driven ships) will be deployed to recover the balloon and TV. The rapid recovery of

such items would limit the timeframe within which listed species could interact with (and therefore be exposed to stressors from) the expended flight hardware.

2.4.2 Employment of Vessel Operating Protocols

To ensure that in-water species are not exposed to ship-induced stressors (e.g., ship strike), constant vigilance would be maintained for the presence of ESA-listed marine mammals and sea turtles. Vessels would remain at least 92 m (300 ft) from Hawai‘ian monk seals and humpback whales and at least 46 m (150 ft) from all other marine mammals and sea turtles. Vessel speeds would be reduced to 18.5 km/hr (10 kt) or less when piloting in the proximity of marine mammals and further reduced to 9.25 km/hr (5 kt) or less when piloting in areas of known or suspected sea turtle activity. If marine mammals or sea turtle approach a vessel, activity would stop, allowing the animal to safety depart the immediate area prior to resuming operation. Additionally, to prevent the introduction of marine alien species, all submerged and waterline surfaces would be cleaned of algae or other organisms prior to vessel use and ballast water would be managed in accordance with U.S. Coast Guard Regulations (33 CFR Part 151).

Likewise, the operators of LDSD search and recovery aircraft are required to operate at an altitude greater than 457 m (1,500 ft), at which the effects of overflight (e.g., startle) would be minimal. Furthermore, should aircraft operators observe marine mammals or sea turtles, they would not undertake potentially harassing (e.g., repeated circling) patterns until the individuals are no longer under the aircraft’s flight path.

2.4.3 Reporting

Under the ESA (and the PMNM Permit General Terms and Conditions), NASA has a continuing duty to monitor the effects of its ongoing actions on listed species. As such, by December 31 of each year between the years 2015 and 2019, NASA will submit to NMFS a report on the outcomes of its proposed action. Annual reports will include the following: (a) the dates of all SFDT launches; (b) locations (GPS coordinates) of all SFDT flight terminations and resultant recoveries; (c) any available information on the fate of expended flight hardware after flight termination, including sink rate, evidence that components failed to sink, or evidence that components later reappeared on the surface; (d) information on attempts to recover hardware after flight termination; and (e) any evidence that listed species were adversely affected by the action.

2.5 *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.” **Figure 9** depicts the action area for the proposed SFDTs, which includes the airspace, land, water column, and seabed within which the balloon and TV could fly and expended flight hardware could land and ultimately come to rest. The action area also accounts for where the flight and deposition of meteorological support equipment (i.e., MET balloons, Super Loki rockets, ROBIN spheres) could occur.

The action area is defined by the addition of three shapes. The basic shape, depicted in light pink in **Figure 9**, is the LDSD operations area defined by a 315 km (170 nm) arc centered on Mākaha Ridge, Kauaʻi, which is the TV to PMRF telecommunications limit. This operations area is wholly inside the USN Hawaiʻian Range Complex, and is where the balloon would loft the TV, the TV would perform the SFDT, and expended flight hardware would land. The second orange shape is an approximately 11 km (6 nm) buffer along the western and northern PMRF to TV telecommunications arc. If the TV and balloon were to land at the northern or western boundary of the telecommunications limit, this buffer accounts for a conservative estimate of the distance floating hardware could drift with westerly flowing surface currents (**Flament 1996**) for the 12 hours it could take for recovery vessels to reach them. This buffer also includes a conservative estimate of potential lateral drift of the unrecovered flight train as it descends to the ocean floor. The third shape is a dark pink circle, having a 17 km (9 nm) radius centered at the MET balloon release location on PMRF, within which 2,000 gram and 30 gram MET balloons would land upon bursting at altitude.

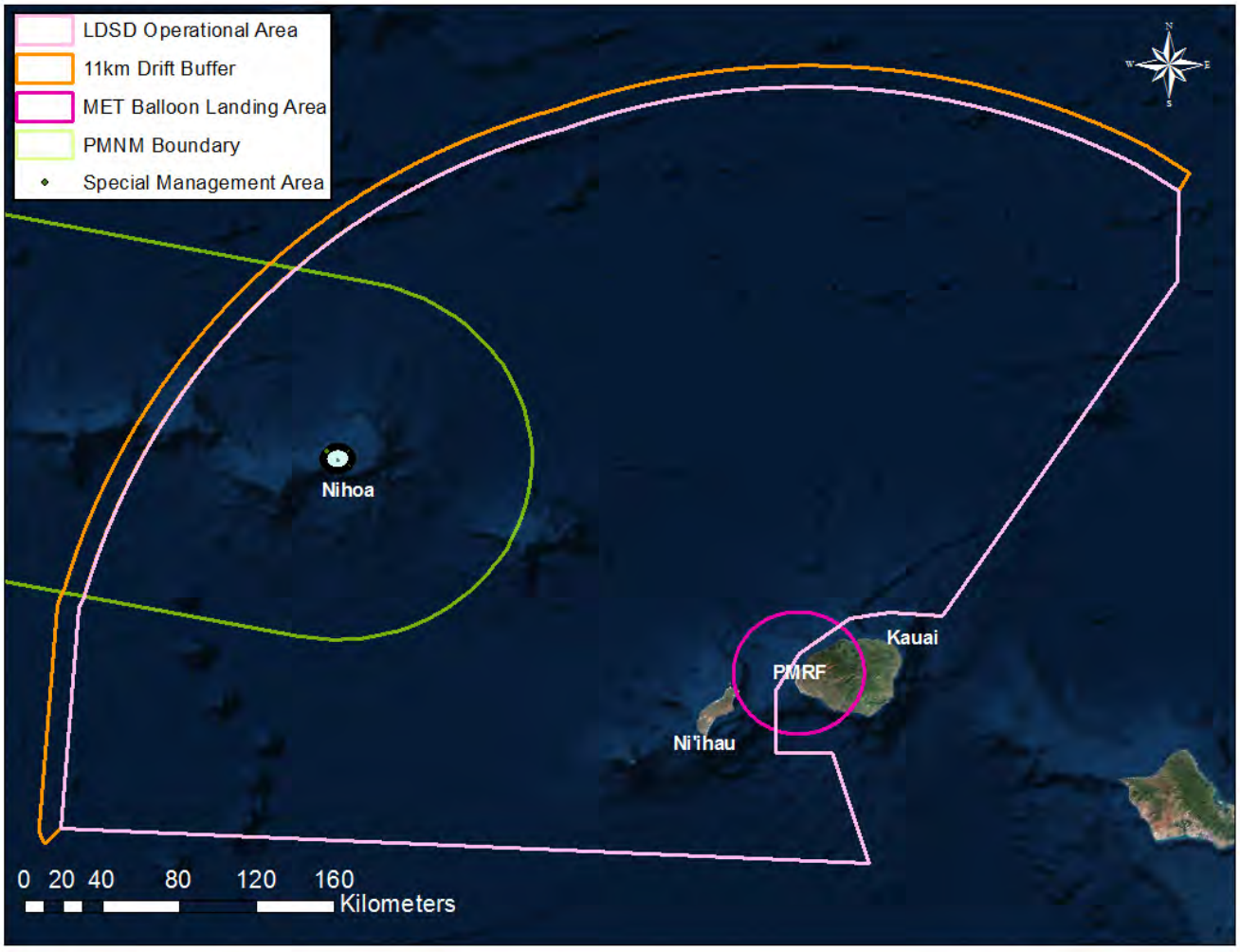


Figure 9: LDSD SFDT Action Area

It should be noted that under nominal flight conditions, the action area would not include the terrestrial or marine areas comprising Niʻihau, Nihoa Island, and the Special Management Area within 5.6 km (3.0 nm) surrounding Nihoa Island. To ensure that flight hardware does not land within these areas, one of two scenarios would occur: (1) the LDSD Project would initiate the SFDT in such a manner that expended flight hardware would be recovered or sink before drifting into either area or (2) the flight system would overfly these areas and the TV would be dropped outside either area. Therefore, with the exception of an in-flight system failure, expended flight hardware would not be deposited on Niʻihau, Nihoa Island, or within the Special Management Area surrounding Nihoa Island.

2.6 *Connected Federal Action Also Considered in This BE*

As the action area would include a portion of the PMNM, on January 27, 2015, NASA submitted to the PMNM permit coordinator an application seeking authorization to allow for access to PMNM waters. NASA is seeking this authorization via the established permitting process defined in Presidential Proclamation 8031 and codifying regulations in 50 CFR Part 404. PMNM issues permits in six categories (Research, Education, Conservation and Management, Native Hawaiʻian Practices, Special Ocean Use, and Recreation). Per recommendation of the PMNM permit coordinator, NASA is requesting authorization under Permit Category-Conservation and Management. The permit application seeks the ability to potentially drop and recover floating expended flight hardware from five years of future flights beginning with two scheduled SFDTs in 2015 within the boundary of PMNM, but outside of the Special Management Area surrounding Nihoa Island (**Figure 9**). This permit would also allow NASA to enter the PMNM for recovery purposes if the flight hardware is dropped outside the PMNM but carried into the PMNM by ocean currents.

Under the assumption that all possible trajectories were allowed to fly, NASA estimates the balloon has approximately a 0.4 percent chance of reaching float altitude within PMNM and a 20 percent chance of entering PMNM after reaching float altitude. These probabilities are reduced when NASA and the USN apply the project's established Go/No Go criteria (e.g., safety restrictions, proper weather conditions, operational status of all LDSD subsystems, telemetry checks, and readiness of recovery systems). These test rules eliminate trajectories that are predicted to fly out directly over large populated areas or follow a trajectory outside boundaries established by NASA, the USN and the Federal Aviation Administration.

3.0 Listed Species & Critical Habitat in the Action Area

The following ESA-listed marine species and critical could occur within the action area, or may be affected by the proposed action.

3.1 *Mysticetes*

Mysticetes are one of the two suborders of cetaceans and are characterized by having baleen plates for filter feeding (**Bannister 2009**). Two types of mysticetes occur in the action area: balaenids and rorquals (a family and a group, respectively).

3.1.1 Balaenids

Balaenids include the bowhead whales and right whales (**Bannister 2009**). One right whale species has the potential to occur in the action area.

3.1.1.1 North Pacific Right Whale

The North Pacific right whale (*Eubalaena japonica*) is ESA-listed as endangered throughout its range (**35 FR 18319**). Right whale adults typically are 13 to 16 m (43 to 52 ft) in length but North Pacific individuals may measure up to 18 m (59 ft) and weigh up to 100 metric tons (110 tons: **Kenney 2009**). The North Pacific right whale is comprised of two populations – western and eastern – that are considered isolated from each other (**Brownell et al. 2001**). The population of the eastern North Pacific is considered to be the smallest whale population in the world for which an abundance estimate is known, at approximately 30 animals (**Wade et al. 2010**). No reliable population estimate presently exists for the species in the western North Pacific, however it may number at least in the low hundreds (**Brownell et al. 2001**; **Clapham et al. 2004**).

Right whales migrate annually between high-latitude feeding grounds and low-latitude calving and breeding grounds (**Kenney 2009**). Feeding takes place in spring, summer, and fall in higher-latitude feeding grounds, where ocean temperatures are cooler and overall biological productivity is much higher (**Kenney 2009**). The specific locations of such feeding grounds are not well-known. Based on historical whaling records and the few recent sightings, **Clapham et al. (2004)** found that the principal feeding grounds were most likely in the Sea of Okhotsk, central and eastern Bering Sea, and Gulf of Alaska, all of which are more oceanic (offshore) habitats than those utilized by their well-studied North Atlantic counterparts. Breeding and calving both occur during the winter months, but the locations of such habitats for North Pacific right whales are unknown (**Kenney 2009**).

The primary food source for North Pacific right whales is zooplankton (e.g., copepods). Right whales are skim-feeders: they feed by removing prey from the water using baleen while moving with their mouth open through a patch of zooplankton, typically within the upper 10 to 20 m (33

to 66 ft) of the water column (**Watkins & Schevill 1976; Woodward et al. 2006; Parks et al. 2011**).

Occurrence of this species within the Hawai‘ian Islands, and, furthermore, the action area, would be considered rare based upon historical sightings data. For example, in April 1996, a right whale was sighted off of Maui (**Salden & Mickelsen 1999**). This was the first documented sighting of a right whale in Hawai‘ian waters since 1979 (**Herman et al. 1980**; **Rowntree et al. 1980**). Further supporting this conclusion is earlier work by **Scarff (1986)**, who reviewed information from the mid-1800s and that from **Rowntree et al. (1980)** and **Herman et al. (1980**), concluding that individuals in the waters off Hawai‘i, particularly during the time when the proposed action would occur (i.e., June-July), represented stragglers, not concentrations of wintering right whales. Although **Kennedy et al. (2012)** recently documented a high- to low-latitude migration of the individual sighted in April 1996, confirming that right whales at least occasionally travel across the North Pacific between Hawai‘i and Alaska, the authors caution that it is still premature to call the present record definitive proof of an annual migration.

3.1.2 Rorquals

Rorquals, of the family Balaenopterida, are the largest group of baleen whales, and include the blue, fin, sei, and humpbacks (**Bannister 2009**).

3.1.2.1 Blue Whale

The blue whale (*Balaenoptera musculus*) is ESA-listed as endangered throughout its range (**35 FR 18319**). It is the largest of the baleen whales, with lengths exceeding 30 m (100 ft: **Sears & Perrin 2009**). The North Pacific blue whale is comprised of two stocks – western and eastern. NMFS considers blue whales found in Hawai‘i as part of the western North Pacific stock (**Carretta et al. 2005**). Blue whales typically migrate between high-latitude feeding grounds and low-latitude wintering areas (**Sears & Perrin 2009)**. However, some individuals have been observed to remain in the same region year-round (e.g., **Watkins et al. 2000**). The western stock feeds in summer in the southwest of Kamchatka, south of the Aleutian Islands, and in the Gulf of Alaska (**Stafford 2003**; **Watkins et al. 2000**). In winter, they migrate to lower latitudes in the western Pacific and, much less frequently, in the central Pacific, including Hawai‘i (**Thompson & Friedl 1982**).

Blue whales are “lunge feeders” targeting dense patches of euphausiids and other crustacean meso-zooplankton (**Sears & Perrin 2009**) in the upper 150 to 200 m (490 660 ft) of the water column (**Croll et al. 2001, 2005**).

The presence of blue whales in the action area would be considered rare. With the exception of occasional encounters (e.g., O‘ahu: **Thompson & Friedl 1982**), there are few records of blue whales in Hawai‘ian waters. This conclusion is especially true during the time of year when the proposed action would occur, as individuals would be expected to be at higher latitudes in summer foraging grounds.

3.1.2.2 Fin Whale

The fin whale (*Balaenoptera physalus)* is ESA-listed as endangered throughout its range (**35 FR 18319**). The second largest of the whales in the family Balaenopteridae, fin whales range in length up to approximately 26 m (85 ft), with females slightly larger than males (**Aguilar 2009**). Fin whales are considered a cosmopolitan species and occur from polar to tropical waters, with the greatest concentrations usually outside of the continental slope (**Aguilar 2009**). Fin whales engage in north-south movements from wintering grounds to summer feeding areas (**Aguilar 2009**). The locations where breeding and calving occur remain largely unknown (**Rice 1998**) because, unlike other mysticetes, calving does not appear to take place in distinct inshore areas (**Reeves et al. 2002; Mizroch et al. 2009**). Reviewing historic catch, acoustic, and observation data, **Mizroch et al. (2009)** found that, during summer, fin whales range from the Chukchi Sea south to 35° N on the Sanriku coast of Honshu (Japan), to the Subarctic Boundary (approximately 42° N) in the western and central Pacific. During winter months, Pacific fin whales have been documented over a wide area from 60° N south to 23° N (**Mizroch et al. 2009**).

A 2002 shipboard line-transect survey of the entire Hawai‘ian Islands Economic Exclusion Zone (EEZ) resulted in an abundance estimate of 174 fin whales (**Barlow 2003**). However, **Barlow (2006)** did not provide a density estimate for fin whales in Hawai‘i because the survey (originally analyzed in **Barlow 2003**) was not conducted during the peak period of abundance (i.e., winter).

Fin whales are “lunge feeders,” feeding at similar depths and prey as blue whales (**Goldbogen et al. 2007**). Fin whales feed almost exclusively on euphausiids (**Aguilar 2009**).

Occurrence of this species within the action area, particularly during the time of year when the action would occur, would be highly unlikely. Summarizing observations of fin whales in the Hawai‘ian Islands, **Mizroch et al. (2009)** found that, while several sightings from the 1970s were during the month of May, no recent reports (e.g., O‘ahu: **Thompson & Friedl 1982, McDonald & Fox 1999**; Kaua‘i: **Mobley et al. 1996**) were between May and July. As with the other mysticetes potentially within the action area, fin whales would typically be at higher latitude foraging grounds during the summer months.

3.1.2.3 Sei Whale

The sei whale (*Balaenoptera borealis*) is ESA-listed as endangered throughout its range (**35 FR 18319**). Individuals range in length up to approximately 20 m (66 ft), which makes it the third largest whale in the family Balaenopteridae (**Horwood 2009**). Like most balaenopterids, sei whales are found in all oceans and migrate long distances north-south from high-latitude summer feeding grounds to lower-latitude winter areas. They range even farther offshore than fin whales and tend to be nomadic (**Mizroch et al. 1984**). In the North Pacific Ocean, their summer distribution extends from California westward to Japan and northward to the Aleutian Islands. In the eastern North Pacific, their winter distribution ranges from Piedras Blancas in California to

the Revillagigedo Islands off Mexico. However, in the central and western North Pacific, their winter distribution is largely unknown (**Rankin & Barlow 2007**).

The NMFS divides Pacific Ocean sei whales into three stocks, one of which inhabits the waters around Hawai‘i. A 2002 shipboard line-transect survey of the entire Hawai‘ian Islands EEZ located groups of sei whales northeast of Maui (late November) and east of Hawai‘i, resulting in a summer and fall abundance estimate of 77 sei whales (**Barlow 2003**). **Barlow (2006)** did not provide a density estimate for sei whales in Hawai‘i because the survey (originally analyzed in **Barlow 2003**) was not conducted during the peak period of abundance (i.e., winter).

Sei whales are primarily skimmers rather than lunge swallowers, feeding on patches of copepods (their preferred prey), euphausiids, fish, and squid, if available (**Horwood 2009**).

3.1.2.4 Humpback Whale

The humpback whale (*Megaptera novaeangliae*) is ESA-listed as endangered throughout its range (**35 FR 18319**). Humpback whales are shorter and stouter than most other balaenopterids. At maturity, individuals are typically between 14 and 15 m (46 and 49 ft: **Clapham 2009**). In the North Pacific, there are three separate humpback whale populations with the Central North Pacific stock occurring within Hawai‘ian waters (**Allen & Angliss 2014**). Employing the most recent survey data from the SPLASH study (**Calambokidis et al. 2008**), **Allen & Angliss (2014)** conservatively estimated the minimum abundance for the Central West Pacific stock to be approximately 5,800 individuals.

Humpbacks are typically found in coastal or shelf waters in summer and close to islands or reef systems in winter (**Clapham 2009**). The species is highly migratory, moving seasonally between low-latitude winter breeding areas and high-latitude summer feeding grounds (**Clapham & Mead 1999**). In summer, the majority of whales from the Central North Pacific stock are found in the Aleutian Islands, Bering Sea, Gulf of Alaska, and Southeast Alaska and northern British Columbia (**Calambokidis et al. 2001**). Humpback whales use Hawai‘ian waters as a major breeding ground during winter and spring (November through April: **Baker et al. 1986**). **Calambokidis et al. (1997)** estimated that up to half of the North Pacific populations of humpback whales migrate to the Hawai‘ian Islands during the winter. Peak abundance around the Hawai‘ian Islands is from late February through early April (**Mobley et al. 2001**; **Carretta et al. 2005**). During the fall–winter period, primary occurrence is generally within approximately 90 kilometers (50 nm) offshore, which takes into consideration both the available sighting data and the preferred breeding habitat (shallow [< 200 m (660 ft)] waters: **Herman & Antinoja 1977**; **Mobley et al. 1999**). The greatest densities of humpback whales (including calves) are in the four-island region consisting of Maui, Moloka‘i, Kaho‘olawe, and Lana‘i, as well as Penguin Bank (**Mobley et al. 1999, 2001**) and around Kaua‘i (**Mobley 2005**). However, coupling spatial modeling with observation data, **Johnston et al. (2007)** also identified extensive areas of suitable wintering habitat within the Northwestern Hawai‘ian Islands (NWHI).

Humpbacks have shorter and coarser baleen bristles than other baleen whales and feed on both euphausiids and schooling fish (**Clapham 2009**). Primarily classified as "swallowers" rather than "skimmers," feeding primarily occurs in the upper 150 m (490 ft) of the water column (**Goldbogen et al. 2008; Ware et al. 2011**).

Of the mysticetes potentially within the action area, the humpback whale is the species most likely to occur. Its presence during the time the action is conducted (i.e., June-August) would be unlikely, as it would be in northern foraging grounds, returning to the nearshore waters of the action area in late fall.

3.2 *Odontocetes*

Odontocetes are the second suborder of cetaceans and are characterized by having teeth (**Hooker 2009**).

3.2.1 False Killer Whale

Three stocks of false killer whales (*Pseudorca crasidens*) are recognized within Hawai'ian waters: the Hawai'i pelagic stock, the Main Hawai'ian Islands (MHI) insular stock, and the NWHI insular stock (**Carretta et al. 2014**). The MHI insular Distinct Population Segment (DPS) is ESA-listed as endangered throughout its range (**77 FR 70915**). A member of the dolphin family, females reach lengths of almost 5 m (16 ft), while males are almost 6 m (20 ft: **Baird 2009**). In adulthood, false killer whales can weigh approximately 680 kilograms (1,500 pounds). False killer whales are considered to be very social animals, usually traveling in groups of 20 to 100 individuals (**Baird 2009**).

Forney et al. (2010) defined the general boundaries of the MHI insular stock to include a "core" use area extending 40 km (22 nm) from shore and an "extended" offshore boundary ranging from the outer boundary of the "core" area out to 140 km (76 nm) from the MHI. **Baird et al. (2012)** found three areas of frequent use by the MHI insular population: the north side of the island of Hawai'i (both east and west sides), a large area extending from north of Maui to northwest of Moloka'i, and a small area to the southwest of Lana'i. The depth distribution for high-use areas was mean depth of 623 m (2,070 ft), relative to an overall median depth of 1,679 m (5,500 ft: **Baird et al. 2012**). Tracks from tagged individuals provided documentation that individuals from the central and eastern MHI use the area around Kaua'i and Ni'ihau (**Baird et al. 2010**, **2011**). Knowledge of seasonal movements of this species is still evolving. **Baird et al. (2012)** provided satellite tracking data for a large number of individuals, however their data did not cover the timeframe between March and June. Although the authors acknowledge that the species does use some of the same areas during these months, as in the months for which data is available, more information is needed to determine whether additional areas outside of their identified high use areas are frequented (**Baird et al. 2012**).

In Hawai'i, false killer whales have been documented feeding on a wide variety of large fish, including wahoo (*Acanthocybium solandri*), tunas (*Thunnus* spp.), and broadbill swordfish

(*Xiphias gladius*) (**Baird et al. 2008**). Little is known about the diving behavior of this species in Hawai‘i (**Baird et al. 2012**). However, a recent tracking study by **Baird et al. (2014)** off the coast of Kaua‘i has contributed to the knowledge base. The single tagged individual in the study was observed to dive to median depths of approximately 138 m (453 ft) with a maximum recorded dive of 928 m (3,040 ft). As the median depth of the waters within which the individual was monitored was 710 m (2,330 ft), some of the deepest dives were likely at, or near, the sea floor (**Baird et al. 2014**).

3.2.2 Sperm Whale

The sperm whale (*Physeter macrocephalus*) is ESA-listed as endangered throughout its range (**35 FR 18319**). The largest odontocete, male sperm whales are 18.5 m (60 ft) in length, females 12.5 m (41 ft: **Rice 1989**). Sperm whales are typically found in deep oceanic waters, with females almost always inhabiting water deeper than 1,000 m (3,300 ft: **Whitehead 2009**). **Baird et al. (2013)** most commonly encountered sperm whales in Hawai‘ian waters deeper than 3,000 m (10,000 ft). Sperm whales are widely distributed throughout the Hawai‘ian Islands year-round (**Au et al. 2014**; **Baird et al. 2013**; **Barlow 2006**; **Mobley et al. 2000**), and have been found to be the most abundant large whale in Hawai‘ian waters during summer and fall months (**Barlow 2006**). **Barlow (2006)** estimated there to be approximately 6,900 sperm whales in Hawai‘ian waters based on his survey work conducted between August and November 2002. A recent yearlong acoustic monitoring study conducted by **Au et al. (2014)** within and adjacent to the action area most frequently identified sperm whales on the southwest side of Kaua’i between the months of March and June.

In comparison to the other cetacean species in the action area, sperm whales forage at deeper water depths. Maximum-recorded dive depths differ across regions, with values of 644 and 985 m (2,110 and 3,230 ft) for the Gulf of Mexico and Atlantic Ocean, respectively (**Watwood et al. 2006**), 1,400 m (4,600 ft) in the north Pacific Ocean (**Aoki et al. 2012**), and up to nearly 1,900 m (6,230 ft) off the coast of Norway (**Teloni et al. 2008**). Though individuals do forage at the ocean floor, the majority of foraging observed occurred higher in the water column (**Aoki et al. 2012**; **Mathias et al. 2012; Miller et al. 2013; Teloni et al. 2008; Wahlberg 2002**).

Sperm whales spend about 70 to 80 percent of their time at depths of several hundred meters (**Amano & Yoshioka 2003**; **Watkins et al. 1993**), and most of their diet consists of mesopelagic and bathypelagic cephalopods (**Clarke 1980**; **Clarke et al. 1993**; **Kawakami 1980**). Multiple hypotheses exist regarding the means sperm whales locate prey. However, it is generally accepted that foraging individuals rely heavily on emitting acoustic “clicks” during dives to echolocate prey items (**Madsen et al. 2002**; **Miller et al. 2004**).

3.3 *Pinnipeds*

One species of phocid (true seal), the Hawai‘ian monk seal, is known to inhabit the action area. Additionally, designated and proposed Hawai‘ian monk seal critical habitat is within the action area.

3.3.1 Hawai‘ian Monk Seal

The Hawai‘ian monk seal (*Neomonachus schauinslandi*; formerly *Monachus schauinslandi*) is ESA-listed as endangered throughout its range (**41 FR 51611**). Adults range in length from 2.1 to 2.4 m (7 to 8 fr) and weights are between 170 and 240 kg (375 and 529 lb), with females slightly larger than males (**Gilmartin & Forcada 2009**). The species occurs only in the central North Pacific and are managed as a single stock, although there are six main reproductive subpopulations at French Frigate Shoals, Laysan Island, Lisianski Island, Pearl and Hermes Reef, Midway Atoll, and Kure Atoll (**Ragen & Lavigne 1999**), all of which are outside the action area. The vast majority of the population is present in the NWHI. Monk seal births in Hawai‘i usually occur from February to August, peaking in April to June, but births are known in all months (**Gilmartin & Forcada 2009**).

Until recently, this species occurred almost exclusively at remote atolls in the NWHI. In the last decade, however, sightings of Hawai‘ian monk seals in the MHI have increased considerably (**Baker & Johanos 2004**). Most monk seal haulout events in the MHI have been on the western islands of Ni’ihau and Kaua’i (**Baker & Johanos 2004**), including the PMRF Main Base beach. The best estimate of the total population size is approximately 1,060 individuals in the Hawai‘ian Islands Archipelago, of which at least 150 are in the MHI (**Baker et al. 2011**) and the remaining 910 in the NWHI. Recent population trends indicate that the population in the MHI is growing whereas that in the NWHI is decreasing (**Baker et al. 2011**). A recent analysis of range-wide movements by **Johanos et al. (2013)** demonstrates connectivity (albeit rare; 10 seals in 30 years of observations) between the NWHI and MHI subpopulations and highlighted an approximately 2,400 km (1,300 nm) transit by a female spanning the entire Hawai‘ian archipelago. Intra-region movements were more common (**Johanos et al. 2013**).

Hawai‘ian monk seals have a diverse prey base, including demersal fish, squid, octopus, eels, and crustaceans (**Parrish et al. 2000; Cahoon et al. 2013**), with little observed difference between those of the NWHI and MHI subpopulations (**Cahoon et al. 2013**). They mostly forage within their resident atolls and along the barrier reefs, but may also forage at distant seamounts and submerged reefs hundreds of kilometers from their colonies (**Gilmartin & Forcada 2009; Stewart et al. 2006**). **Stewart et al. (2006)** found most (75 percent) core foraging areas to occur within 20 km (11 nm) of the respective colony. Although individuals have been observed diving to depths of approximately 500 m (1,640 ft: summarized by **Stewart et al. 2006**), the majority of foraging activity typically occurs at depths less than 100 m (330 ft: **Parrish et al. 2000, 2005, 2008; Stewart et al. 2006**).

3.3.2 Hawai‘ian Monk Seal Critical Habitat

Hawai‘ian monk seal critical habitat has been designated under the ESA to include all beach areas, sand spits and islets, including all beach vegetation to its deepest extent inland, and lagoon waters out to a depth of 37 m (120 ft [or 20 fathoms]) in designated areas of use (**53 FR 18988**).

Essential features of critical habitat for Hawai‘ian monk seals include the following: terrestrial coastal areas with characteristics preferred for pupping and nursing; shallow, sheltered aquatic areas adjacent to coastal locations preferred for pupping and nursing; marine areas preferred for foraging; areas with low levels of anthropogenic disturbance; marine areas with adequate prey quantity and quality; and areas used for hauling out, resting, or molting.

NMFS has proposed to extend critical habitat in the NWHI out to the 500 m (1,640 ft) depth contour and to include Sand Island at Midway Islands; and by designating six new areas in MHI. Specific areas proposed for the MHI include terrestrial and marine habitat from 5 m (16 ft) inland from the shoreline extending seaward to the 500 m (1,640 ft) depth contour around Ka‘ula Island, Ni‘ihau, Kaua‘i, O‘ahu, Maui Nui (including Kaho‘olawe, Lana‘i, Maui, and Moloka‘i), and Hawai‘i (**76 FR 32026**). Several zones within the action area (e.g., PMRF offshore areas) have been excluded from designation in the proposed rule due to national security reasons (**76 FR 32026**).

3.4 *Sea Turtles*

There are two families of sea turtles (**Wynne & Schwartz 1999**). The Cheloniidae family contains six genera and six distinct species. These species are loggerhead, green, flatback, hawksbill, Kemp’s ridley, and olive ridley. The family Dermochelyidae is comprised of only one genus and species, commonly referred to as the leatherback sea turtle. Five species of federally-listed sea turtles could potentially occur within the action area.

3.4.1 Cheloniids

3.4.1.1 Green Turtle

The Hawai‘ian population of green sea turtle (*Chelonia mydas*) is ESA-listed as threatened throughout its range (**43 FR 32800**). On February 16, 2012, NMFS received a petition to classify the species in Hawai‘i as a DPS and to delist that DPS under the ESA. On August 1, 2012, NMFS made a positive 90-day finding (**77 FR 45571**), determining that the petitioned action may be warranted. A comprehensive status review is underway to inform the 12-month finding.

Green sea turtles are the largest of all the hard-shelled sea turtles, but have a comparatively small head. While hatchlings are just 50 mm (2 in) long, adults can grow to more than 1.2 m (4 ft) long and weigh 136 to 159 kg (300 to 350 lb). The green sea turtle is the most common sea turtle species occurring in the waters around the Hawai‘ian Islands. Green turtles live in nearshore coastal habitats, with high fidelity to specific reef, rock, bay, or lagoon feeding

locations. The species' breeding and nesting season ranges between mid-April and mid-August of each year (**Balazs 1976**). During the breeding season males and females swim 800 to 1,300 km (430 to 700 nm) from their feeding grounds in the MHI to their nesting beaches. More than 90 percent of all green sea turtle breeding and nesting activity in Hawai'ian waters occurs at French Frigate Shoals (**Balazs 1980**), with the main rookery on East Island (**Tiwari et al. 2010**). Occasional nesting activity has been observed within the action area at the PMRF beach, however most individuals observed at PMRF are basking. Upon nesting, most adults migrate to the coastal waters surrounding the MHI (especially around Maui and Kaua'i) (**Balazs 1976**). Hatchling green turtles emerge from their nests and enter the ocean, a time after which little is known until they enter neritic foraging grounds approximately five to ten years later (**Reich et al. 2007**). Consequently, post-hatchling green sea turtles in this oceanic phase can occur hundreds of kilometers from landmasses in water depths at least kilometers deep (**Parker et al. 2011**).

Adult green sea turtles are unique among sea turtles in that they are primarily herbivorous, feeding on seagrasses, sea lettuce, and algae, and to a lesser extent, jellyfish, salps, and sponges (**Bjorndal 1997**). During the oceanic phase of life, young green turtles are primarily carnivorous, foraging on prey items commonly found within the first 100 m (330 ft) of the water column, including zooplankton, crustaceans, and mollusks **(Parker et al. 2011)**. Most of the adults' time is spent at depths less than 30 m (100 ft) when on the foraging grounds but they can dive to depths of over 100 m (330 ft) when migrating, although the majority of their migratory dives are usually much shallower (1 to 4 m [3 to 13 ft] diurnal; 35 to 55 m [115 to 180 ft] nocturnal: **Rice & Balazs 2008**).

3.4.1.2 Hawksbill Turtle

The hawksbill sea turtle (*Eretmochelys imbricate*) is ESA-listed as endangered throughout its range (**35 FR 8491**). Hawksbill sea turtles are the second most common species in the offshore waters of the Hawai'ian Islands, although they are far less abundant than green sea turtles. In Hawai'i, hawksbills nest on MHI beaches, primarily along the east coast of the island of Hawai'i and, to a much lesser extent, Maui, O'ahu, and Moloka'i (**NMFS & USFWS 1998a**). Peak nesting activity occurs from late July to early September (**Katahira et al. 1994**). Similar to other species of sea turtles, upon hatching, young hawksbills inhabit an oceanic habitat, returning years later to neritic habitats as larger juveniles (**Musick & Limpus 1997**).

In a study of satellite-tracked females, **Parker et al. (2009)** found post-nesting movements of adult Hawai'ian hawksbills to be relatively short-range (90 to 345 km [49 to 186 nm] from nesting beaches), and largely confined to coastal waters (depths less than 30 m [100 ft]) within the MHI. The west coast of O'ahu was the farthest west that the individuals tracked in the **Parker et al. (2009)** study traveled when foraging. Previous sightings of immature Hawai'ian hawksbills (e.g., **Keuper-Bennett & Bennett 2002**) have also been in very shallow areas of the MHI.

Sightings of hawksbills in the NWHI are even more rare (**NMFS & USFWS 1998a**). Summarizing historic and contemporary sightings of hawksbill sea turtles in the NWHI, **Van Houten et al. (2012)** identified six definitive observations and three potential nesting records. Based on this information, the authors conclude that hawksbills currently occur within the NWHI (albeit in low numbers), with a lack of regular monitoring within this geographic area likely contributing to the infrequency of documented observations (**Van Houten et al. 2012**).

Studies of hawksbill diet have identified sponges (Caribbean: **Meylan 1988**) and, to a lesser extent, tunicates (eastern Pacific: **Carrión-Cortez et al. 2013**) as primary forage items. In a study of Eastern Pacific hawskbills, **Gaos et al. (2012)** rarely observed adult hawksbills diving deeper than 20 m (66 ft) in the water column.

3.4.1.3 North Pacific Loggerhead Turtle

The North Pacific DPS of the loggerhead sea turtle (*Caretta caretta*) is ESA-listed as endangered throughout its range (**75 FR 58868**). This reddish-brown turtle averages approximately 0.9 m (3 ft) in length and 136 kg (300 lb) in weight. Nesting in the Pacific basin is restricted to the western region (primarily Japan and Australia), with those in U.S. waters likely originating from Japanese beaches (**NMFS & USFWS 1998c**). There is no loggerhead nesting on the western seaboard of the United States or in Hawai‘i (**Balazs 1982**). However, southern California and western Mexico serve as important coastal foraging areas (**NMFS & USFWS 1998c**). Only four records of occurrence exist for Hawai‘i, all of which were juveniles and most likely drifted over from Mexico or Japan (**NMFS & USFWS 1998c**).

Central North Pacific loggerheads in oceanic habitats have been shown to forage primarily on floating organisms, including gastropods, pelagic crabs, barnacles and, to a lesser extent, pyrosomas, among others (**Parker et al. 2002**). In a study of tagged North Pacific loggerheads within the open ocean, **Polovina et al. (2004)** found individuals to associate with oceanic eddies and fronts, most frequently occupying the uppermost stratum of the water column, spending approximately 90 percent of their time at depths less than 40 m (130 ft; 40 percent of time at the surface), with occasional dives to depths in excess of 100 m (330 ft).

3.4.1.4 Olive Ridley Turtle

The olive ridley sea turtle (*Lepidochelys olivacea*) is ESA-listed as threatened throughout its range (**43 FR 32800**). They are regarded as the most abundant sea turtles in the world, with nesting occurring primarily on beaches of India, southern Mexico, and northern Costa Rica (**NMFS & USFWS 1998d**). **Balazs & Hau (1986)** reported a single Hawai‘ian nesting event on the island of Maui in September 1985. In-water sightings are also rare, with the majority of those observed as takes within the Hawai‘ian-based longline fishery (e.g, **Work & Balazs 2010**).

An analysis of stomach contents from eight olive ridleys caught in the Hawai‘i-based longline fishery indicates that, while olive ridleys do forage on some organisms at the ocean’s surface, their most common prey are pyrosomas and salps which are found at deeper depths (**Polovina et**

al. 2004). In this same study, **Polovina et al. (2004)** found olive ridleys to most frequently occupying the epipelagic stratum of the water column, spending approximately 60 percent of their time at depths less than 40 m (130 ft; 20 percent of time at the surface), with occasional dives to depths in excess of 150 m (490 ft). **Swimmer et al. (2006)** recorded an olive ridley in the eastern Pacific Ocean diving in excess of 400 m (1,310 ft). However, most dives were less than 100 m (330 ft).

3.4.2 Dermochelyids

3.4.2.1 Leatherback Turtle

The leatherback sea turtle (*Dermochelys coriaacea*) is ESA-listed as endangered throughout its range (**35 FR 8491**). Leatherbacks are the largest marine turtle, with a curved carapace length often exceeding 1.5 m (5 ft) and front flippers that can span 2.7 m (9 ft: **NMFS & USFWS 1998b**). Leatherback sea turtles are a highly oceanic species and undertake long journeys of over 2,800 km (1,510 nm), in some cases reaching cold seas far from their tropical nesting grounds (**Hughes et al. 1998**).

Two populations of leatherbacks occur in the Pacific Ocean – eastern and western. Eastern Pacific leatherback turtles nest in Mexico and Costa Rica during the boreal winter (October through March: **Eckert et al. 2012**). In contrast, western Pacific leatherback turtles nest year-round at beaches across Australia, Malaysia, Indonesia, and Papua New Guinea (**Eckert et al. 2012**). Once leatherback hatchlings enter the oceanic environment, little is known about this portion of their life until they recruit to neritic habitats as juveniles. It is hypothesized that areas of upwelling and/or convergence zones may serve as nursery grounds (**Musick & Limpus 1997**).

Migratory routes of adult leatherbacks are not well-known. However, recent satellite telemetry studies have documented transoceanic migrations between nesting beaches and foraging areas in the Pacific Ocean basin (**Bailey et al. 2012**) and have characterized the post-nesting movements of summer and winter nesters (**Benson et al. 2011**). The oceanic areas visited by foraging turtles are mainly characterized by sea currents and related features, which can influence leatherback feeding-related movements. In particular, convergence zones and eddies may concentrate nutrients and organisms, and thus represent patches of high prey abundance targeted by foraging turtles (**Carr 1987**). Recent research by **Seminoff et al. (2012)** demonstrates that most adult Pacific leatherbacks demonstrate fidelity to foraging areas between nesting events. Leatherbacks are regularly observed in the offshore waters at the southern end of the Hawai‘ian archipelago, potentially during their movement from one area of the Pacific Ocean to another (**NMFS & USFWS 1998b**).

Leatherbacks primarily forage on gelatinous zooplankton, including cnidarians (jellyfish and siphonophores) and, to a lesser extent, tunicates (pyrosomes and salps) at or just below the sea surface (**Bjorndal 1997**). Leatherback sea turtles are the deepest reptilian divers: maximum dives ranging from 630 m (2,070 ft: **Hays et al. 2004**) up to 1,280 m (4,200 ft: **Doyle et al. 2008**) have been observed in the oceanic Atlantic. However, dives are typically much shallower (generally < 300 m [980 ft]: **Houghton et al. 2008**).

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4.0 Environmental Baseline Conditions

This section identifies and describes known human-induced sources of impact to the listed species in the action area, except those caused by the proposed action. A recent, comprehensive environmental baseline of the action area is provided in the *Biological Opinion and Conference Report on U.S. Navy Hawai'i-Southern California Training and Testing* (**NMFS 2014**). As such, this section provides a summary of conditions as described in that document.

The listed species within the action area are exposed to a host of anthropogenic stressors, including:

- Intentional killing
- Commercial and subsistence harvesting
- Interaction with commercial fishing gear
- Vessel strikes
- Habitat degradation
- Invasive species
- Disease
- Interaction with marine debris
- U.S. Navy training and testing activities
- Ambient noise
- Commercial and private whale watching
- Scientific research

Of the above listed stressors, intentional killing and commercial and subsistence harvesting are (in relative terms) the least likely to affect the species on an ongoing basis while the proposed action is occurring. For example, while there have been several documented Hawai'ian monk seal killings, the numbers of these incidents is relatively low (**Carretta et al. 2014**). Likewise, while historic whaling practices in the action area may be having latent effects on species in the action area, this practice is now outlawed. Vessel strikes, most commonly considered a threat to large whale species, but also a potential threat to sea turtles, occur within the action area but at an unknown extent. Habitat degradation, owing to the introduction of toxins into the aquatic environment, and the transmission of anthropogenic noise into the water column are also occurring, again with adverse, albeit unquantifiable effects at the species level. Both disease (resulting from anthropogenically-introduced pathogens) and invasive species are to some degree affecting species within the action area.

Due to oceanic transport patterns in the Pacific Ocean, marine debris is commonly encountered within the action area (**Kubota 1994**), at times to the detriment of nearly all listed species within the action area (cetaceans: **Baulch & Perry 2014**; sea turtles: **Schuyler et al. 2014**; all species: **Laist 1997**). The U.S. Navy frequently conducts testing and training activities with the action area, including mid- and low frequency active sonar, high frequency active acoustic monitoring,

and sink exercises. Naval operations also introduce military expendable materials into the water column, a potential ingestion or entanglement stressor. While it is probable that multiple listed species are unavoidably exposed to elevated underwater sound levels during Naval activities within the action area, the strict mitigation and monitoring undertaken during these exercise has proven to be effective in ensuring that exposures are not lethal.

Unrelated to Naval activities, listed species are also exposed to regular anthropogenic noise in both deep and shallow water habitats (**Urick 1983**). Scientific research also results in lethal (i.e., Hawai‘ian monk seal males) and non-lethal take of all species potentially within the action area. Finally, entrapment and entanglement in commercial fishing gear is one of the most frequently documented sources of human-caused mortality in both large whale and sea turtle species.

As concluded in **NMFS 2014**, despite the persistent adverse effects of the environmental baseline, blue, fin, humpback, and sperm whale populations appear to be increasing, or at least not declining, within the action area. Likewise, Hawai‘ian monk seals in the MHI appear to be increasing in numbers (**Baker et al. 2011**). Conversely, MHI false killer whales and Hawai‘ian monk seals in the NWHI continue to decline in numbers, as do sea turtle species, including green, hawksbill, leatherback, and loggerheads, exposed to the combined threats of entanglements in fishing gear, overharvests, and loss of their nesting habitat.

5.0 Effects of the Action

This section addresses potential impacts on listed species and critical habitat that NMFS has identified as having the potential to occur within the action area. In preparing this analysis, the proposed action is divided by the stressors it could impart upon listed species and critical habitat. Species are grouped, when possible, under each stressor instead of providing a repeated analysis of effects for each species. Despite this "grouping" analytical approach, species-specific considerations are elucidated when they could have a bearing on either the likelihood or significance of the stressor.

5.1 *Supersonic Flight*

Once a MET rocket is launch and again when the TV is released from the scientific balloon, they would be accelerated to a velocity beyond the sound barrier, at which point they would create sonic booms. When heard at the ground, a sonic boom consists of two shock waves of approximately equal strength. The complete ground pattern of a sonic boom depends on the size, shape, speed, and trajectory of the vehicle creating it. Since typical aircraft fly supersonically with relatively low horizontal angles, the boom is directed toward the ground. However, for the TV ascent trajectory, which would have a much higher horizontal angle (i.e., between 60 and 72 degrees), the boom would be directed laterally. This causes the sonic boom to propagate much further downrange when compared to typical aircraft sonic booms. Extended propagation usually results in very shallow propagation angles, relatively lower sonic boom levels, and negligible energy being transmitted to the earth's surface.

Of all factors affecting the intensity of sonic booms, altitude has the most significant influence. The magnitude of the sonic boom will decrease with increasing altitude of the vehicle, as this requires the boom to travel further through the atmosphere. Given that the TV's flight would become supersonic at altitudes in excess of 3,500 m (115,000 ft), and, when considered in conjunction with the high angle of attack during ascent, the resultant energy transferred to the water's surface would be negligible. Comparatively, given the MET rocket's small mass, aerodynamic shape, and high launch and steep descent angles, the resultant energy transfer would be less than that of the TV. Therefore, the remainder of the discussion focuses on the sonic boom created by the TV.

Atmospheric reentry of an object can also generate a sonic boom on the ground as the body falls back to Earth. For this case, the propagation is directed toward the ground, so the boom is more concentrated around the impact site. As the descent of the TV would also be at supersonic speeds (yet still above 30,500 m [100,000 ft] above ground level [AGL]), this portion of flight would create a more intense (in terms relative to the ascent phase) sonic boom. However, in absolute terms, the potential overpressure felt at the ocean's surface would also be minor for the following reasons.

Herron (2007) modeled the re-entry of NASA's Crew Exploration Vehicle, also a "blunt body vehicle", although substantially heavier (6,700 kg [14,800 lb]) than the TV (3,040 kg [6,700 lb] at drop; 1,300 kg [2,900 lb] when solid propellant is consumed). The results of her work predicted maximum overpressure values ranging from 15.8 to 20.6 pascals (Pa; 0.33 up to 0.43 pounds per square foot [psf]). Similarly, **Hilton & Henderson (1974)** measured the overpressures created by the reentry of the 5,800-kg (12,800-lb) Apollo 15 capsule into the Pacific Ocean, recording values ranging from approximately 9.6 to 38.3 Pa (0.2 to 0.8 psf), depending on lateral distance from the impact location and altitude of the descending spacecraft. By comparison, the NASA Space Shuttle generated maximum overpressures in excess of 59.9 Pa (1.25 psf: **NASA 1989**) and typical supersonic aircraft generate maximum overpressures in the range of 47.9 to 143.6 Pa (1 to 3 psf: **Richardson et al. 1995**). In an unrelated study of sonic booms of similar magnitude (i.e., 9.6 Pa [0.2 psf]) to those presented in **Herron (2007)** and **Hilton & Henderson (1974)**, observers on the ground who were operating the sonic boom recording equipment within the predicted footprint of the sounding rocket boom "heard the boom but felt that they would not have noticed it had they been engaged in an unrelated activity" (**Plotkin et al. 2006**).

It is expected that the overpressure values generated by the TV reentry would be even less than those predicted by **Herron (2007)** or recorded by **Hilton & Henderson (1974)**, as larger and heavier objects must displace more air and create more lift to sustain flight, thereby creating sonic booms stronger than those of smaller, lighter items. In summary, all other variables being equal, the larger and heavier the object in flight, the stronger the shock waves will be. Therefore, given that both studies indicated only minor overpressures from substantially heavier vehicles of generally the same geometry, it is reasonable to conclude that the TV's overpressures at the ocean's surface would also be minor.

Furthermore, little, if any, of the energy received at the ocean's surface would be expected to propagate into the water (**Richardson et al. 1995**). Although a surface sound wave is produced, it would be transient and diminish rapidly with depth (**Richardson et al. 1995**). As such, the most probable exposure route would be if an individual were at the surface.

5.1.1 Aspects of Stressor Common to All Species

Individuals exposed to a sonic boom could potentially change their behavior, such as becoming alert, diving, or swimming laterally.

5.1.2 Considerations Specific to Cetaceans

Given that nearly all cetacean species would be outside the action area during each test campaign, those potentially within the action area (i.e., sperm whales) would be at depths of several hundred meters for a majority of the time (**Amano & Yoshioka 2003**; **Watkins et al. 1993**). When considered in conjunction with the infrequent nature of the testing, it may be concluded that the potential for exposing an individual to a weak sonic boom would be highly unlikely. Even if it were to occur, it is doubtful that a behavioral response would even be evoked.

5.1.3 Considerations Specific to Hawai'ian Monk Seal and Critical Habitat

Species

The potential exists for exposing Hawai'ian monk seals to the TV sonic boom, especially when individuals are hauled out of the water. A primary concern of sound exposure on pinnipeds is whether the source would result in either temporary or permanent hearing loss. **Southall et al. (2007)** proposed a 149 decibel (dB) exposure criterion for assessing the potential injury to pinnipeds in air exposed to a single sound pulse. Therefore, when considered within the context of these criteria, the expected reentry sonic boom under the proposed action (within the range of 114 dB at 9.6 Pa [0.2 psf] to 126 dB at 38.3 Pa [0.8 psf]) would cause no temporary or permanent hearing damage to Hawai'ian monk seals.

Adverse behavioral effects on pinnipeds exposed to sonic booms could including leaving the beach to enter the water, increased aggression, reduced maternal care, and prolongation of molting (**Perry et al. 2002**). However, research conducted by **Perry et al. (2002)** exposed two species of seals (gray and harbor seals) to more intense sonic booms than those predicted for the proposed action, concluded that, while several individuals demonstrated elevated heart rates and increased vigilance, the sonic boom exposure did not notably affect the breeding or molting behavior of these animals. **Holst et al. (2011)** reported similar results when evaluating the effects of sonic boom on harbor seals and elephant seals. Despite the sonic booms generated by the rockets studied by **Holst et al. (2011)** being greater than those expected under the proposed action, the authors did not observe the booms to result in greater responses by the studied animals than in control groups, summarizing the effects as minor and localized. **Southall et al. (2007)** proposed a 109 dB criterion for single pulse sound behavioral disturbance of pinnipeds in air, though the authors noted that it is likely conservative and based upon observation of strong responses (e.g., stampeding behavior) of some species, especially harbor seals, to sonic booms from aircraft and missile launches under certain conditions. Furthermore, supported by the more recent work by **Holst et al. (2011)**, and the fact that nearly all of the sound energy of the TV's sonic boom would be below 75 hertz (Hz; the minimum estimated range of hearing as presented in **Southall et al. [2007]**), it is questionable whether seals would react to sonic booms at such low overpressures.

In conclusion, although the referenced studies were conducted on different seal species than those potentially within the action area, in consideration of the relatively lower sonic boom profile generated by the proposed action, and its infrequent nature, it may be reasoned that, if an individual were exposed to a sonic boom created by the LDSD TV, the resultant physiological or behavior effects would be negligible.

Critical Habitat

Sonic booms would have only a negligible effect on either designated or proposed Hawai‘ian monk seal critical habitat. Although it is possible that some sound could enter the aquatic habitat, particularly during rough sea conditions (**Richardson et al. 1995**), it would be small in intensity (given the flight altitudes and limited potential for air-to-water sound transmission [**Richardson et al. 1995**]) and transient in nature. Likewise, aside from the transient low pressure sound from a sonic boom, terrestrial critical habitat would be unaffected.

5.1.4 Considerations Specific to Sea Turtles

With the exception of green sea turtles, and to a much lesser extent, hawksbills, the potential for exposing other species of sea turtles to the TV-generated sonic boom would be unlikely based on historic sightings data. However, should a sea turtle be exposed to a sonic boom, it is unlikely to evoke much, if any, of a physiological or behavioral response at the levels and frequencies which would be propagated to the ocean’s surface.

Physiologically, although not specific to sea turtles, but using the best proxy available, **Bowles et al. (1999)** exposed desert tortoises to single and repeated simulated sonic booms. None of the eight individuals experienced temporary hearing loss after exposure to single or paired sonic booms (143 dB peak; greater than that expected under the proposed action). As such, in consideration of the low magnitude and infrequent occurrence of the sonic booms under the proposed action, it may be reasoned that exposed sea turtle species would not be subjected to measurable physiologic effects.

Likewise, behaviorally, the majority of energy in a sonic boom is less than 100 Hz. Early research on the hearing of green sea turtles by **Ridgway et al. (1969)** identified their maximum hearing sensitivity to be between 300 and 400 Hz. Consequently, while the potential for a sea turtle detecting the audible stimulus, should it be exposed to it, cannot be completely ruled out, it may be concluded that the resultant behavioral effect, if one even were to occur, would be minor. The sea turtles in more recent studies which demonstrated notable behavioral responses (e.g., diving) to impulsive sounds (e.g., airguns: **DeRuiter & Doukara 2012**) were exposed to far more intense stimuli than would be anticipated under the proposed action.

5.2 *Direct or Proximate Strike*

5.2.1 Aspects of Stressor Common to All Species

During the oceanic landing of flight hardware, there would be only a remote likelihood of the TV, balloon, or MET rocket stages striking or landing near a listed species. Even if a strike were to occur, it is not possible to predict the exact consequence and outcome. However, several general conclusions can be drawn. The likelihood for injurious effects would be greatest if the individual were at the surface breathing or foraging, with the potential for injury decreasing substantially with depth. In the event that the TV, balloon, or MET rocket stage were to land near a surfacing individual, the extent of effects would likely be limited to a short-term startle reaction.

5.2.2 Considerations Specific to Cetaceans

The occurrence of either mysticete species within the action area at the time of either flight termination or test execution and subsequent descent of flight hardware would be rare, as all species are known to migrate to northern waters outside the action area during the summer months. Furthermore, the infrequent nature of the action (up to twice per year over a five-year term) renders a direct or proximate strike a highly unlikely event.

Although odontocete species would be within the action area during the time when the action would occur, both species spend about 70 to 80 percent of their time at depths of several hundred meters (**Amano & Yoshioka 2003; Watkins et al. 1993**). When coupled with the infrequent nature of the testing, and low density of individuals within the action area, the chance of a direct or proximate strike would also be very low.

5.2.3 Considerations Specific to Hawai‘ian Monk Seal and Critical Habitat

Species

Hawai‘ian monk seals would occur within the action area during the time of test execution. However, the probability of a direct or proximate strike would be very low for the following reasons. First, the core locations of all six reproductive subpopulations are outside the action area. Second, while some individuals have been shown to undergo long distance movements from their “home” colonies (**Johanos et al. 2014**), the majority of Hawai‘ian monk seals tend to remain within 50 km (27 nm) of these areas (**Curtice et al. 2011**), which, again, for most, would be outside the action area. Third, although birthing and nursing would be spread over a much wider window than just the June to August timeframe, during this time a portion of the adult females and young of the year would be on land (largely outside the action area), further reducing the number of individuals potentially within the action area. Finally, the infrequent nature of the proposed action supports the conclusion that a direct strike would be unlikely.

Critical Habitat

Aquatic: Should either the TV, or balloon land within aquatic Hawai‘ian monk seal critical habitat, it would temporarily occupy a small portion of the epipelagic portion of the water column that would have otherwise been available for use as foraging grounds for the species. However, in consideration of the mandatory recovery of all major hardware items, the resultant effects would be only transient in nature. Should unrecoverable flight hardware (i.e., the flight train or MET rocket stages) enter critical habitat upon descent, it would only occupy the water column for a very short time, and, upon landing on the ocean floor, would represent a very small portion of the overall habitat available for the species. It is possible that, over time, the material would either trap, or otherwise become covered with sediment, further reducing the detraction from habitat value. The occurrence of floating expended hardware entering aqueous critical habitat would be possible, though unlikely due to the low number of these items being flown per year and the very large areal extent of the action area.

Terrestrial: Should either the TV, balloon, or MET rocket stages land within terrestrial Hawai‘ian monk seal critical habitat, is would occupy a small portion of habitat that would have otherwise been available for pupping, basking, or resting. The physical impact of the descending items could crush shoreline vegetation or penetrate the surface of the beach (i.e., create a “divot”). However, such effects would be transient as all materials would be located and removed by the project as soon as practicable. Likewise, any physical disturbance created would be remediated to pre-project conditions.

Nonetheless, the potential for this stressor to occur would be highly unlikely. As discussed in Section 2.5 of this BE, the island of Nihoa and its 5.6 km (3.0 nm) buffer would be categorically avoided when conducting each SFDT. Under normal conditions, these areas would be overflown. It would only be in the case of a catastrophic failure of the flight system that flight hardware would descend into designated terrestrial critical habitat.

5.2.4 Considerations Specific to Sea Turtles

All sea turtles could be in the action area during the summer months when the proposed action would occur. However, with the exception of green, and, to a much lesser extent, hawksbill sea turtles, their occurrence would be rare, based on historic sightings data. Even in the case of green sea turtles, the most populous species within the action area, when considering the infrequent nature of the action, the low density of individuals within the action area, and the fact that sea turtles spend a significant portion of their time below the sea surface (**Lutcavage & Lutz 1997**), the probability of a direct or proximate strike would be very low.

5.3 *Entanglement*

5.3.1 Aspects of Stressor Common to All Species

According to the literature (major reviews by **Laist 1987, 1997; Derraik 2002**), 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.

5.3.2 Considerations Specific to Cetaceans

For either cetacean species, the relative size difference between the (comparatively small) floating MET balloons and ROBIN spheres and a (much larger) individual of either species renders the probability of entanglement negligible. Being hollow aluminum columns, MET rocket stages do not pose a risk of entanglement. As such, they will not be discussed further and this Section will focus on the larger TV, balloon, and balloon flight train.

Mysticetes

Traveling or feeding baleen whales could potentially become entangled in the floating TV or balloon or sinking balloon flight train once they enter the water column. Should feeding whales encounter the floating or descending flight hardware, the debris could enter the buccal cavity, wrap around and damage baleens, lodge within the esophagus, or become wrapped around the tongue or rostrum. Entanglement of pectoral or caudal fins may result from an encounter between traveling whales and the floating or descending flight hardware. While fishing gear has been the primary type of debris observed on entangled cetaceans (e.g., humpbacks: **García-Godos et al. 2013**), entanglement in other types of plastic-based materials has also been reported (e.g., fin whales: **Sadove & Morreale 1990**) (**Baulch & Perry 2014**).

However, multiple factors render this potential stressor highly unlikely. First, the occurrence of either mysticete species within the action area at the time when the proposed action would be conducted (and, therefore, when the majority of flight hardware would be in-water) would be rare as all species are known to migrate to northern waters outside the action area during the summer months. Moreover, with the exception of humpback whales, the occurrence of any mysticete species within the action area at any time would be rare based upon historical sightings data.

Second, the rapid recovery of the larger TV and balloon system from the water column would further reduce the risk of potential entanglement with the largest flight hardware items. Furthermore, since the unrecovered flight hardware would sink rapidly following water impact, the material would not be available for entanglement except but for a brief period of time (less than an hour) during its descent to the ocean floor. Upon reaching the sea floor, none of the mysticetes potentially within the action area are likely to interact with the flight hardware as they would not likely be engaged in foraging behaviors at that depth, and, consequently, would be located higher in the water column.

Finally, the infrequent nature of the action (twice per year over a five-year term) renders the probability of a mysticete encountering any flight hardware, whether within the water column or on the seafloor, a highly unlikely event.

Odontocetes

False Killer Whale: Although false killer whales have not been definitively reported as becoming entangled in marine debris (**Baulch & Perry 2014**), the potential exists for such a stressor to occur should flight hardware land within the species' range. However, multiple factors render this outcome highly unlikely. First, the greatest concentrations of the species are farther east in the MHIs, outside the action area (**Baird et al. 2012**). Second, the species generally forages on prey that is typically found in the uppermost portion of the water column. Because the floating balloon system and TV would be recovered soon after landing in the water, the potential for this stressor would be short in duration. Furthermore, the rapid descent of

unrecoverable flight hardware to depths beyond which false killer whales typically forage renders the chance of this species encountering these objects remote. Finally, the infrequent nature of the action and the low density of the species (when compared to the size of its range within the action area) render this event highly improbable.

Sperm Whale: Both lethal and non-lethal entanglements in marine debris have been reported for sperm whales (**Haase & Felix 1994; Kock et al. 2006; Pace et al. 2008**). Sperm whales have been found with bands and strands of plastic, polypropylene rope, cables, and other plastic materials wrapped around the mandible (**Arbelo et al. 2013**). Typically, these types of entanglements result in necrotic tissues, extremely poor body condition (due to limited ability to feed successfully), and have even been cited as contributing to an animal's ultimate death (**Jacobsen et al. 2010**).

Sperm whales feed at greater depths than mysticetes (e.g., 400 to 600 m [1,310 to 1,970 ft]) and sometimes at or near the benthos (**Mathias et al. 2012; Miller et al. 2013; Teloni et al. 2008**), potentially putting them at higher risk for entanglement with the unrecovered materials once they are on the seafloor. However, dive depth data from studies of sperm whales indicate that, while individuals occasionally forage at the seafloor, typical feeding is at lesser water depths. For example, **Teloni et al. (2008)** recorded over 72 percent of sperm whale dives at depths shallower than 400 m (1,310 ft) in a Norwegian canyon approximately 2,000 m (6,560 ft) deep. Similarly, half of the sperm whales observed by **Wahlberg (2002)** undertook dives of maximum depths of 700 to 800 m (2,300 to 2,620 ft) in water depths of approximately 1,500 m (4,920 ft). A study conducted by **Miller et al. (2013)** indicated typical dive depths of 400 m (1,310 ft) in the Kaikoura Canyon of coastal New Zealand, with bottom depths between 600 and 1,000 m (1,970 and 3,280 ft). **Mathias et al. (2012)** found that sperm whales typically foraged at depths of approximately 400 m (1,310 ft) in a study area with water depths of approximately 800 m (2,620 ft). **Papastavrou et al. (1989)** recorded average dive depths in tropical latitudes of approximately 400 m (1,310 ft) in waters 2,000 to 4,000 m (6,560 to 13,100 ft) deep. As such, while it is possible that a foraging sperm whale could encounter the flight train once on the seafloor, the likelihood of entanglement is remote given their tendency to more frequently forage higher in the water column.

To further support this conclusion, a Geographic Information System (GIS) (**Environmental Systems Research Institute 2010**) – based bathymetry analysis was conducted (using data from **IOC et al. 2003**) to determine the distribution of water depths in the action area. The analysis indicated that approximately 96 percent of the waters in the action are deeper than 2,000 m (6,560 ft), which is more than the deepest reported sperm whale foraging dive ("possibly to 2,000 m"; **Watkins et al. [1993]**). Therefore, in summary, while a sperm whale undertaking a deeper (greater than 2,000 m [6,560 ft]) foraging dive to the ocean floor (where the unrecovered flight hardware would remain) is possible, when considered in conjunction with the fact that most recorded foraging has occurred at shallower depths, the low density of individuals in the action area, and the infrequent nature of the proposed action, it may be concluded that the

probability of a foraging sperm whale becoming entangled in the items on the sea floor would be very low. Likewise, given the sink rate of the unrecovered flight hardware, it is expected that the items would be below the stratum of the water column most commonly used for sperm whale foraging in approximately one to two hours, rendering the potential for entanglement negligible.

5.3.3 Considerations Specific to Hawai‘ian Monk Seal and Critical Habitat

Species

Hawai‘ian monk seals are particularly susceptible to entanglement with marine debris, with pups and juveniles the most vulnerable life stage (**Henderson 1990**; **Henderson 2001**). Entanglement most often involves derelict fishing gear including nets, fish line, and associated hardware. As discussed under *Direct or Proximate Strike,* the majority of seal colonies are outside the action area with most individuals remaining in close proximity to the islands. Furthermore, the rapid recovery of floating materials from the water column and rapid sinking of unrecovered materials renders the chance of entanglement unlikely. Although the unrecovered material theoretically could present an entanglement hazard if it were to land in shallow nearshore depths, the vast majority (greater than 99 percent) of waters in the action area are deeper than the maximum recorded dive depths of Hawai‘ian monk seals, below which there would be no potential for interaction. Finally, historic reports of entanglement support the conclusion that the potential for entanglement with unrecovered items under the proposed action is negligible. There are no known cases of Hawai‘ian monk seal being entangled in military expended material (**NMFS 2014**), which is analogous to the MET balloons and ROBIN spheres.

Critical Habitat

The entanglement stressor is not applicable to either designated or proposed Hawai‘ian monk seal critical habitat.

5.3.4 Considerations Specific to Sea Turtles

It is possible that sea turtles might encounter or approach the floating MET balloons or ROBIN spheres. Likewise, in-water turtles could encounter the floating TV or balloon and subsequently become entangled (**Carr 1987**), as sea turtles have been observed to feed under floating debris. **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, SFDT flights from PMRF would be infrequent, not exceeding two per year over a five-year term. Second, the majority of buoyant materials (i.e., balloon, TV) would be recovered. The unrecovered flight train’s expected sink rate would effectively remove it from the water column stratum most commonly frequented by migrating and foraging sea turtles in less than one hour. Though it is possible that the ultimate location of the flight hardware on the seafloor could be within the range of depths observed for diving sea turtles, particularly leatherbacks (maximum recorded

dive depths to 1,280 m [4,200 ft: **Doyle et al. 2008**]), it has recently been determined from satellite telemetry that very deep dives (>300 m [980 ft]) are rare (**Houghton et al. 2008**). Finally, the low density of sea turtles in the action area makes the likelihood of an individual becoming entangled in the descending or seafloor-resting flight hardware highly unlikely.

5.4 *Ingestion*

5.4.1 Aspects of Stressor Common to All Species

Foraging individuals at or near the sea surface could ingest portions of the expended flight hardware, particularly the floating MET balloons or ROBIN spheres. 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; Derraik 2002**).

5.4.2 Considerations Specific to Cetaceans

Compared to entanglement, ingestion of debris, particularly plastics, has been reported more frequently for cetacean species (**Baulch & Perry 2014**). There are numerous reports in the literature (e.g., **Arbelo et al. 2013; Sadove & 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 & Zarzur 1999**).

Mysticetes

Based on research conducted by **Irwin (2012)**, it is possible that degraded or intact latex MET balloons would remain afloat for months following their landing in the ocean. Likewise, the Mylar ROBIN spheres would not be expected to degrade at the surface, descending through the water column under the weight of fouling organisms. However, when considered over the entire pelagic portion of the action area and the distributed or dilute nature of these relatively small items, the probability of an individual of either species encountering an item is very low. Furthermore, in the unlikely instance that a large mysticete were to ingest a small item from a degraded balloon, interference with alimentary processes would not necessarily occur. This is due to the fact that, if the material is weak enough to break away from the larger item, it would likely be too weak to cause an obstruction of the gut once ingested (**Andrady 1990**).

Moreover, as discussed in this document under *Entanglement*, the likelihood of mysticete whales encountering large pieces of floating or descending flight hardware (i.e., TV, balloon, or flight train) would be negligible because of 1) their absence from the action area during testing; 2) the recovery of the balloon and TV shortly after landing on the ocean's surface; and 3) the rapid descent of the unrecovered flight train to the seafloor.

Odontocetes

False Killer Whale: With the exception of a single report of a false killer whale ingesting a plastic jug in Florida (**Barros et al. 1990**), there are no definitive reports of the species ingesting marine debris (**Baulch & Perry 2014**). Regardless, the potential exists for such a stressor to occur should flight hardware land within the species' range. However, in consideration of the infrequency of the proposed action, the low density of individuals within the action area, the large size of most floating materials (rendering ingestion unlikely), and their recovery upon landing in the water, the probability of an individual encountering floating material from the proposed action is very low.

Sperm Whale: Sperm whales may be more susceptible than other whale species to ingestion of debris, as they feed within a wide range of the water column (**de Stephanis et al. 2013**). Fatalities associated with ingestion of plastic bags and other materials have been reported in sperm whales. In one case, the variability in size and age of the pieces suggested the material was ingested from the surface rather than bitten off from active fishing gear (**Jacobsen et al. 2010**), while, in another case (**Walker & Coe 1990**), ingestion was thought to occur incidentally while feeding on benthic prey. However, as also discussed in this document under *Entanglement*, given the large proportion (96 percent) of deep water (greater than 2,000 m [6,560 ft]) in the action area, and shallower "typical" foraging depths (400 to 800 m [1,310 to 2,620 ft]) observed in sperm whales, the likelihood of a foraging sperm whale encountering the descended flight hardware would be remote. Additionally, **de Stephanis et al. (2013)** summarized 17 sperm whale plastic ingestion incidents reported worldwide, finding that the mass of ingested debris ranged from approximately 20 grams to 2.5 kilograms (0.04 to 5.5 lb) while surface areas ranged from under 1.0 square meter (m^2 [10.8 square feet (ft^2)]) to approximately 30 m^2 [323 ft^2]. Based on squid morphometric data from **Bolstad (2007)** and **Semmens & Jackson (2005)**, this range of debris sizes generally corresponds with the size and mass of the forage resources most commonly identified (oceanic squids, *Moroteuthis* spp.) in the stomachs of sperm whales (**Kawakami 1980**). As such, the data from these studies further support the conclusion that, with the exception of the MET balloons and ROBIN spheres, ingestion would be unlikely, as both the most commonly ingested prey and reported debris items are significantly smaller than the items entering the water under the proposed action.

Even so, when considered over the entire pelagic portion of the action area and the distributed or dilute nature of the temporarily floating items, the probability of an individual encountering a concentration of positively- or neutrally-buoyant MET balloons or ROBIN spheres years into the future is very low. Finally, the low density of sperm whales in the action area makes the likelihood of an individual interacting with the expended materials at any point during their presence in the water column or on the seafloor highly unlikely.

5.4.3 Considerations Specific to Hawai‘ian Monk Seal and Critical Habitat

Species

Although Hawai’ian monk seals have not been definitively reported to ingest marine debris (**Baulch & Perry 2014**), the potential exists for such a stressor to occur should flight hardware land within the species’ range. However, in consideration of the infrequency of the proposed action, the low density of individuals within the action area, the large size of most floating materials (rendering ingestion unlikely), and their recovery upon landing in the water, the probability of an individual encountering the floating material would be very low.

Critical Habitat

The ingestion stressor is not applicable to either designated or proposed Hawai‘ian critical habitat.

5.4.4 Considerations Specific to Sea Turtles

In a comprehensive review of 37 sea turtle debris ingestion studies undertaken since **Balazs (1985)**, **Schuyler et al. (2014)** found that, while all species potentially within the action area 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 (including rubber balloons) 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.

Parker et al. (2011) summarized the diets of oceanic Hawai‘ian green sea turtles, documenting that these individuals mostly foraged on *Pyrosoma* spp., which can grow up to 60 cm (2 ft) in length and 2 - 4 cm (1 - 1.5 in) wide. Likewise, in a study of leatherbacks foraging in the northern Atlantic Ocean, **Heaslip et al. (2012)** found that the diameters of gelatinous prey ingested by the observed individuals ranged between 3.0 and 22.0 cm (1.2 to 8.9 in; the larger being roughly the diameter of a soccer ball). These findings strongly suggest that, with the exception of the MET balloons and ROBIN spheres, the substantially larger flight hardware (i.e., balloon, TV, flight train) would not be within the size range of (or resemble) prey typically encountered and ingested by foraging sea turtles. However, in the longer term, the possibility of the MET balloons fragmenting into smaller buoyant pieces, which would be more readily ingested by sea turtles, could occur.

Regardless, multiple factors render the potential of an individual sea turtle encountering either of the floating items unlikely. First, with the exception of green sea turtles, the potential for other species to occur within the action area would be low, and likely only when transiting between other areas in the Pacific Ocean. Second, the infrequent nature of the proposed action makes the likelihood of an individual interacting with the expended materials at any point during their

presence in the water column or on the seafloor highly unlikely. Finally, when considered over the entire pelagic portion of the action area and the distributed or dilute nature of the degraded particles, the probability of an individual encountering a concentration of floating items from the proposed action years into the future would be very low. Even in the highly unlikely scenario that an individual were to ingest a small piece of a MET balloon, for example, it is possible that adverse physiological effects would not result (e.g., **Parker et al. 2011**).

5.5 *Aircraft Overflight*

5.5.1 Aspects of Stressor Common to All Species

Transmission of noise from aircraft into the water would be possible. However, individuals would have to be at or near the surface at the time of an overflight in order to be exposed to elevated sound levels. Likewise, a visual stimulus from overflight could also lead to a change in behavior, although this would likely be temporary.

5.5.2 Considerations Specific to Cetaceans

Responses to aircraft overflight have been shown to vary by species. For example, smaller delphinids have been shown to react to fixed-wing aircraft overflights either neutrally or with a startle response whereas more "cryptic" species (e.g., ziphiids) tend to react more overtly, often diving when overflown (**Wursig et al. 1998**). It has also been reported that dolphins generally show no reaction to the overflight of aircraft unless the aircraft's shadow passes directly over them (**Richardson et al. 1995**). **Patenaude et al. (2002)** observed mysticetes (bowhead whales [*Balaena mysticetes*]) during spring migration in Alaska and recorded their short-term responses to fixed-wing aircraft activity. Few (approximately 2 percent) of the observed bowheads reacted to overflights (between 60 and 457 m [200 and 1,500 ft] AGL), with the most common behavioral responses being abrupt dives, short surfacing episodes, breaching, and tail slaps (**Patenaude et al. 2002**). The majority of these responses occurred when the aircraft was below altitudes of 182 m (600 ft) and lateral distances of 250 m (820 ft: **Patenaude et al. 2002**), which is below the range of altitudes (i.e., above 457 m [1,500]) which would be flown during surveillance under the proposed action. Of note is that the authors state "there was little if any reaction by bowheads when the aircraft circled at altitude 460 m…" (1,500 ft: **Patenaude et al. 2002**). Regarding odontocetes, **Wursig et al. (1998)** found in their study that most Gulf of Mexico sperm whales dive when overflown by fixed wing aircraft. **Richter et al. (2006)** documented only minor behavioral effects (i.e., both longer surface time and time to first vocalization) of whale-watching aircraft on New Zealand sperm whales. However, details on flight altitude and airspeed were not provided. **Smultea et al. (2008)** studied sperm whales in Hawai‘i, documenting that diving responses to fixed winged overflights occurred at approximately 250 m (820 ft) AGL.

As mysticete species would not likely be within the action area during the time when aircraft surveillance and recovery flights would occur, and the flights would be infrequent in nature, it

may be concluded that exposing a mysticete to this stressor would be highly unlikely. Although sperm whales would be within the action area during the time when the action would occur, they spend about 70 to 80 percent of their time at depths of several hundred meters (**Amano & Yoshioka 2003; Watkins et al. 1993**), where it is unlikely that they would be exposed to aircraft-induced stressors (i.e., visual and/or acoustic cues). Furthermore, in consideration of the infrequent nature and short duration of aircraft flights, the relatively high altitude (above 457 m [1,500 ft] AGL) at which they would surveil, and limited behavioral responses documented in available research, it is expected that potential effects on marine mammals, should they even occur, would be negligible. This conclusion is further supported by **Richardson et al. (1995)**, who summarized available information at the time of their publication and stated that research does not indicate that the occasional overflight would cause long-term displacement of whales.

5.5.3 Considerations Specific to Hawai‘ian Monk Seal and Critical Habitat

Species

Based on the responses of other pinniped species to aircraft overflight, it is expected that Hawai‘ian monk seals would be most responsive to aircraft-induced visual or acoustic stimuli when hauled out for pupping or molting (**Richardson et al. 1995**). Observed reactions would vary in severity, and could range from becoming alert to rushing into the water. While not specific to Hawai‘ian monk seal, **Richardson et al. (1995)** presented available research at the time, which, in summary, supports the conclusion that the surveillance and recovery aircraft proposed under the proposed action would have limited, if any, potential for disturbance at the altitudes at which they would fly. Furthermore, given that the flight hardware would only land within or adjacent to terrestrial areas in the event of an off-nominal flight termination scenario, the probability of the need for repeated flights around terrestrial areas where seals would be hauled out would be low. Furthermore, because the terrestrial areas within the action area (e.g., Nihoa) are only home to a small number of monk seals, the possibility of exposing an individual to an aircraft-induced stressor such that a behavioral response is evoked is also considered to be very low.

There are few specific data on the reactions of in-water pinnipeds to aircraft overflight (**Richardson et al. 1995**). Based on observations when conducting aerial surveys of pinniped populations, it is likely that Hawai‘ian monk seals would dive if overflown by fixed wing aircraft at low altitude. However, in consideration of the facts that 1) the aircraft would be operated at least 457 m (1,500 ft) AGL; 2) the SFDT flights would be infrequent in nature; and 3) the low density of individuals within the action area, the probability of exposing an in-water individual to an aircraft-induced stressor would be very low. Even if a seal were to be overflown, the resultant effect is unlikely to reduce the individual’s fitness.

Critical Habitat

Aircraft overflight would have only a negligible effect on either designated or proposed Hawai‘ian monk seal critical habitat. Although it is possible that some aircraft-induced sound could enter the water column, particularly during rough sea conditions (**Richardson et al. 1995**), it would be low in intensity (given the flight altitudes and limited potential for air-to-water sound transmission [**Richardson et al. 1995**]) and transient in nature. Likewise, aside from the transient sound transmitted at ground level by aircraft overflight, the terrestrial critical habitat would be otherwise unaffected.

5.5.4 Considerations Specific to Sea Turtles

Species-specific studies on the reaction of sea turtles to fixed wing aircraft overflight are lacking. Based on sea turtle sensory biology (**Bartol & Musick 2003**), sound from low flying aircraft could likely be heard by a sea turtle at or near the ocean surface. Turtles might also detect low flying aircraft via visual cues such as the aircraft's shadow (similar to the findings of **Hazel et al. [2007]** regarding watercraft), potentially eliciting a brief startle reaction such as a dive or lateral movement. However, in consideration of 1) the fact that sea turtles spend a significant portion of their time below the sea surface (**Lutcavage & Lutz 1997**); 2) with the exception of green sea turtles, the rarity of other species within the action area; and 3) the infrequent nature of the surveillance flights, the probability of exposing an individual to an acoustically- or visually-induced stressor from aircraft overflight would be very low. Furthermore, because the surveillance and recovery aircraft would be flown at altitudes (i.e., above 457 m [1,500 ft] AGL), well above those which are employed by wildlife agencies when performing aerial surveys of in-water sea turtles (e.g., 152 m [500 ft]: **Epperly et al. 1995**), it can be reasoned that potential effects on an in-water individual, even should it be overflown, would be insignificant.

5.6 *Recovery Vessel Operation*

5.6.1 Aspects of Stressor Common to All Species

Collisions with vessels could result in either non-lethal (e.g., blunt trauma, lacerations) or lethal injuries, depending on a number of factors, including vessel speed. In the case of a proximate approach, the acoustic or visual stimuli (or combination of the two) from recovery vessels could cause exposed individuals to change their behavior, including diving or swimming laterally to avoid the oncoming vessel. To ensure that in-water species are not exposed to ship-induced stressors (e.g., ship strike), vessel operators would employ all vessel operating protocols stipulated in Section 2.4.2 of this BE.

5.6.2 Considerations Specific to Cetaceans

Collisions with ships have been a stressor inflicted upon large whale species for many years, particularly since vessels began to attain speeds in excess of 24 km/hr (13 kt: **Laist et al. 2001**). Mysticetes, and in particular, fin and right whales, have been the most frequently reported

species affected by ship strikes (**Jensen & Silber 2003**; **Laist et al. 2001**). **Lammers et al. (2013)** summarized records of collisions between vessels and North Pacific humpback whales in Hawai‘ian waters, concluding that collisions were most frequently reported outside the action area (i.e., the waters between Maui, Moloka‘i, Lana‘i, and Kaho‘olawe), and that their observed rise in frequency of collision was likely due to the continued recovery of humpbacks in Hawai‘i, increases in vessel traffic, and improved reporting practices.

In the event that a vessel strikes a whale, studies have found that the probability of its lethality increase with ship speed (**Gende et al. 2011**; **Vanderlaan & Taggart 2007**). For example, **Vanderlaan & Taggart (2007)** found the probability of a lethal strike increased from 20 percent to 100 percent at speeds between 17 and 37 km/hr (9 and 20 kt), and that lethality from ship strike increased most rapidly between 19 and 26 km/hr (10 and 14 kt). As project recovery vessels would cruise at speeds between approximately 15 and 26 km/hr (8 and 14 kt), the potential exists for an injurious, even lethal, ship strike.

However, several factors render this stressor highly unlikely. First, with the exception of sperm whales, the other species of cetaceans would occur in very low numbers, if at all, within the action area during the time when ship-based recovery operations would be conducted. Although sperm whales could be in the action area during this time, they spend about 70 to 80 percent of their time at depths of several hundred meters (**Amano & Yoshioka 2003; Watkins et al. 1993**), at which there would be no possibility of an individual encountering a project vessel. Coupled with the infrequent nature of the action, the small number of recovery vessels employed in support of the activity, and the employment of vessel operating protocols, the probability of striking a listed cetacean would be very low.

In the event of a proximate approach, the potential reactions of cetaceans to various types of vessels vary considerably among populations, locations and time of year (**Scheidat et al. 2004**). However, as discussed previously in this section regarding ship strike, the probability of a project vessel encountering a listed whale species would be unlikely, and, even if it were to occur, the temporary behavioral reaction (e.g., humpback increase in speed: **Scheidat et al. 2004**; change in sperm whale ventilation rate: **Richter et al. 2006**) associated with a proximate approach would not measurably affect an individual’s fitness. This conclusion is further supported by research in Hawai‘i by **Bauer et al. (1993)**, who noted obvious short-term reactions of wintering humpbacks to vessel traffic but concluded that longer-term effects were not apparent. Similarly, after studying the reactions of male sperm whales to whale-watching vessels in the waters off New Zealand, **Richter et al. (2006)** concluded that the minor behavioral changes they observed were not likely of biological significance.

5.6.3 Considerations Specific to Hawai‘ian Monk Seal and Critical Habitat

Species

In general, very little data (and that largely anecdotal) exists regarding the reactions of seals to vessels. However, available information suggests that seals are rather tolerant of vessels (**Richardson et al. 1995**). Likewise, little data is available regarding the potential for (and effects of) ship strikes.

However, given that the flight hardware would only land within or adjacent to terrestrial areas in the event of an off-nominal flight termination scenario, the probability of the need for ship use in shallow waters around terrestrial areas (where seals would be hauled out) would be low. Additionally, because the terrestrial areas within the action area (e.g., Nihoa) are only home to a small number of monk seals, and since vessel operating protocols would be employed to avoid monk seals, the possibility of exposing an individual to a vessel-induced stressor such that a behavioral response is evoked is also considered to be very low.

Critical Habitat

Consistent with the above discussion regarding the effects of vessels on the species, it is unlikely that vessels would enter, and therefore affect, designated or proposed Hawai‘ian monk seal critical habitat. Should entry into critical habitat occur, the resultant effects would be transient and infrequent, and limited to the propagation of vessel noise into the water column and the physical movement of waters in the epipelagic stratum of the water column due to the ships' wake. NASA would require its vessel operators to prepare for and take all necessary precautions to prevent discharges of oil and releases of waste or hazardous materials that may impair water quality. In the event of such an occurrence, notification and response would be in accordance with applicable requirements of 40 CFR Part 300. Additionally, to prevent the introduction of marine alien species, all submerged and waterline vessel surfaces would be cleaned of algae or other organisms prior to vessel use and ballast water would be managed in accordance with U.S. Coast Guard Regulations (33 CFR Part 151). As such, the proposed action would only have negligible effects on the water column comprising either the designated or proposed Hawai‘ian monk seal critical habitat.

5.6.4 Considerations Specific to Sea Turtles

The potential exists for a project recovery vessel to strike a sea turtle. All sea turtles must surface to breathe and several species are known to bask at the surface. Although sea turtles can move either horizontally or vertically to avoid an incoming vessel, **Hazel et al. (2007)** found that green sea turtles may not be able to move out of the way of vessels cruising at more than 4 km/hr (2 kt). Furthermore, these same researchers suggested that green sea turtles may use auditory cues to react to approaching vessels rather than visual cues, making them more susceptible to strike as vessel speed increases (**Hazel et al. 2007**). Project recovery vessels would travel faster than this in open water between port and the recovery site. However, several factors render sea

turtle strike highly unlikely. First, with the exception of green sea turtles, the other species of sea turtles occur in very low numbers within the action area. Coupled with the infrequent nature of the action, and small number of recovery vessels employed in support of the proposed activity, as well as the employment of vessel operating protocols, the probability of striking a listed sea turtle would be very low.

6.0 Conclusions

Following ESA consultation guidance developed by **NMFS** (**2013**), NASA applied the following rationale to arrive at its final determinations of effect on listed species in the LDSD SFDT action area:

First, based on the analysis in this BE, the proposed action is likely to produce stressors to which listed individuals would respond if exposed. However, the likelihood of such exposure has been determined to be extremely remote. Therefore, NASA's determination process is based on "Proposition B" in the NMFS guidance document, which is:

> *The action is likely to produce potential stressors..., endangered or threatened individuals are not likely to be exposed to one or more of those potential stressors or subsidies or one or more of the Action's direct or indirect consequences on the environment;*

Next, once NASA accepted Proposition B as true, NASA identified the first of four potential determination outcomes (identified as outcome 3.1 in the NMFS guidance document) as being applicable to the action considered in this BE, which is:

> *If an agency … accepts Proposition B as true (the action produces stressor or subsidies, but the probability of exposing listed individuals to those stressors is so small that it would not be reasonable to expect them to occur) and can defend that acceptance based on all of the relevant evidence available and the appropriate background, the agency is justified in a "may affect, but not likely to adversely affect" determination (because the probability of effects would be discountable).*

As such, NASA concludes that the proposed action "may affect, not likely to adversely affect," all listed species and critical habitat in the action area. **Table 2** on the following page presents a summary of determinations for each species and critical habitat potentially affected by NASA's action:

Table 2: Summary of Endangered Species Act Determinations

Species	ESA Status	NASA ESA Determination
Cetaceans		
North Pacific right whale	Endangered	NLAA
Blue whale	Endangered	NLAA
Fin whale	Endangered	NLAA
Sei whale	Endangered	NLAA
Humpback whale	Endangered	NLAA
False killer whale (MHI Insular)	Endangered	NLAA
Sperm whale	Endangered	NLAA
Pinnipeds		
Hawai‘ian Monk Seal	Endangered	NLAA
Hawai‘ian Monk Seal Critical Habitat	Designated / Proposed	NLAA / NLAM
Sea Turtles		
Green sea turtle	Threatened	NLAA
Hawksbill sea turtle	Endangered	NLAA
North Pacific loggerhead sea turtle	Endangered	NLAA
Olive ridley sea turtle	Threatened	NLAA
Leatherback sea turtle	Endangered	NLAA

Key: NLAA = May affect, not likely to adversely affect (for listed species and designated critical habitat)
NLAM = Not likely to adversely modify (for proposed critical habitat)

7.0 Literature Cited

Aguilar, A. (2009). Fin whale, *Balaenoptera physalus*. In Perrin, W. F., Wursig, B., & Thewissen, J. G. M. (Eds.), *Encyclopedia of marine mammals (2nd Ed.)* (pp. 433-437). Accessed online via Elsevier.

Ahmad, Z., Herman, J. R., Vasilkov, A. P., Tzortziou, M., Mitchell, B. G., & Kahru, M. (2003). Seasonal variation of UV radiation in the ocean under clear and cloudy conditions. In *Optical Science and Technology, SPIE's 48th Annual Meeting* (pp. 63-73). International Society for Optics and Photonics. November.

Alldredge, A. L., & Silver, M. W. (1988). Characteristics, dynamics and significance of marine snow. *Progress in Oceanography*, 20(1), 41-82.

Allen, B. M., and R. P. Angliss. (2014). Alaska marine mammal stock assessments, 2013. U.S. Department of Commerce, NOAA Technical Memorandum. NMFS-AFSC-277, 294 p.

Allen, N. S., Edge, M., Mohammadian, M., & Jones, K. (1994). Physicochemical aspects of the environmental degradation of poly (ethylene terephthalate). *Polymer Degradation and Stability*, *43*(2), 229-237.

Amano, M., & Yoshioka, M. (2003). Sperm whale diving behavior monitored using a suction-cup-attached TDR tag. *Marine Ecology Progress Series*, *258*(6).

Andrady, A.L. (1990). Environmental Degradation of Plastics under Land and Marine Exposure Conditions. In R. S. Shomura & M. L. Godfrey (Eds.), *Proceedings of the 2nd International Conference on Marine Debris, vol. 1* (pp. 848-869). United States Department of Commerce, Honolulu, Hawaii, USA.

Andrady, A. L. (1994). Assessment of environmental biodegradation of synthetic polymers. *Journal of Macromolecular Science, Part C: Polymer Reviews*, *34*(1), 25-76.

Andrady, A. L. (2011). Microplastics in the marine environment. *Marine Pollution Bulletin*, *62*(8), 1596-1605.

Andrady, A. L., Hamid, H. S., & Torikai, A. (2003). Effects of climate change and UV-B on materials. *Photochemical & Photobiological Sciences*, *2*(1), 68-72.

Aoki, K., Amano, M., Mori, K., Kourogi, A., Kubodera, T., & Miyazaki, N. (2012). Active hunting by deep-diving sperm whales: 3D dive profiles and maneuvers during bursts of speed. *Marine Ecology Progress Series*, *444*, 289-301.

Aral, H., & Vecchio-Sadus, A. (2008). Toxicity of lithium to humans and the environment—a literature review. *Ecotoxicology and Environmental Safety*, *70*(3), 349-356.

Arbelo, M., de los Monteros, A. E., Herráez, P., Andrada, M., Sierra, E., Rodríguez, F., & Fernández, A. (2013). Pathology and causes of death of stranded cetaceans in the Canary Islands (1999–2005). *Dieases of Aquatic Organisms, 103:* 87-99.

Au, W. W., Giorli, G., Chen, J., Copeland, A., Lammers, M. O., Richlen, M., ... & Moretti, D. (2014). Presence and seasonal variation of deep diving foraging odontocetes around Kaua‘i, Hawai‘i using remote autonomous acoustic recorders. *The Journal of the Acoustical Society of America*, *135*(1), 521-530.

Baird, R.W. (2009). False killer whale, *Pseudorca crassidens*. In Perrin, W. F., Wursig, B., & Thewissen, J. G. M. (Eds.), *Encyclopedia of marine mammals (2nd Ed.)* (pp. 405-406). Accessed online via Elsevier.

Baird, R. W., Gorgone, A. M., McSweeney, D. J., Webster, D. L., Salden, D. R., Deakos, M. H., ... & Mahaffy, S. D. (2008). False killer whales (*Pseudorca crassidens*) around the main Hawai‘ian Islands: Long-term site fidelity, inter-island movements, and association patterns. *Marine Mammal Science*, *24*(3), 591-612.

Baird, R.W., Hanson, M.B., Schorr, G.S., Webster, D.L., ... & Andrews, R.D. (2012). Range and primary habitats of Hawai‘ian insular false killer whales: informing determination of critical habitat. *Endangered Species Research*, 18:47-61.

Baird, R.W., Jarvis, S.M., Webster, D.L., Rone, B.K., Shaffer, J.A., Mahaffy, S.A., Gorgone, A.M., and Moretti, D.J. (2014*). Odontocete studies on the Pacific Missile Range Facility in July/August 2013; satellite-tagging, photo-identification, and passive acoustic monitoring*. Prepared for Commander, U.S. Pacific Fleet, submitted to the Naval Facilities Engineering Command, Pacific, by HDR Environmental, Operations, and Construction, Inc.

Baird, R.W., Schorr, G.S., Webster, D.L., McSweeney, D.J., Hanson, M.B., & Andrews, R.D. (2010). Movements and habitat use of satellite-tagged false killer whales around the main Hawai‘ian Islands. Endangered Species Research, 10: 107−121

Baird, R.W., Schorr, G.S., Webster, D.L., McSweeney, D.J., Hanson, M.B., Andrews, R.D. (2011) *Movements and spatial use of false killer whales in Hawai‘i: satellite tagging studies in 2009*. Report prepared under Order No. AB133 F09SE 4132 from the Pacific Islands Fisheries Science Center, Honolulu, HI. http://www.cascadiaresearch.org/Hawai‘i/publications.htm

Baird, R. W., Webster, D. L., Aschettino, J. M., Schorr, G. S., & McSweeney, D. J. (2013). Odontocete Cetaceans Around the Main Hawai‘ian Islands: Habitat Use and Relative Abundance from Small-Boat Sighting Surveys. *Aquatic Mammals*, *39*(3).

Baker, C. S. (1986). Migratory movement and population structure of humpback whales (*Megaptera novaeangliae*) in the central and eastern North Pacific. *Marine Ecology Progress Series*, *31*, 105-119.

Baker, J. D., Harting, A. L., Wurth, T. A., & Johanos, T. C. (2011). Dramatic shifts in Hawai‘ian monk seal distribution predicted from divergent regional trends. *Marine Mammal Science*, *27*(1), 78-93.

Bailey, H., Benson, S. R., Shillinger, G. L., Bograd, S. J., Dutton, P. H., Eckert, S. A., ... & Spotila, J. R. (2012). Identification of distinct movement patterns in Pacific leatherback turtle populations influenced by ocean conditions. *Ecological Applications*, *22*(3), 735-747.

Baker, J.D. & Johanos, T.C. (2004). Abundance of the Hawai‘ian monk seal in the main Hawai‘ian Islands. *Biological Conservation*, 116:103-110.

Balazs, G. H. (1976). Green turtle migrations in the Hawai‘ian Archipelago. *Biological Conservation*, *9*(2), 125-140.

Balazs, G.H. (1980). *Synopsis of biological data on the green turtle in the Hawai‘ian Islands*. NOAA-TM-NMFS-SWFC-7. 141 pp.

Balazs, G. H. (1985). Impact of ocean debris on marine turtles: entanglement and ingestion. In *Proceedings of the Workshop on the Fate and Impact of Marine Debris* (Vol. 2729).

Balazs, G. H., & Hau, S. (1986). Geographic distribution: *Lepidochelys olivacea* in Hawai‘i. *Herpetological Review*, *17*(2), 51.

Bannister, J.L. (2009). Baleen Whales (Mysticetes). In Perrin, W. F., Wursig, B., & Thewissen, J. G. M. (Eds.), *Encyclopedia of marine mammals (2nd Ed.)* (pp. 80-89). Accessed online via Elsevier.

Barlow, J. (2003). *Cetacean abundance in Hawai‘ian waters during summer/fall 2002*. Admin. Rep. LJ-03-13. Southwest Fisheries Science Center, National Marine Fisheries Service, 8604 La Jolla Shores Drive, La Jolla, CA 92037.

Barlow, J. (2006). Cetacean abundance in Hawai‘ian waters estimated from a summer/fall survey in 2002. *Marine Mammal Science*, *22*(2), 446-464.

Barnes, D. K., Galgani, F., Thompson, R. C., & Barlaz, M. (2009). Accumulation and fragmentation of plastic debris in global environments. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *364*(1526), 1985-1998.

Barros, N. B., Odell, D. K. and Patton, G. W. (1990). Ingestion of plastic debris by stranded marine mammals from Florida. Page 746 in R. S. Shomura and M. L. Godfrey (eds). *Proceedings of the Second International Conference on Marine Debris*. U. S. Department of Commerce. NOAA Tech. Memo. NMFS, NOAA-TM-NMFS-SWFSC-154, Honolulu, Hawaii.

Bartol, S.M., and Musick. J.A. (2003). Sensory biology of sea turtles. In P. L. Lutz, J. A. Musick, & J. Wyneken (Eds.), *The biology of sea turtles, Volume II (*pp. 79-102). CRC Press, Boca Raton, Florida.

Bauer, G. B., Mobley, J. R., & Herman, L. M. (1993). Responses of wintering humpback whales to vessel traffic. *The Journal of the Acoustical Society of America*, *94*(3), 1848-1848.

Baulch, S., & Perry, C. (2014). Evaluating the impacts of marine debris on cetaceans. *Marine Pollution Bulletin*, *80*(1), 210-221.

Benson, S. R., Eguchi, T., Foley, D. G., Forney, K. A., Bailey, H., Hitipeuw, C., ... & Dutton, P. H. (2011). Large-scale movements and high-use areas of western Pacific leatherback turtles, *Dermochelys coriacea*. *Ecosphere*, *2*(7), art84.

Bergmann, M., & Klages, M. (2012). Increase of litter at the Arctic deep-sea observatory HAUSGARTEN. *Marine Pollution Bulletin*, *64*(12), 2734-2741.

Bolstad, K. S. (2007). Systematics and distribution of the New Zealand onychoteuthid fauna (Cephalopoda: Oegopsida), including a new species, Notonykia nesisi sp. nov. *Reviews in Fish Biology and Fisheries*, *17*(2-3), 305-335.

Bowles, A.E., Eckert, S.E., Matesic, Jr., J., Starke, L., Francine, J., and Stinson, H. (1999). *Effects of flight noise from jet aircraft and sonic booms on hearing, behavior, heart rate, and oxygen consumption of desert tortoises* (*Gopherus agassizii*). Report by Hubbs-Sea World Research Institute and Parsons Engineering Science for U.S. Air Force, Armstrong Laboratory, Brooks Air Force Base TX, on Contract F33615-89-D-4003, Order 0132, May. 131 pp.

Brownell, Jr., R.L., P.J. Clapham, T. Miyashita, & T. Kasuya. (2001). Conservation status of North Pacific right whales. *Journal of Cetacean Research and Management*, Special Issue, 2:269-286.

Bjorndal, K. (1997). Foraging ecology and nutrition of sea turtles. In P. L. Lutz and J. A. Musick (Eds.), *The biology of sea turtles (*pp. 199-232). CRC Press, Boca Raton, Florida.

Burchette, D. K. (1989). A study of the effect of balloon releases on the environment. National Association of Balloon Artists.

Cahoon, M. K., Littnan, C. L., Longenecker, K., & Carpenter, J. R. (2013). Dietary comparison of two Hawai‘ian monk seal populations: the role of diet as a driver of divergent population trends. *Endangered Species Research, 20*, 137-146.

Calambokidis, J. E.A. Falcone, T.J. Quinn, A.M. Burdin, P.J. Clapham, J.K.B. Ford, C.M. Gabriele, R. LeDuc, D. Mattila, L. Rojas-Bracho, J.M. Straley, B.L. Taylor, J. Urbán R., D. Weller, B.H. Witteveen, M. Yamaguchi, A. Bendlin, D. Camacho, K. Flynn, A. Havron, J. Huggins, and Maloney, N. (2008). *SPLASH: Structure of Populations, Levels of Abundance and Status of Humpback Whales in the North Pacific*. Final report for Contract AB133F-03-RP-00078. 58 p.

Calambokidis, J., Steiger, G. H., Straley, J. M., Herman, L. M., Cerchio, S., Salden, D. R., ... & Ii, T. J. Q. (2001). Movements and population structure of humpback whales in the North Pacific. *Marine Mammal Science*, *17*(4), 769-794.

Calambokidis, J., Steiger, G.H., Straley, J.M., Quinn II, T.J., Herman, L.M., Cerchio, S., Salden, D.R., … & Rasmussen, K. (1997). *Final Report – Abundance and population structure of humpback whales in the North Pacific basin*. Unpublished contract report to the National Marine Fisheries Service, La Jolla, California.

Carr, A. (1987). Impact of nondegradable marine debris on the ecology and survival outlook of sea turtles. *Marine Pollution Bulletin*, *18*(6), 352-356.

Carretta, J.V., Forney, K.A., Muto, M.M., Barlow, J., Baker, J.D. & Lowry, M.S. (2005) U.S. Pacific Marine Mammal Stock Assessments: 2004. US Department of Commerce. NOAA Technical Memorandum, NMFS-SWFSC-375, La Jolla, California, USA.

Carretta, J.V., E. Oleson, D.W. Weller, A.R. Lang, K.A. Forney, J. Baker, B. Hanson, … & Mattila, D.K. (2014). U.S. Pacific Marine Mammal Stock Assessments, 2013. NOAA-TM-NMFS-SWFSC-532. 406 pp.

Carrión-Cortez, J., Canales-Cerro, C., Arauz, R., & Riosmena-Rodríguez, R. (2013). Habitat Use and Diet of Juvenile Eastern Pacific Hawksbill Turtles (*Eretmochelys imbricata*) in the North Pacific Coast of Costa Rica. *Chelonian Conservation and Biology*, *12*(2), 235-245.

Clapham, P.J. (2009). Humpback whale, *Megaptera novaeangliae*. In Perrin, W. F., Wursig, B., & Thewissen, J. G. M. (Eds.), *Encyclopedia of marine mammals (2nd Ed.)* (pp. 582-585). Accessed online via Elsevier.

Clapham, P.J., C. Good, S.E. Quinn, R.R. Reeves, J.E. Scarff, & R.L. Brownell. (2004). Distribution of North Pacific right whales (*Eubalaena japonica*) as shown by 19th and 20th century whaling catch and sighting records. *Journal of Cetacean Research and Management*, 6:1-6.

Clapham, P.J., & Mead, J.G. (1999). *Megaptera novaeangliae*. *Mammalian Species*, 604, 1-9.

Clarke, M. R., Martins, H. R. & Pascoe, P. (1993). The diet of sperm whales (*Physeter macrocephalus*) off the Azores. *Philosophical Transactions of the Royal Society B, 339*, 67–82.

Croll, D. A., Acevedo-Gutiérrez, A., Tershy, B. R., & Urbán-Ramírez, J. (2001). The diving behavior of blue and fin whales: is dive duration shorter than expected based on oxygen stores? *Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology*, *129*(4), 797-809.

Croll, D. A., Marinovic, B., Benson, S., Chavez, F. P., Black, N., Ternullo, R., & Tershy, B. R. (2005). From wind to whales: trophic links in a coastal upwelling system. *Marine Ecology Progress Series*, *289*(117), 30.

DeRuiter, S. L., & Doukara, K. L. (2012). Loggerhead turtles dive in response to airgun sound exposure. *Endangered Species Research*, *16*(1), 55-63.

de Stephanis, R., Giménez, J., Carpinelli, E., Gutierrez-Exposito, C., & Cañadas, A. (2013). As main meal for sperm whales: Plastics debris. *Marine Pollution Bulletin, 69*: 206–214.

Doyle, T. K., Houghton, J. D., O'Súilleabháin, P. F., Hobson, V. J., Marnell, F., Davenport, J., & Hays, G. C. (2008). Leatherback turtles satellite-tagged in European waters. *Endangered Species Research*, *4*(1-2), 23-31.

Eckert, K. L., Wallace, B. P., Frazier, J. G., Eckert, S. A., & Pritchard, P. C. H. (2012). Synopsis of the biological data on the leatherback sea turtle (*Dermochelys coriacea*). Washington, DC: US Department of Interior, Fish and Wildlife Service.

Edge, M., Hayes, M., Mohammadian, M., Allen, N. S., Jewitt, T. S., Brems, K., & Jones, K. (1991). Aspects of poly (ethylene terephthalate) degradation for archival life and environmental degradation. *Polymer Degradation and Stability*, *32*(2), 131-153.

Energizer Holdings, Incorporated. (n.d.). Energizer CRV3 Product Datasheet. 2 pp.

Environmental Systems Research Institute. (2010). ArcGIS 10.0. Redlands, California.

Epperly, S. P., Braun, J., & Chester, A. J. (1995). Aerial surveys for sea turtles in North Carolina inshore waters. *Fishery Bulletin*, *93*(2), 254-261.

Ezuber, H., El-Houd, A., & El-Shawesh, F. (2008). A study on the corrosion behavior of aluminum alloys in seawater. *Materials & Design*, *29*(4), 801-805.

Flament, P. (1996). *Ocean Currents*. In: Ocean Atlas of Hawai'i. Available online at: http://oos.soest.hawaii.edu/pacioos/outreach/oceanatlas/currents.php

Foley, A.M. (1990). *A Preliminary Investigation on Some Specific Aspects of Latex Balloon Degradation*. Florida Department of Natural Resources, Florida Marine Research Institute. St. Petersburg, FL. August 3. 4 pp.

Forney, K. A., Baird, R. W., & Oleson, E. M. (2010). *Rationale for the 2010 Revision of Stock Boundaries for the Hawaii Insular and Pelagic Stocks of False Killer Whales, Pseudorca crassidens*. NOAA-TM-NMFS-SWFSC-741. 7 pp.

Fowler, G. A., & Reiniger, R. F. (1981). Some field and laboratory results obtained with Kevlar mooring lines. In *OCEANS 81* (pp. 151-155). IEEE. September.

Gaos, A. R., Lewison, R. R., Wallace, B. P., Yañez, I. L., Liles, M. J., Baquero, A., & Seminoff, J. A. (2012). Dive behaviour of adult hawksbills (*Eretmochelys imbricata*, Linnaeus 1766) in the eastern Pacific Ocean highlights shallow depth use by the species. *Journal of Experimental Marine Biology and Ecology*, *432*, 171-178.

García-Godos, I., Waerebeek, K. V., Alfaro-Shigueto, J., & Mangel, J. C. (2013). Entanglements of large Cetaceans in Peru: Few records but high risk. *Pacific Science*, *67*(4), 523-532.

Gende, S. M., Hendrix, A. N., Harris, K. R., Eichenlaub, B., Nielsen, J., & Pyare, S. (2011). A Bayesian approach for understanding the role of ship speed in whale-ship encounters. *Ecological Applications*, *21*(6), 2232-2240.

Gilmartin, W.G. & Forcada, J. (2009). Monk seals, *Monachus monachus, M. tropicalis, and M. schauinslandi*. In Perrin, W. F., Wursig, B., & Thewissen, J. G. M. (Eds.), *Encyclopedia of marine mammals (2nd Ed.)* (pp. 741-744). Accessed online via Elsevier.

Godard, H. P. (1960). The corrosion behavior of aluminum in natural waters. *Canadian Journal of Chemical Engineering*, *38*(5), 167-173.

Goldbogen, J. A., Calambokidis, J., Croll, D. A., Harvey, J. T., Newton, K. M., Oleson, E. M., ... & Shadwick, R. E. (2008). Foraging behavior of humpback whales: kinematic and respiratory patterns suggest a high cost for a lunge. *Journal of Experimental Biology*, *211*(23), 3712-3719.

Goldbogen, J. A., Pyenson, N. D., & Shadwick, R. E. (2007). Big gulps require high drag for fin whale lunge feeding. *Marine Ecology Progress Series*, *349*, 289-301.

Gopalan, R., Somashekar, B. R., & Dattaguru, B. (1989). Environmental effects on fibre—Polymer composites. *Polymer Degradation and Stability*, *24*(4), 361-371.

Gregory, M.R., & Andrady, A.L. (2003). Plastics in the marine environment. In: *Plastics and the Environment* (ed A.L. Andrady), John Wiley and Sons, 379-401.

Guedes Soares, C., Garbatov, Y., & Zayed, A. (2011). Effect of environmental factors on steel plate corrosion under marine immersion conditions. *Corrosion Engineering, Science and Technology*, *46*(4), 524-541.

Haase, B., & Félix, F. (1994). A note on the incidental mortality of sperm whales (*Physeter macrocephalus*) in Ecuador. *Report of the International Whaling Commission*, 481-483.

Haines, J. R., & Alexander, M. (1974). Microbial degradation of polyethylene glycols. *Applied Microbiology*, *29*(5), 621-625.

Hall, L. (2015). *Parachute*. In: *How Products are Made, Volume 5*. Online at: http://www.madehow.com/Volume-5/Parachute.html.

Hays, G. C., Houghton, J. D., Isaacs, C., King, R. S., Lloyd, C., & Lovell, P. (2004). First records of oceanic dive profiles for leatherback turtles, *Dermochelys coriacea*, indicate behavioural plasticity associated with long-distance migration. *Animal Behaviour*, *67*(4), 733-743.

Hazel, J., Lawler, I. R., Marsh, H., & Robson, S. (2007). Vessel speed increases collision risk for the green turtle *Chelonia mydas*. *Endangered Species Research*, *3*, 105-113.

Hegde, R. R., Dahiya, A., Kamath, M. G., Kanaguli, M., & Kotra, R. (2004). *Nylon fibers*. Online at: http://www.engr.utk.edu/mse/Textiles/Nylon% 20fibers.htm.

Henderson, J.R. (1990). Recent Entanglements of Hawai‘ian Monk Seals in Marine Debris. In R. S. Shomura & M. L. Godfrey (Eds.), *Proceedings of the 2nd International Conference on Marine Debris, vol. 1* (pp. 540–553). United States Department of Commerce, Honolulu, Hawai‘i, USA.

Henderson, J. R. (2001). A pre-and post-MARPOL Annex V summary of Hawai‘ian monk seal entanglements and marine debris accumulation in the Northwestern Hawai‘ian Islands, 1982–1998. *Marine Pollution Bulletin*, *42*(7), 584-589.

Herman, L.M. and R.C. Antinoja. (1977). Humpback whales in Hawai‘ian waters: Population and pod characteristics. *Scientific Report of the Whales Research Institute*, 29:59-85.

Herman, L. M., Baker, C. S., Forestell, P. H., & Antinoja, R. C. (1980). Right whale, Balaena glacialis, sightings near Hawai‘i: a clue to the wintering grounds?. *Marine Ecology Progress Series*, *2*, 271-275.

Herron, M. (2007). Sonic Boom Assessment for the Crew Exporation Vehicle. AIAA Atmospheric Flight Mechanics Conference and Exhibit, 20-23 August 2007, Hilton Head, SC. AIAA-6635. 23 pp.

Hilton, D. A., & Henderson, H. R. (1974). Measurements of sonic-boom overpressures from Apollo space vehicles. *The Journal of the Acoustical Society of America*, *56*(2), 323-328.

Holst, M., Greene Jr, C. R., Richardson, W. J., McDonald, T. L., Bay, K., Schwartz, S. J., & Smith, G. (2011). Responses of Pinnipeds to Navy Missile Launches at San Nicolas Island, California. *Aquatic Mammals*, *37*(2).

Holmström, A. (1975). Plastic films on the bottom of the Skagerack. *Nature*, *255*, 622-623.

Hooker, S.K. (2009). Toothed Whales, Overview. In Perrin, W. F., Wursig, B., & Thewissen, J. G. M. (Eds.), *Encyclopedia of marine mammals (2nd Ed.)* (pp. 1173-1179). Accessed online via Elsevier.

Horwood, J. (2009). Sei Whale, *Balaenoptera borealis*. In Perrin, W. F., Wursig, B., & Thewissen, J. G. M. (Eds.), *Encyclopedia of marine mammals (2nd Ed.)* (pp. 1001-1003). Accessed online via Elsevier.

Houghton, J. D., Doyle, T. K., Davenport, J., Wilson, R. P., & Hays, G. C. (2008). The role of infrequent and extraordinary deep dives in leatherback turtles (*Dermochelys coriacea*). *Journal of Experimental Biology*, *211*(16), 2566-2575.

Hughes, G. R., Luschi, P., Mencacci, R., & Papi, F. (1998). The 7000-km oceanic journey of a leatherback turtle tracked by satellite. *Journal of Experimental Marine Biology and Ecology*, *229*(2), 209-217.

IOC, IHO, & BODC (International Oceanographic Commission, International Hydrographic Organization, and British Oceanographic Data Centre). (2003). *Centenary Edition of the GEBCO Digital Atlas*, published on CD-ROM on behalf of the Intergovernmental Oceanographic Commission and the International Hydrographic Organization as part of the General Bathymetric Chart of the Oceans, British Oceanographic Data Centre, Liverpool, U.K.

Irwin, S.W. (2012). *Mass Latex Balloon Releases and the Potential Effects on Wildlife*. Doctoral Dissertation. Clemson University Department of Wildlife and Fisheries Biology, Clemson, SC. August. 73 pp.

Jacobsen, J. K., Massey, L., & Gulland, F. (2010). Fatal ingestion of floating net debris by two sperm whales (*Physeter macrocephalus*). *Marine Pollution Bulletin*, *60*(5), 765-767.

Jensen, A.S., & Silber, G.K. (2003). *Large Whale Ship Strike Database*. U.S. Department of Commerce, NOAA Technical Memorandum. NMFS-OPR-, 37 pp.

Johanos, T. C., Harting, A. L., Wurth, T. A., & Baker, J. D. (2013). Range-wide movement patterns of Hawai‘ian monk seals. *Marine Mammal Science*, 30(3): 1165-1174.

Johnston, D. W., Chapla, M. E., Williams, L. E., & Mattila, D. K. (2007). Identification of humpback whale *Megaptera novaeangliae* wintering habitat in the Northwestern Hawai‘ian Islands using spatial habitat modeling. *Endangered Species Research*, *3*(3), 249-257.

Joos, F., Plattner, G. K., Stocker, T. F., Körtzinger, A., & Wallace, D. W. (2003). Trends in marine dissolved oxygen: Implications for ocean circulation changes and the carbon budget. *Eos, Transactions American Geophysical Union*, *84*(21), 197-201.

Katahira, L.K., Forbes, C.M., Kikuta, A.H., Balazs, G.H., & Bingham, M. (1994). Recent findings and management of hawksbill turtle nesting beaches in Hawai‘i. Page 69 in K.A. Bjorndal, A.B. Bolton, D.A. Johnson, and P.J. Eliazar (compilers), *Proceedings of the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation*. NOAA Technical Memorandum NMFS-SEFSC-351. 323 pp.

Kawakami, T. (1980). A review of sperm whale food. *Scientific Reports of the Whales Research Institute*, *32*:199–218.

Kennedy, A. S., Salden, D. R., & Clapham, P. J. (2012). First high‐to low‐latitude match of an eastern North Pacific right whale (*Eubalaena japonica*). *Marine Mammal Science*, *28*(4), E539-E544.

Kenney, R.D. (2009). Right whales, *Eubalaena glacialis, E. japonica, and E. australis*. In Perrin, W. F., Wursig, B., & Thewissen, J. G. M. (Eds.), *Encyclopedia of Marine Mammals (2nd Ed.)* (pp. 962-972). Accessed online via Elsevier.

Keuper-Bennett, U., & Bennett, P. A. (2002). Home sweet home: Aspects of green turtle and hawksbill presence in their feeding, resting and cleaning areas off Honokowai, West Maui, Hawai‘i (1989–1999). In A. Mosier, A. Foley, and B. Brost, comps. *Proceedings of the 20th Annual Symposium on Sea Turtle Biology and Conservation.* NOAA Technical Memorandum NMFS-SEFSC-477 (pp. 57-59).

Kock, K. H., Purves, M. G., & Duhamel, G. (2006). Interactions between cetacean and fisheries in the Southern Ocean. *Polar Biology*, *29*(5): 379-388.

Kubota, M. (1994). A mechanism for the accumulation of floating marine debris north of Hawai‘i. *Journal of Physical Oceanography*, *24*(5), 1059-1064.

Laist, D.W. (1987). Overview of the biological effects of lost and discarded plastic debris in the marine environment. *Marine Pollution Bulletin* 18(6): 319–326.

Laist, D.W. (1997). Impacts of marine debris: entanglement of marine life in marine debris including a comprehensive list of species with entanglement and ingestion records. Pp.

99–140. In J. M. Coe and D. B. Rogers (Eds.), *Marine Debris: Sources, Impacts and Solutions*. Springer, New York, NY, USA.

Laist, D. W., Knowlton, A. R., Mead, J. G., Collet, A. S., & Podesta, M. (2001). Collisions between ships and whales. *Marine Mammal Science*, *17*(1), 35-75.

Lammers, M., Pack, A., Lyman, E., & Espiritu, L. (2013). Trends in collisions between vessels and North Pacific humpback whales (*Megaptera novaeangliae*) in Hawai‘ian waters (1975–2011). *Journal of Cetacean Research and Management*, *13*(1), 73-80.

Lobelle, D., & Cunliffe, M. (2011). Early microbial biofilm formation on marine plastic debris. *Marine Pollution Bulletin*, *62*(1), 197-200.

Lutcavage, M.E. & Lutz, P.L. (1997). Diving Physiology. In P. L. Lutz and J. A. Musick (Eds.), *The biology of sea turtles* (pp. 277-296). CRC Press, Boca Raton, Florida.

Madsen, P., Wahlberg, M., & Møhl, B. (2002). Male sperm whale (*Physeter macrocephalus*) acoustics in a high-latitude habitat: implications for echolocation and communication. *Behavioral Ecology and Sociobiology*, *53*(1), 31-41.

Mathias, D., Thode, A. M., Straley, J., Calambokidis, J., Schorr, G. S., & Folkert, K. (2012). Acoustic and diving behavior of sperm whales (*Physeter macrocephalus*) during natural and depredation foraging in the Gulf of Alaska. *The Journal of the Acoustical Society of America*, *132*(1), 518-532.

McDonald, M. A., & Fox, C. G. (1999). Passive acoustic methods applied to fin whale population density estimation. *The Journal of the Acoustical Society of America*, *105*(5), 2643-2651.

Melchers, R. E. (2005). Effect of immersion depth on marine corrosion of mild steel. *Corrosion*, *61*(9), 895-906.

Meylan, A. (1988). Spongivory in hawksbill turtles: a diet of glass. *Science (Washington)*, *239*(4838), 393-395.

Miller, B., Dawson, S., & Vennell, R. (2013). Underwater behavior of sperm whales off Kaikoura, New Zealand, as revealed by a three-dimensional hydrophone array. *The Journal of the Acoustical Society of America*, *134*(4), 2690-2700.

Miller, P. J., Johnson, M. P., & Tyack, P. L. (2004). Sperm whale behaviour indicates the use of echolocation click buzzes ‘creaks’ in prey capture. *Proceedings of the Royal Society of London Series B: Biological Sciences*, *271*(1554), 2239-2247.

Mizroch, S. A., Rice, D. W., & Breiwick, J. M. (1984). The sei whale, *Balaenoptera borealis*. *Marine Fisheries Review*, *46*(4), 25-29.

Mizroch, S. A., Rice, D. W., Zwiefelhofer, D., Waite, J., & Perryman, W. L. (2009). Distribution and movements of fin whales in the North Pacific Ocean. *Mammal Review*, *39*(3), 193-227.

Mobley, J.R. (2005). Assessing responses of humpback whales to North Pacific Acoustic Laboratory (NPAL) transmissions: Results of 2001–2003 aerial surveys north of Kaua‘i. *Journal of the Acoustical Society of America*, 117:1666-1673.

Mobley, J.R., G.B. Bauer, and Herman, L.M. (1999). Changes over a ten-year interval in the distribution and relative abundance of humpback whales (*Megaptera novaeangliae*) wintering in Hawai‘ian waters. *Aquatic Mammals*, 25:63-72.

Mobley, J.R., Smultea, M., Norris, T. & Weller, D. (1996) Fin whale sighting north of Kaua‘i, Hawai‘i. *Pacific Science*, 50, 230–233.

Mobley, J.R., Spitz, S.S., Forney, K.A., Grotenfendt, R., & Forestell, P.H. (2000). *Distribution and abundance of odontocete species in Hawai‘ian waters: preliminary results of 1993–98 aerial surveys*. Administrative Report LJ-00–14C. Available from the NOAA Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037. 26 pp.

Mobley, J.R., S.S. Spitz, and Grotefendt, R. (2001). *Abundance of humpback whales in Hawai‘ian waters: Results of 1993-2000 aerial surveys*. Report prepared for the Hawai‘i Department of Land and Natural Resources and the Hawai‘ian Islands Humpback Whale National Marine Sanctuary, NOAA, U.S. Department of Commerce.

Mordecai, G., Tyler, P. A., Masson, D. G., & Huvenne, V. A. (2011). Litter in submarine canyons off the west coast of Portugal. *Deep Sea Research Part II: Topical Studies in Oceanography*, *58*(23), 2489-2496.

Morét-Ferguson, S., Law, K. L., Proskurowski, G., Murphy, E. K., Peacock, E. E., & Reddy, C. M. (2010). The size, mass, and composition of plastic debris in the western North Atlantic Ocean. *Marine Pollution Bulletin*, *60*(10), 1873-1878.

Musick, J.A. & Limpus, C.J. (1997). Habitat utilization and migration in juvenile sea turtles. In P. L. Lutz and J. A. Musick (Eds.), *The biology of sea turtles* (pp. 137-163). CRC Press, Boca Raton, Florida.

NASA (National Aeronautics and Space Administration). (1989). *Descent Sonic Boom Measurements For STS-26.* Document Number: JSC-23579. Houston, TX. April.

NASA (National Aeronautics and Space Administration). (2013). *Final Environmental Assessment Low Density Supersonic Decelerator Technology Demonstration Mission*

Pacific Missile Range Facility. Space Technology Mission Directorate, Washington, DC. May.

NMFS (National Marine Fisheries Service). **(**2014). *Biological Opinion and Conference Report on U.S. Navy Hawai'i-Southern California Training and Testing*. Endangered Species Act Interagency Cooperation Division of the Office of Protected Resources, National Marine Fisheries Service. FPR-2012-9026. April 23. 446 pp.

NMFS (National Marine Fisheries Service). **(**2013). *Effects Determination Guidance*. Pacific Islands Regional Office, NOAA Fisheries Service. Retrieved from http://www.fpir.noaa.gov/Library/PRD/ESA%20Consultation/Effects_Determination_Guidance_05-06-2013.pdf

NMFS & USFWS (National Marine Fisheries Service and U.S. Fish and Wildlife Service). (1998a). Recovery Plan for U.S. Pacific Populations of the Hawksbill Turtle (*Eretmochelys imbricata*). National Marine Fisheries Service, Silver Spring, MD.

NMFS & USFWS (National Marine Fisheries Service and U.S. Fish and Wildlife Service). (1998b). Recovery Plan for U.S. Pacific Populations of the Leatherback Turtle (*Dermochelys coriacea*). National Marine Fisheries Service, Silver Spring, MD.

NMFS & USFWS (National Marine Fisheries Service and U.S. Fish and Wildlife Service). (1998c). Recovery Plan for U.S. Pacific Populations of the Loggerhead Turtle (*Caretta caretta*). National Marine Fisheries Service, Silver Spring, MD.

NMFS & USFWS (National Marine Fisheries Service and U.S. Fish and Wildlife Service). (1998d). Recovery Plan for U.S. Pacific Populations of the Olive Ridley Turtle (*Lepidochelys olivacea*). National Marine Fisheries Service, Silver Spring, MD.

Ortega-Ortiz, C. D., Elorriaga-Verplancken, F. R., Olivos-Ortiz, A., Liñán-Cabello, M. A., & Vargas-Bravo, M. H. (2014). Insights into the Feeding Habits of False Killer Whales (*Pseudorca crassidens*) in the Mexican Central Pacific. *Aquatic Mammals*, *40*(4), 386-393.

Pace, D.S., Miragliuolo, A., Mussi, B. (2008). Behavior of a social unit of sperm whales (*Physeter macrocephalus*) entangled in a drift net off Capo Palinuro (southern Tyrrhenian Sea, Italy). *Journal of Cetacean Research and Management, 10*(2), 131–135.

Papastavrou, V., Smith, S. C., & Whitehead, H. (1989). Diving behaviour of the sperm whale, *Physeter macrocephalus*, off the Galápagos Islands. *Canadian Journal of Zoology*, *67*(4), 839-846.

Parker, D. M., Balazs, G. H., King, C. S., Katahira, L., & Gilmartin, W. (2009). Short-Range Movements of Hawksbill Turtles (*Eretmochelys imbricata*) from Nesting to Foraging Areas within the Hawai‘ian Islands 1. *Pacific Science*, *63*(3), 371-382.

Parker, D.M., Cooke, W., & Balazs, G.H. (2002) Dietary components of pelagic loggerhead turtles in the North Pacific Ocean. In*: Proceedings of the Twentieth Annual Symposium on Sea Turtle Biology and Conservation*, February 29–March 4, 2000, Orlando, FL. US Department of Commerce, NOAA Technical Memorandum NMFS-SEFSC. 417:148–151.

Parker, D. M., Dutton, P. H., & Balazs, G. H. (2011). Oceanic diet and distribution of haplotypes for the green turtle, *Chelonia mydas*, in the Central North Pacific. *Pacific Science*, *65*(4), 419-431.

Parks, S. E., Warren, J. D., Stamieszkin, K., Mayo, C. A., & Wiley, D. (2011). Dangerous dining: surface foraging of North Atlantic right whales increases risk of vessel collisions. *Biology Letters*, rsbl20110578.

Parrish, F. A., Craig, M. P., Ragen, T. J., Marshall, G. J., & Buhleier, B. M. (2000). Identifying Diurnal Foraging Habitat of Endangered Hawai‘ian Monk Seals Using a Seal-Mounted Video Camera. *Marine Mammal Science*, *16*(2), 392-412.

Parrish, F. A., Marshall, G. J., Buhleier, B., & Antonelis, G. A. (2008). Foraging interaction between monk seals and large predatory fish in the Northwestern Hawai‘ian Islands. *Endangered Species Research*, *4*(3), 299.

Parrish, F. A., Marshall, G. J., Littnan, C., Heithaus, M., Canja, S., Becker, B., ... & Antoneijs, G. A. (2005). Foraging of juvenile monk seals at French Frigate Shoals, Hawai‘i. *Marine Mammal Science*, *21*(1), 93-107.

Patenaude, N. J., Richardson, W. J., Smultea, M. A., Koski, W. R., Miller, G. W., Würsig, B., & GReene, C. R. (2002). Aircraft sound and disturbance to bowhead and beluga whales during spring migration in the Alaskan Beaufort Sea. *Marine Mammal Science*, *18*(2), 309-335.

Pegram, J. E., & Andrady, A. L. (1989). Outdoor weathering of selected polymeric materials under marine exposure conditions. *Polymer Degradation and Stability*, *26*(4), 333-345.

Perry, E. A., Boness, D. J., & Insley, S. J. (2002). Effects of sonic booms on breeding gray seals and harbor seals on Sable Island, Canada. *The Journal of the Acoustical Society of America*, *111*(1), 599-609.

Plotkin, K. J., Haering Jr, E. A., & Murray, J. E. (2006). Low-Amplitude Sonic Boom From a Descending Sounding Rocket. In Innovations in Nonlinear Acoustics: *ISNA17-17th International Symposium on Nonlinear Acoustics including the International Sonic Boom Forum* (Vol. 838, No. 1, pp. 615-618). AIP Publishing.

Polovina, J. J., Balazs, G. H., Howell, E. A., Parker, D. M., Seki, M. P., & Dutton, P. H. (2004). Forage and migration habitat of loggerhead (*Caretta caretta*) and olive ridley (*Lepidochelys olivacea*) sea turtles in the central North Pacific Ocean. *Fisheries Oceanography*, *13*(1), 36-51.

Ragen, T.J. and D.M. Lavigne. (1999). The Hawai‘ian monk seal: Biology of an endangered species. pp. 224-245. In J.R. Twiss, Jr. and R.R. Reeves, Eds. *Conservation and Management of Marine Mammals*, Washington D.C.: Smithsonian Institution Press.

Rankin, S., & Barlow, J. (2007). Vocalizations of the sei whale *Balaenoptera borealis* off the Hawai‘ian Islands. *Bioacoustics*, *16*(2), 137-145.

Reeves, R. R., Smith, T. D., Webb, R. L., Robbins, J., & Clapham, P. J. (2002). Humpback and fin whaling in the Gulf of Maine from 1800 to 1918. *Marine Fisheries Review*, *64*(1), 1-12.

Reich, K. J., Bjorndal, K. A., & Bolten, A. B. (2007). The ‘lost years’ of green turtles: using stable isotopes to study cryptic lifestages. *Biology Letters*, *3*(6), 712-714.

Riewald, P., Walden, R., Whitehill, A., & Koralek, A. (1986). Design and Deployment Parameters Affecting the Survivability of Stranded Aramid Fiber Ropes in the Marine Environment. In *OCEANS'86* (pp. 284-293). IEEE. September.

Reinhart, F. M. (1969). *Corrosion of Materials in Hydrospace-Part V-Aluminum Alloys* (No. NCEL-TN-N-1008). Naval Civil Engineering Laboratory, Port Hueneme, CA.

Rice, D. W. (1998). *Marine mammals of the world: systematics and distribution* (No. 4). Society for Marine Mammalogy.

Rice, M. R., & Balazs, G. H. (2008). Diving behavior of the Hawai‘ian green turtle (*Chelonia mydas*) during oceanic migrations. *Journal of Experimental Marine Biology and Ecology*, *356*(1), 121-127.

Richardson, W.J., Greene Jr., C.R, Malme, C.I., & Thomson, D.H. (1995). *Marine Mammals and Noise*. Academic Press, San Diego, CA.

Richter, C., Dawson, S., & Slooten, E. (2006). Impacts of commercial whale watching on male sperm whales at Kaikoura, New Zealand. *Marine Mammal Science*, *22*(1), 46-63.

Ridgway, S. H., Wever, E. G., McCormick, J. G., Palin, J., & Anderson, J. H. (1969). Hearing in the giant sea turtle, *Chelonia mydas*. *Proceedings of the National Academy of Sciences*, *64*(3), 884-890.

Rosak, D. A. (1985). *Evaluation of Lithium Sulfur Dioxide Batteries. US Army Communications-Electronics Command and US Army Electronics Research and Development Command, Fort Monmouth, New Jersey, 1 May-1 October 1984* (No. USAEHA-37-26-0427-85). Army Environmental Hygeine Agency, Aberdeen Proving Ground, MD. 17 pp.

Rowntree, V., Darling, J., Silber, G., & Ferrari, M. (1980). Rare sighting of a right whale (*Eubalaena glacialis*) in Hawai‘i. *Canadian Journal of Zoology*, *58*(2), 309-312.

Sadove, S. S., & Morreale, S. J. (1990). Marine mammal and sea turtle encounters with marine debris in the New York Bight and the northeast Atlantic. In R. S. Shomura & M. L. Godfrey (Eds.), *Proceedings of the 2nd International Conference on Marine Debris, vol. 1* (pp. 562-570). United States Department of Commerce, Honolulu, Hawai‘i, USA.

Salden, D.R. and Mickelsen, J. (1999). Rare sighting of a North Pacific right whale (*Eubalaena glacialis)* in Hawai‘i. *Pacific Science* 53(4):341-345.

Scarff, J. E. (1986). Historic and present distribution of the right whale (*Eubalaena glacialis*) in the eastern North Pacific south of 50 N and east of 180 W. *Report of the International Whaling Commission (Special Issue 10)*, 43-63.

Scheidat, M., Castro, C., Gonzalez, J., & Williams, R. (2004). Behavioural responses of humpback whales (*Megaptera novaeangliae*) to whalewatching boats near Isla de la Plata, Machalilla National Park, Ecuador. *Journal of Cetacean Research and Management*, *6*(1), 63-68.

Sears, R. & Perrin W.F. (2009). Blue whale *Balaenoptera mulculus*. In Perrin, W. F., Wursig, B., & Thewissen, J. G. M. (Eds.), *Encyclopedia of marine mammals (2nd Ed.) (*pp. 120-124). Accessed online via Elsevier.

Secchi, E. R., & Zarzur, S. (1999). Plastic debris ingested by a Blainville's beaked whale, *Mesoplodon densirostris*, washed ashore in Brazil. *Aquatic Mammals*, *25*(1), 21-24.

Seminoff, J.A., Benson, S.R., Arthur, K.E., Dutton, P.H., Tapilatu, R., & Popp, B.N. (2012). Stable isotope tracking of endangered sea turtles: validation with satellite telemetry and δ15N analysis of amino acids. *PLoS ONE*, 7(5): e37403

Semmens, J. M., & Jackson, G. D. (2005). Evaluation of biochemical indices for assessing growth and condition of the deepwater squid *Moroteuthis ingens*. *Marine Ecology Progress Series*, *289*, 215-223.

Smultea, M. A., Mobley, J. J. R., Fertl, D., & Fulling, G. L. (2008). An unusual reaction and other observations of sperm whales near fixed-wing aircraft. *Gulf and Caribbean Research*, *20*, 75-80.

Southall, B.L., Bowles, A.E., Ellison, W.T., Finneran, J.J. Gentry, R.L., Greene, C.R. Jr., Kastak, David, Ketten, D.R., Miller, J.H., Nachtingall, P.E., Richardson, W.J., Thomas, J.A., and Tyack, P.L. (2007). Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations. *Aquatic Mammals* 33(4): 411-509.

Stafford, K. M. (2003). Two types of blue whale calls recorded in the Gulf of Alaska. *Marine Mammal Science*, *19*(4), 682-693.

Stewart, B. S., Antonelis, G. A., Baker, J. D., & Yochem, P. K. (2006). Foraging biogeography of Hawai‘ian monk seals in the northwestern Hawai‘ian Islands. *Atoll Research Bulletin*, *543*(13), 1-145.

Swimmer, Y., Arauz, R., McCracken, M., McNaughton, L., Ballestero, J., Musyl, M., ... & Brill, R. (2006). Diving behavior and delayed mortality of olive ridley sea turtles *Lepidochelys olivacea* after their release from longline fishing gear. *Marine Ecology Progress Series*, *323*, 253-261.

Teloni, V., Mark, J. P., Patrick, M. J., & Peter, M. T. (2008). Shallow food for deep divers: Dynamic foraging behavior of male sperm whales in a high latitude habitat. *Journal of Experimental Marine Biology and Ecology*, *354*(1), 119-131.

Terry, B., & Slater, K. (1998). Comparative analysis of synthetic fibres for marine rope. *Journal of Consumer Studies & Home Economics*, *22*(1), 19-24.

Thompson, P. O., & Friedl, W. A. (1982). A long term study of low frequency sounds from several species of whales off Oahu, Hawaii. *Cetology*, *45*, 1-19.

Thompson, R. C., Olsen, Y., Mitchell, R. P., Davis, A., Rowland, S. J., John, A. W., & Russell, A. E. (2004). Lost at sea: where is all the plastic? *Science*, *304*(5672), 838-838.

Tiwari, M., Balazs, G. H., & Hargrove, S. (2010). Estimating carrying capacity at the green turtle nesting beach of East Island, French Frigate Shoals. *Marine Ecology Progress Series*, *419*, 289-294.

Tylecote, R. F. (1977). Durable materials for sea water: the archaeological evidence. *International Journal of Nautical Archaeology*, *6*(4), 269-283.

Urick, R.J. (1983). *Principles of underwater sound, Third edition*. McGraw-Hill Book Company. Peninsula Publishing, Los Altos, CA.

Van Cauwenberghe, L., Vanreusel, A., Mees, J., & Janssen, C. R. (2013). Microplastic pollution in deep-sea sediments. *Environmental Pollution, 182*, 495-499.

Van Houtan, K. S., Kittinger, J. N., Lawrence, A. L., Yoshinaga, C., Born, V. R., & Fox, A. (2012). Hawksbill sea turtles in the northwestern Hawai‘ian Islands. *Chelonian Conservation and Biology*, *11*(1), 117-121.

Vargel, C. (2004). *Corrosion of aluminum*. Oxford: Elsevier Ltd.

Wade, P. R., Kennedy, A., LeDuc, R., Barlow, J., Carretta, J., Shelden, K., ... & Clapham, P. J. (2010). The world's smallest whale population?. *Biology Letters*, rsbl20100477.

Wahl, M. (1989). Marine epibiosis. I. Fouling and antifouling: some basic aspects. *Marine Ecology Progress Series*, *58*, 175-189.

Wahlberg, M. (2002). The acoustic behaviour of diving sperm whales observed with a hydrophone array. *Journal of Experimental Marine Biology and Ecology*, *281*(1), 53-62.

Walker, W.A. & J. M. Coe. (1990). Survey of marine debris ingestion by odontocete cetaceans. In R. S. Shomura & M. L. Godfrey (Eds.), *Proceedings of the 2nd International Conference on Marine Debris*, *vol. 1* (pp. 747–774). United States Department of Commerce, Honolulu, Hawaii, USA.

Ware, C., Friedlaender, A. S., & Nowacek, D. P. (2011). Shallow and deep lunge feeding of humpback whales in fjords of the West Antarctic Peninsula. *Marine Mammal Science*, *27*(3), 587-605.

Watkins, W.A., J.E. George, M.A. Daher, K. Mullin, D.L. Martin, S.H. Haga, & DiMarzio, N.A. (2000). *Whale call data for the North Pacific November 1995 through July 1999: Occurrence of calling whales and source locations from SOSUS and other acoustic systems*. Technical Report WHOI-00-02. 160pp.

Watkins, W. A., Daher, M. A., Fristrup, K. M., Howald, T. J. & Notarbartolo di Sciara, G. (1993). Sperm whales tagged with transponders and tracked underwater by sonar. *Marine Mammal Science, 9* (1), 55–67.

Watkins, W. A., & Schevill, W. E. (1976). Right whale feeding and baleen rattle. *Journal of Mammalogy*, 58-66.

Watwood, S. L., Miller, P. J., Johnson, M., Madsen, P. T., & Tyack, P. L. (2006). Deep-diving foraging behaviour of sperm whales (*Physeter macrocephalus*). *Journal of Animal Ecology, 75*: 814–825.

Whitehead, H. (2009). Sperm whale, *Physeter macrocehpalus*. In Perrin, W. F., Wursig, B., & Thewissen, J. G. M. (Eds.), *Encyclopedia of marine mammals (2nd Ed.) (*pp. 1091-1097). Accessed online via Elsevier.

Woodward, B. L., Winn, J. P., & Fish, F. E. (2006). Morphological specializations of baleen whales associated with hydrodynamic performance and ecological niche. *Journal of Morphology*, *267*(11), 1284-1294.

Work, T. M., & Balazs, G. H. (2010). Pathology and distribution of sea turtles landed as bycatch in the Hawai‘i-based North Pacific pelagic longline fishery. *Journal of Wildlife Diseases*, *46*(2), 422-432.

Wursig, B., Lynn, S. K., Jefferson, T. A., & Mullin, K. D. (1998). Behaviour of cetaceans in the northern Gulf of Mexico relative to survey ships and aircraft. *Aquatic Mammals*, *24*, 41-50.

Wynne, K. and Schwartz, M. (1999). *Guide to Marine Mammals & Turtles of the U.S. Atlantic & Gulf of Mexico*. Rhode Island Sea Grant No NA86RG0076 from the NOAA NMFS, Office of Protected Resources.

Ye, S., & Andrady, A. L. (1991). Fouling of floating plastic debris under Biscayne Bay exposure conditions. *Marine Pollution Bulletin*, *22*(12), 608-613.

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Appendix E
LDSD Technology Demonstration Mission Biological Evaluation Submitted to USFWS

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National Aeronautics and
Space Administration

Goddard Space Flight Center
Wallops Flight Facility
Wallops Island, VA 23337

Reply to Attn of: 250.W

March 6, 2015

Mr. Aaron Nadig
Island Team Manager
Pacific Islands Fish and Wildlife Office
U.S. Fish and Wildlife Service
300 Ala Moana Boulevard, Room 3-122
Honolulu, Hawai‘i 96850

Dear Mr. Nadig:

This correspondence has been sent to you regarding U.S. Fish and Wildlife Service (USFWS) project tracking number 2015-TA-0128. As described in our February 2015 request to your office for technical assistance, the National Aeronautics and Space Administration (NASA) proposes to fund the 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 Kaua‘i, Hawai‘i. NASA would perform up to two LDSD Supersonic Flight Dynamics Tests annually over the next 5 years, starting in June 2015 and ending in August 2019. Enclosed is a Biological Evaluation (BE) to initiate informal consultation under Section 7(a)(2) of the Endangered Species Act (ESA).

Please note that the BE also considers the connected actions of the National Oceanic and Atmospheric Administration and the USFWS. In accordance with the authorities granted to them under Presidential Proclamation 8031 and 50 CFR Part 404, NASA has requested that they, along with the State of Hawai‘i, issue the LDSD Project a permit to enter the Papahānaumokuākea Marine National Monument. If NASA's permit application were to be approved, their action of issuing the permit would be subject to ESA consultation requirements. As such, NASA has assumed the role as Lead Agency (50 CFR § 402.07) and prepared this BE to fulfill the ESA obligations of all three federal action agencies.

As described in the enclosed BE, the proposed action *may affect, but is not likely to adversely affect*, the following ESA-listed and candidate species and designated critical habitat under your agency's jurisdiction:

Species and Critical Habitat within the LDSD Action Area- Kauaʻi and Niʻihau

Common Name	Scientific Name	ESA Status
Plants		
ōlulu*	*Brigharnia insignis*	Endangered
ʻAwikiwiki*	*Canavalia pubescens*	Endangered
Puʻukaʻa*	*Cyperus trachysanthos*	Endangered
Na Pali Beach hedyotis	*Hedyotis st.-johnii*	Endangered
ʻIhiʻihi*	*Marsilea villosa*	Endangered
Lauʻehu*	*Panicum niihauense*	Endangered
Wahane*	*Pritchardia aylmer-robinsonii*	Endangered
Māʻoliʻoli	*Schiedea apokremnos*	Endangered
ʻOhai*	*Sesbania tomentosa*	Endangered
NCN	*Spermolepis hawaiiensis*	Endangered
NCN*	*Vigna o-wahuensis*	Endangered
Dwarf iliau	*Wilkesia hobdyi*	Endangered
ʻōlulu critical habitat*	N/A	Designated
Lauʻehu critical habitat	N/A	Designated
Insects		
Hawaiian picture-wing fly	*Drosophila musaphilia*	Endangered
Hawaiian picture-wing fly	*Drosophila sharpi*	Endangered
Birds		
Hawaiian duck**	*Anas wyvilliana*	Endangered
Hawaiian goose	*Branta sandvicensis*	Endangered
Hawaiian coot**	*Fulica alai*	Endangered
Hawaiian gallinule**	*Gallinula chloropus sandvicensis*	Endangered
Hawaiian stilt**	*Himantopus mexicanus knudseni*	Endangered
Short-tailed albatross	*Phoebastria albatrus*	Endangered
Hawaiian petrel**	*Pterodroma sandwichensis*	Endangered
Newell's shearwater**	*Puffinus auricularis newelli*	Threatened
Band-rumped storm-petrel**	*Oceanodroma castro*	Candidate
Mammals		
Hawaiian hoary bat	*Lasiurus cinereus semotus*	Endangered
Sea Turtles		
Green sea turtle**	*Chelonia mydas*	Threatened
Hawksbill sea turtle**	*Eretmochelys imbricate*	Endangered

Key: NCN = No common name

* = Species or critical habitat found only on Niʻihau

** = Species found on both Niʻihau and Kauaʻi

Species and Critical Habitat within the LDSD Action Area – Nihoa Island

Common Name	Scientific Name	ESA Status
Plants		
NCN	*Amaranthus brownii*	Endangered
Loulu	*Pritchardia remota*	Endangered
NCN	*Schiedea verticillata*	Endangered
‘Ohai	*Sesbania tomentosa*	Endangered
‘Ihi	*Portulaca villosa*	Candidate
Popolo	*Solanum nelsonii*	Candidate
A. brownii critical habitat	N/A	Designated
Loulu critical habitat	N/A	Designated
‘Ohai critical habitat	N/A	Designated
S. verticillata critical habitat	N/A	Designated
Birds		
Nihoa millerbird	*Acrocephalus familiaris kingi*	Endangered
Nihoa finch	*Telespyza ultima*	Endangered
Sea Turtles		
Green sea turtle	*Chelonia mydas*	Threatened
Hawksbill sea turtle	*Eretmochelys imbricate*	Endangered

Key: NCN = No common name

We request your concurrence with our determinations, and hereby request informal consultation under Section 7 of the ESA.

We look forward to hearing from you. If you have any questions in the meantime, please contact me at (757) 824-2319 or Joshua.A.Bundick@nasa.gov.

Sincerely,

Joshua A. Bundick
Lead, Environmental Planning

Enclosure

cc:
250/Mr. T. Meyer
840/Mr. D. Wilcox
HQ/Ms. T. Norwood
JPL/Ms. V. Ryan
LJT/Mr. S. Combs
LJT/Ms. S. Silbert
NMFS PMNM/Ms. T. Brown
PMRF/Mr. J. Burger
USFWS/Ms. J. Kim

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BIOLOGICAL EVALUATION

LOW DENSITY SUPERSONIC DECELERATORS TECHNOLOGY DEMONSTRATION MISSION

Prepared for:

Low Density Supersonic Decelerators Project

Jet Propulsion Laboratory

Pasadena, CA

Prepared by:

Wallops Flight Facility Environmental Office

NASA Wallops Flight Facility

Wallops Island, VA

Submitted to:

U.S. Fish and Wildlife Service

Pacific Islands Fish and Wildlife Office

Honolulu, HI

March 2015

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1.0 Background/History

This Biological Evaluation (BE) has been prepared to address the effects of the National Aeronautics and Space Administration's (NASA) Low Density Supersonic Decelerators (LDSD) Technology Demonstration Mission (TDM) on species listed as endangered or threatened under the Endangered Species Act (ESA) of 1973, or their designated critical habitat. Section 7 of the ESA assures that, through consultation (or conferencing for proposed species) 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.

The primary action considered herein is NASA's funding of up to two Supersonic Flight Dynamics Tests (SFDT) per summer (June through August) from 2015 through 2019, from the U.S. Navy's (USN's) Pacific Missile Range Facility (PMRF) on Kaua'i, Hawai'i. Also considered in this BE are the connected actions of the National Oceanic and Atmospheric Administration (NOAA) and the USFWS. In accordance with the authorities granted to them under Presidential Proclamation 8031 and 50 CFR Part 404, NASA has requested that they, along with the State of Hawai'i, issue the LDSD Project a permit to enter the Papahānaumokuākea Marine National Monument (PMNM). If NASA's permit application were to be approved, their action of issuing the permit would be subject to ESA consultation requirements. As such, NASA has assumed the role as Lead Agency (50 CFR § 402.07) and prepared this BE to fulfill the ESA obligations of all three federal action agencies.

Because the action would occur over (during flight) and within (in the case of an off-nominal landing) the islands of Kaua'i, Ni'ihau, and Nihoa, it has the potential to impact ESA-listed and candidate species that may occur in the area, shown in **Tables 1 and 2**. Although including ESA candidate species in this BE is not required by law, it is USFWS policy to consider candidate species during its decision-making process. Therefore, NASA has included an assessment of potential effects on candidate species in this BE.

Early coordination and pre-consultation with USFWS was conducted during a series of document reviews, e-mails, and telephone conversations including:

- December 2012 and March 2013: NASA completed the *Low Density Supersonic Decelerator Technology Demonstration Mission Pacific Missile Range Facility Final Environmental Assessment* ("LDSD EA;" **NASA 2013**) and issued a Finding of No Significant Impact on May 10, 2013. During the preparation of the LDSD EA, USFWS was provided copies of both the Coordinating Draft and Public Draft EA. Although USFWS reviewed the LDSD EA, no ESA consultation was conducted.
- February 9, 2015: Via email, NASA requested a species list from the USFWS Pacific Islands Fish and Wildlife Office. On that same day, NASA and USFWS held a telephone conversation to discuss the proposed action.

- February 13, 2015: Via email, USFWS provided NASA an advance copy of the LDSD species list and confirmed that it would work toward a 30-day completion timeline for informal ESA consultation, once in receipt of NASA's BE and determinations of effect.
- February 17, 2015: NASA and USFWS held a telephone call to discuss the necessary contents of the LDSD BE. USFWS indicated that detailed species descriptions and a description of the environmental baseline conditions within the action area were not needed.

Table 1: Summary of Species and Critical Habitat within the LDSD Action Area- Kaua'i and Ni'ihau

Common Name	Scientific Name	ESA Status
Plants		
ōlulu*	*Brigharnia insignis*	Endangered
'Awikiwiki*	*Canavalia pubescens*	Endangered
Pu'uka'a*	*Cyperus trachysanthos*	Endangered
Na Pali Beach hedyotis	*Hedyotis st.-johnii*	Endangered
'Ihi'ihi*	*Marsilea villosa*	Endangered
Lau'ehu*	*Panicum niihauense*	Endangered
Wahane*	*Pritchardia aylmer-robinsonii*	Endangered
Mā'oli'oli	*Schiedea apokremnos*	Endangered
'Ohai*	*Sesbania tomentosa*	Endangered
NCN	*Spermolepis hawaiiensis*	Endangered
NCN*	*Vigna o-wahuensis*	Endangered
Dwarf iliau	*Wilkesia hobdyi*	Endangered
'ōlulu critical habitat*	N/A	Designated
Lau'ehu critical habitat	N/A	Designated
Insects		
Hawaiian picture-wing fly	*Drosophila musaphilia*	Endangered
Hawaiian picture-wing fly	*Drosophila sharpi*	Endangered
Birds		
Hawaiian duck**	*Anas wyvilliana*	Endangered
Hawaiian goose	*Branta sandvicensis*	Endangered
Hawaiian coot**	*Fulica alai*	Endangered
Hawaiian gallinule**	*Gallinula chloropus sandvicensis*	Endangered
Hawaiian stilt**	*Himantopus mexicanus knudseni*	Endangered
Short-tailed albatross	*Phoebastria albatrus*	Endangered
Hawaiian petrel**	*Pterodroma sandwichensis*	Endangered
Newell's shearwater**	*Puffinus auricularis newelli*	Threatened
Band-rumped storm-petrel**	*Oceanodroma castro*	Candidate
Mammals		
Hawaiian hoary bat	*Lasiurus cinereus semotus*	Endangered
Sea Turtles		
Green sea turtle**	*Chelonia mydas*	Threatened
Hawksbill sea turtle**	*Eretmochelys imbricate*	Endangered

Key: NCN = No common name

* = Species or critical habitat found only on Ni'ihau

** = Species found on both Ni'ihau and Kaua'i

Table 2: Summary of Species and Critical Habitat within LDSD Action Area – Nihoa Island

Common Name	Scientific Name	ESA Status
Plants		
NCN	*Amaranthus brownii*	Endangered
ʻIhi	*Portulaca villosa*	Candidate
Loulu	*Pritchardia remota*	Endangered
NCN	*Schiedea verticillata*	Endangered
ʻOhai	*Sesbania tomentosa*	Endangered
Popolo	*Solanum nelsonii*	Candidate
A. brownii critical habitat	N/A	Designated
Loulu critical habitat	N/A	Designated
ʻOhai critical habitat	N/A	Designated
S. verticillata critical habitat	N/A	Designated
Birds		
Nihoa millerbird	*Acrocephalus familiaris kingi*	Endangered
Nihoa finch	*Telespyza ultima*	Endangered
Sea Turtles		
Green sea turtle	*Chelonia mydas*	Threatened
Hawksbill sea turtle	*Eretmochelys imbricate*	Endangered

Key: NCN = No common name

Early Coordination (cont.):

- February 19, 2015: NASA received via U.S. mail the official USFWS species list for the LDSD action area, which included Kauaʻi and Nihoa Islands.
- March 4, 2015: Via email, USFWS provided NASA the official species list for Niʻihau Island.

1.1 *Purpose of the Proposed Action*

NASA's TDMs are used to bridge the gap between need and means, between scientific and engineering challenges and the technological innovations needed to overcome them, and between laboratory development and demonstration in space.

Once a technology is proven in the laboratory environment, the program becomes a bridge from ground to flight testing. System-level technology solutions are given the opportunity to operate in the actual space environment, where they gain operational heritage, reduce risks to future missions by eliminating the need to fly unproven hardware, and continue NASA's long history as a technological innovator. These cutting-edge technologies allow future NASA missions to pursue bolder and more sophisticated science, enable safe and rewarding human missions beyond low-Earth orbit, and enable entirely new approaches to United States space operations.

NASA seeks to use atmospheric drag as a solution to the limitations of parachute-only deceleration systems in thin exoatmospheric environments, saving rocket engines and fuel for final maneuvers and landing procedures. The heavier planetary landers of tomorrow, however, would require much larger

drag devices than those currently employed to slow them. The next-generation drag devices would also need to be deployed at higher supersonic speeds to safely land vehicle, crew, and cargo. NASA's LDSD TDM, led by the California Institute of Technology's Jet Propulsion Laboratory (JPL) in Pasadena, California, would conduct full-scale, stratospheric tests of these technologies in the Earth's stratosphere (which mimics Mars's thin atmosphere), to prove their value for future missions to Mars and potentially other solar system bodies.

NASA's Space Technology Mission Directorate (STMD) established the LDSD Project as a test architecture for the development and full-scale testing of decelerator technologies at representative conditions to those found on the planet Mars. The current decelerator technologies were developed in the 1970s as part of NASA's Viking Program, which sent two probes to the Martian surface. Since these early Mars landers, the main focus on technology development has been on the landing phase of planetary missions. The decelerator technologies that could be developed through the LDSD project enable the following on future missions to Mars:

- Placement of more mass on the Martian surface in a single landing
- Making more of the Martian surface accessible for exploration
- Increasing landing accuracy on the Martian surface

The primary focus of the LDSD Project's campaign in Hawai‘i is to validate a 30 meter (m; 100 feet [ft]) diameter Supersonic Ring Sail (SSRS) parachute behind a 6 m (20 ft) attached torus Supersonic Inflatable Aerodynamic Decelerator (SIAD).

2.0 Description of the Action and Action Area

The LDSD Project seeks to conduct up to two SFDT campaigns in the summer of 2015, with the possibility for up to two additional flights per summer (i.e., June through August) through year 2019, from the USN's PMRF on Kaua'i, Hawai'i.

2.1 *Supersonic Flight Dynamics Test Overview*

Each SFDT flight (**Figure 1**) would consist of releasing from PMRF a 34 million cubic foot (1 million cubic meter [m^3]) helium-filled scientific balloon that carries a Test Vehicle (TV) to a minimum desired float altitude of 37,600 m (120,000 ft). At float altitude, the balloon fully inflates to approximately 122 m (400 ft) tall and 137 m (450 ft) in diameter. The TV is then released, initiating the mission sequence. Once the TV is dropped, a signal is sent that separates the flight train from the balloon and, in the process, rips the balloon to allow for its descent. After the TV drops, small solid-fueled rocket motors ignite and stabilize the TV prior to the main motor ignition. The main motor is a Star 48B, a long nozzle solid-fueled rocket engine. The Star 48B ignites, propelling the TV upwards to an altitude of approximately 55,000 m (180,000 ft) at a speed of approximately Mach 4. The TV then deploys a torus (doughnut-shaped) tube called the SIAD to slow its velocity to approximately Mach 2. The TV then deploys the 30-m (100-ft) diameter SSRS parachute, which carries the TV safely to a controlled oceanic impact in a pre-coordinated operational area off the west coast of Kaua'i.

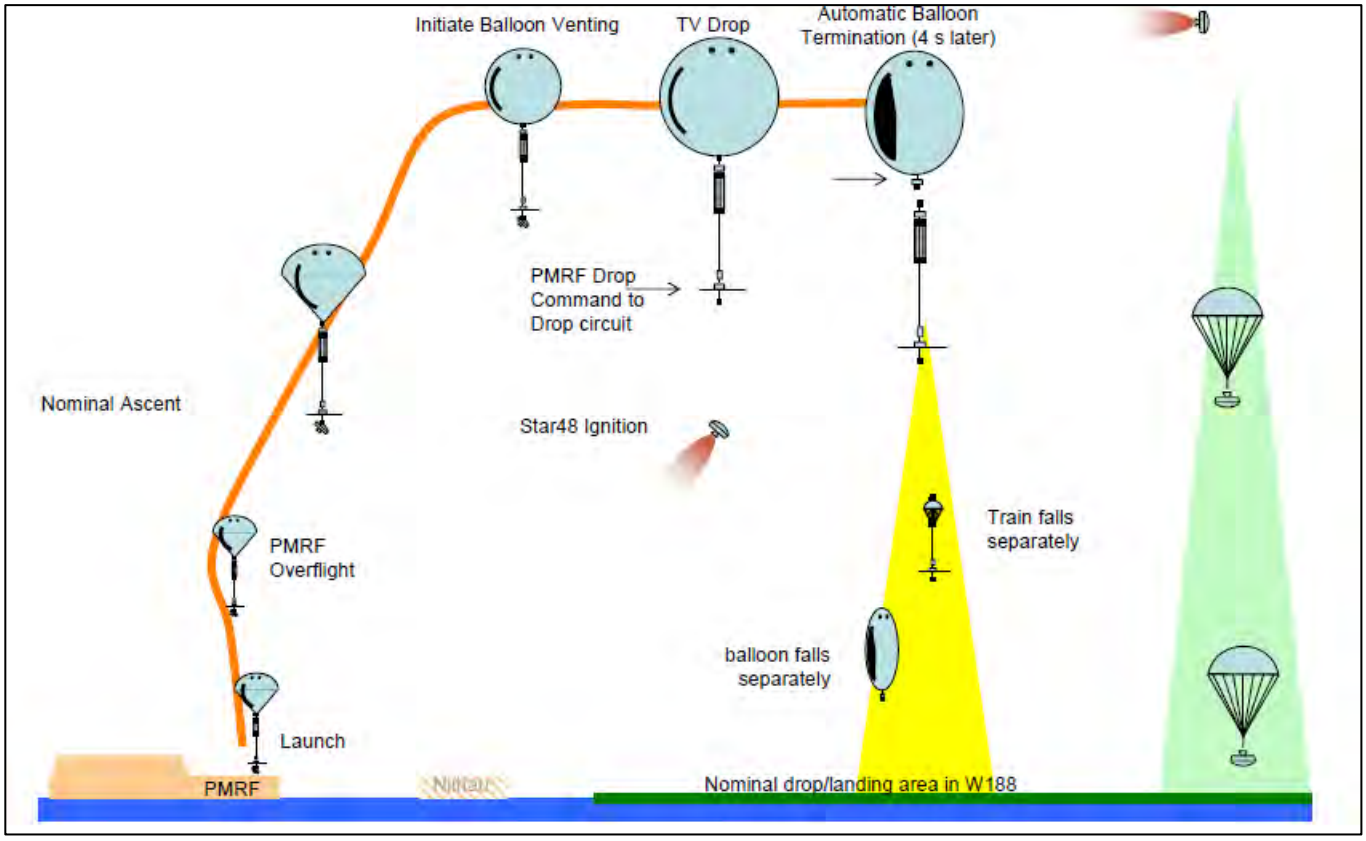


Figure 1: Supersonic Flight Dynamics Test Sequence

2.2 *Pre-launch Activities*

Launch decisions for the SFDT are tied directly to suitability of winds from ground level to a height of approximately 55,000 m (180,000 ft). Meteorological (MET) soundings are used to gauge mid- and upper level wind conditions. Two sizes of latex MET balloons ("2,000 grams" [g] and "30 g"), would be released to measure lower- and mid-level wind conditions from ground up to a height of approximately 33,500 m (110,000 ft) while Super Loki sounding rocket-deployed Rocket Balloon Instruments (ROBINs) are used to calculate upper level wind conditions to a height of approximately 90,000 m (295,000 ft). Each is described in more detail below.

2.2.1 Latex Meteorological Balloons

Radiosondes

During each LDSD campaign, a dress rehearsal is held prior to the first launch attempt of the campaign. This dress rehearsal is used to ensure that all telemetry, command systems, radar tracking, and other systems are functioning properly before the launch attempt. One 2,000 g MET balloon would be released as part of the dress rehearsal. Two 2,000 g MET balloons would be released the day of launch (one 1.5 hours prior to launch and the other 1.5 hours after launch). Each 2,000 g MET balloon would be equipped with a radiosonde that contains instruments capable of making direct in-situ measurements of air temperature, humidity, and pressure (**Figure 2**). These observed data are transmitted immediately to the ground station by a radio transmitter located within the instrument package.

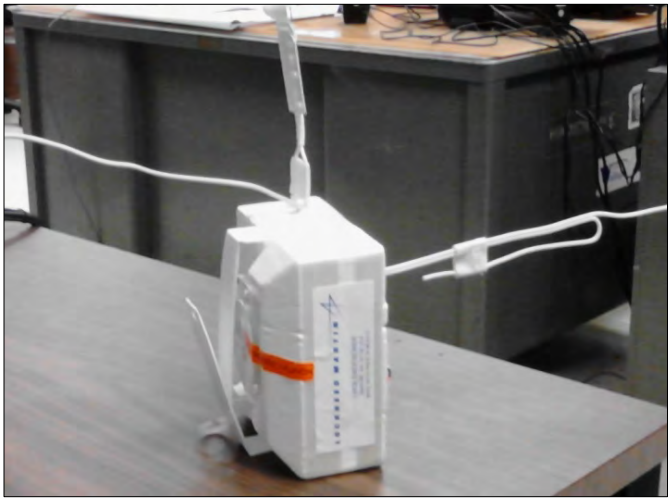


Figure 2: Polystyrene Radiosonde Box with Internal Electronics

The 2,000 g MET balloons are inflated with helium gas and free-fly from the release point on PMRF to a bursting elevation of approximately 35,000 m (115,000 ft). Parachutes then deploy and prevailing winds carry the instrument package over the Pacific. Battery operated (9 volt) radiosondes are not recovered from the ocean. However, they are packed in floating polystyrene containers with waterproof pre-paid labels for return to NASA's scientific balloon contractor. Over the remaining five-year time frame of the LDSD Project, a maximum of 25 radiosonde balloons would be released, burst, and most likely descend to the Pacific Ocean. It is also possible, though unlikely, that a small fraction of these could land on Kaua'i, Ni'ihau Island, or Lehua Islet. Based on wind conditions, these radiosonde balloons should land within

approximately 16 to 32 kilometers (km; 9 to 17 nautical miles [nm]) from the release point on PMRF (**D. Gregory, NASA Balloon Program Office, personal communication, 2015**).

Pilot Balloons

Pilot balloons (30 g MET balloons) are launched to determine wind speed and wind direction (**Figure 3**). They are filled with helium, released to free-fly, and visually tracked with optical instrumentation. Using height and angular direction information from a theodolite to the balloon, wind direction or horizontal movement of the balloon is tracked, calculated, and graphed. For 30 g latex pilot balloons, wind speed and direction can be tracked at altitudes up to 4,500 m (14,800 ft). These balloons do not carry instrumentation on them, rather, they are only balloons.

Starting 25 days before each of the up to two, 10-day launch windows (two work weeks), 30 g latex MET balloons would be released at the rate of one every 30 minutes for two hours before and two hours after sunrise every day. Each balloon would be filled with approximately 0.16 m^3 (5.7 cubic feet [ft^3]) of gaseous helium to a diameter of 64 centimeters (cm; 25 inches [in]). As the balloon rises in altitude, the gaseous helium expands until the balloon bursts completely at about 102 cm (40 in) in diameter.

Figure 3: 30 gram Pilot Balloon and Observation Equipment

If an LDSD launch attempt is not made until the last day of each window, a maximum of 630 pilot balloons could be released per year. For the entire five-year Project, a maximum of 3,150 pilot latex balloons could be released, burst, and land in the action area. Based on wind conditions, approximately 30 to 40 percent of these pilot balloons, equating to between 945 and 1,260 balloons during the remaining five-year term of the LDSD Project, would land in the Pacific Ocean approximately 8 km (4 nm) downrange from their release point on PMRF (**D. Gregory, NASA Balloon Program Office, personal communication, 2015**). The remaining 1,890 to 2,205 pilot balloons would likely land within the island of Kaua‘i.

2.2.2 Super Loki Sounding Rockets

The Super Loki is a two-stage rocket system used to obtain density, temperature, ozone, and wind data at altitudes ranging from 85,000 to 110,000 m (279,000 to 361,000 ft) to ground level. The first stage is

a solid propellant rocket, 0.1 m (0.3 ft) in diameter and 2.0 m (6.6 ft) long. The second stage is an inert instrumented Dart, 0.054 m (0.177 ft) in diameter and 1.26 m (4.13 ft) long. Both stages consist of an aluminum case with an internally burning cast-in-the-case solid propellant. The propellant fuel is a polysulfide polymer and the oxidizer is ammonium perchlorate. The entire rocket is approximately 3.25 m (10.7 ft) long and weighs approximately 30 kilograms (kg; 66 pounds [lb]) with propellants. After ignition, the first stage travels approximately 18,000 m (59,000 ft) in altitude before expending its fuel. The spent first stage rocket then separates from the Dart and follows a trajectory to an ocean impact approximately 5 km (3 nm) downrange. After separation, the second stage Dart ignites and reaches an altitude of approximately 80,000 m (262,000 ft), at which point the motor expends its fuel, the payload is released, and the Dart follows a ballistic trajectory to an ocean impact approximately 31 km (17 nm) downrange.

Each Super Loki rocket would deploy a ROBIN, (a metalized 0.5-mil thick Mylar sphere, 1.0 m [3.3 ft] in diameter, inflated to 12 hectopascal pressure), to a height of approximately 89,900 m (295,000 ft) (**Figure 4**). Since the ROBIN sphere's mass and spherical diameter is known, as the sphere falls from this initial deployment height to a minimum height of approximately 30,500 m (100,000 ft), where the higher external pressure causes the sphere to collapse, radar tracking information can be used to calculate wind direction, wind velocity, temperature, density, and pressure.

Figure 4: ROBIN Sphere Pre- (left) and Post- (right) Inflation

Super Loki MET rockets would be launched in conjunction with the 2,000 g radiosonde balloons. Therefore, over the remaining five-year time frame of the LDSD Project, a maximum of 25 Super Loki first stage motors, 25 Dart second stage motors, and 25 ROBIN spheres would land in the Pacific Ocean west of Kaua'i.

2.2.3 Fate of Unrecovered Meteorological Equipment

Latex Balloons

When a latex balloon is released, the helium gas inside it expands as the balloon rises. Depending on the weight of the balloon and the thickness of the latex, the helium will expand the latex until the balloon bursts. Commonly cited research (**Burchette 1989**) asserts that nearly all latex balloons at burst altitude rupture into small, ribbon-like fragments. However, **Foley** (**1990**) demonstrated that 80 percent of latex balloons studied burst into 2 to 3 mm shreds but, of those, 60 percent (48 percent of the total) remained intact (all or most parts still connected together) and 20 percent burst without shredding at all. Similarly, more recent research

(**Irwin 2012**) noted that only 12 percent of balloons in a trial burst into small pieces and 81 percent were recovered with half the balloon mass intact. As such, from these studies, it is assumed that a portion of the MET balloons used in support of SFDT launch operations would land in small shreds, but most would likely land deflated and fully intact.

Aquatic Landing

Upon landing in an aquatic environment, latex balloon pieces would be positively buoyant, float on the surface, and begin to photo-oxidize due to ultraviolet light exposure. Numerous studies show that latex in water will degrade, losing tensile strength and integrity, though this process can require multiple months of exposure time (**Pegram & 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 (**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 bottom of the water body.

The degree to which such colonization would occur would correspond to the amount of time the balloon would remain at or near the water'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 debris in the aquatic environment. Studies in temperate marine 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 & Andrady 1991; Lobelle & Cunliffe 2011**), or descending farther to rest on the seafloor (**Thompson et al. 2004**).

Terrestrial Landing

Latex balloon pieces that land on Kaua‘i or Ni‘ihau would be exposed to tropical levels of ultraviolet light, humidity, and temperature. Under these conditions, balloon pieces would degrade rapidly from photo-oxidation, plasticizing (from sorbed humidity), and thermo-oxidative degradation caused by heat buildup. The latex degradation process within the terrestrial environment would occur more rapidly than within aquatic areas (**Andrady 1990**). **Irwin (2012)** demonstrated that within 2 weeks of exposure in air, in either sun or shade, latex begins to photo-oxidize and by 10 weeks became brittle. **Andrady (1990)** found that within 6 months of exposure in air, latex lost approximately 94 percent its tensile strength and became weak and brittle, fragmenting into small particles. These particles are then subject to microbial degradation, breaking them down to the molecular level **(Rose & Steinbüchel 2005)**.

<u>Polystyrene Radiosonde Box</u>

Aquatic Landing

Foamed polystyrene is a lightweight, positively buoyant polymer that is degraded by exposure to sunlight, high temperatures, moisture, abrasion, and fouling by microorganisms. According to weathering studies in the marine environment (**Andrady 1990**), foamed polystyrene sheets rapidly undergo yellowing, algal fouling, and embrittlement of the exposed surface. Over a twelve-month exposure period evaluated by **Andrady (1990)**, a surface layer of up to half the original thickness

became brittle enough to crumble on handling. As the polystyrene became more brittle, wind and rain exposure scoured the surface, sloughing off fragments and decreasing the thickness of the material. **Andrady** (**1990**) also determined that the tensile strength of the remaining (non-yellowed) material decreases with the duration of exposure, as the deeper layers become accessible to the free radicals generated during the photoreaction. Foamed polystyrene degraded more quickly in seawater than on land, losing over 60 percent of tensile strength in 4 months and rapidly fragmenting.

As such, it is expected that the radiosonde boxes would remain afloat for a period time following oceanic impact, likely less than a year, during which a combination of fouling (**Wahl 1989**) and photodegradation would cause the material to break into smaller pieces and eventually sink into the water column. As each box would have "return to sender" information on it, the possibility exists for an inestimable portion of these items to be recovered prior to their ultimate degradation and/or descent below the water's surface.

Terrestrial Landing

Expanded polystyrene degrades in the same manner in air as in water but was the only type of material tested by **Andrady (1990)** where the rate of deterioration was faster at sea than on land. In air, the material required an exposure of at least a year to decrease its tensile strength by 40 percent. As such, the radiosonde boxes would remain intact within the action area for a longer period of time than the latex balloons.

Super Loki Rockets

Comprised of aluminum, these negatively buoyant items would sink and slowly corrode on the ocean floor. Small amounts of residual unconsumed solid propellant could be present inside them. However, effects on water quality would be negligible due to the extremely small amount of residual fuel and the effective dilution and buffering capacity of the ocean.

Corrosion of hardware and spent rocket stages into toxic concentrations of metal ions would be localized and temporary because corrosion rates of aluminum are very slow in seawater (**Godard 1960; Ezuber et al. 2008**) and do not change with immersion depth (**Vargel 2004**). Miscellaneous materials such as battery electrolytes are in such small quantities that only temporary, highly localized effects on water quality would be expected.

ROBIN Spheres

The degradation mechanisms for the plastic component (polyethylene terephthalate) of the Mylar ROBIN spheres would be similar to other polymers previously discussed. Studies have demonstrated (**Edge et al. 1991**; **Allen et al. 1994**) that the breakdown of these films is enhanced by increasing temperature, relative humidity, and ultraviolet (UV) irradiation, with high humidity causing the greatest degradation. However, due to the aluminized outer surface, photo-oxidation of the plastic material would be substantially reduced. As such, it is expected that biofouling (**Wahl 1989**) would occur before notable loss of structural integrity, with these items descending to the ocean floor where they would likely remain for many years.

2.3 *Post-launch Recovery Activities*

NASA has a vested interested in recovering the floating expended flight hardware including the scientific balloon, the TV, the flight imagery recorder, and the SIAD. High speed and high resolution memory data storage devices for each flight are onboard the TV and must be recovered. Part of the flight reconstruction process is physical examination of the actual decelerators, so those too must be recovered. Therefore,

accurate tracking information is captured and analyzed in real-time starting at launch of the scientific balloon, during execution of the SFDT, through splash down.

The recovery concept of operations has been demonstrated (**Figures 5 and 6**). During the 2014 campaign, the NASA and USN team demonstrated the ability to precisely predict and track the scientific balloon, TV, and other associated flight hardware through splashdown.

To recover floating expended flight hardware, NASA would deploy three recovery vessels to anchor at positions selected to minimize the recovery operations timeline. The maximum cruise speed of the three vessels would be 22 km per hr [km/hr; 12 knots (kt)] with an average cruising speed of 10 kt. Up to two USN aircraft (either G-2/3 and/or C-12/26) would be flown to perform safety surveillance of the operational area and to assist with locating expended flight hardware for recovery. These aircraft would fly at altitudes between 460 and 7,300 m (1,500 and 24,000 ft) above the ocean surface and would help direct the vessels to the different recovery positions immediately upon splashdown of the floating expended flight hardware. During the 2014 mission, it took the respective vessels approximately 5 hours to reach and recover the supersonic parachute, 6.5 hours to reach and recover the balloon carcass (**Figure 5**), and 4 hours to reach and recover the TV (**Figure 6**). Swimmers, with snorkeling gear, may enter the water to assist in recovery of the floating hardware. As the LDSD project is limited by the 315 km (170 nm) arc centered at Mākaha Ridge, Kaua‘i, swimmers would not enter the water within a Special Preservation Area or the Midway Atoll Special Management Area.

Figure 5: Scientific Balloon Recovery Operations on 2014 SFDT

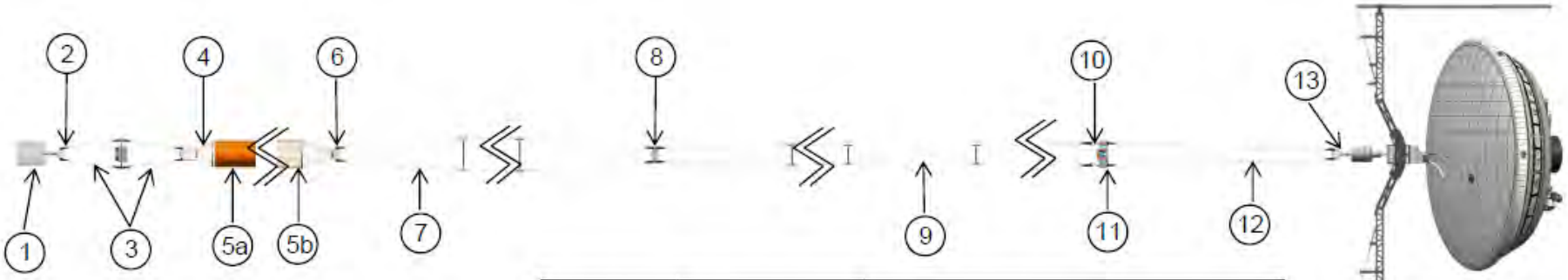
Figure 6: TV Recovery Operations on 2014 SFDT

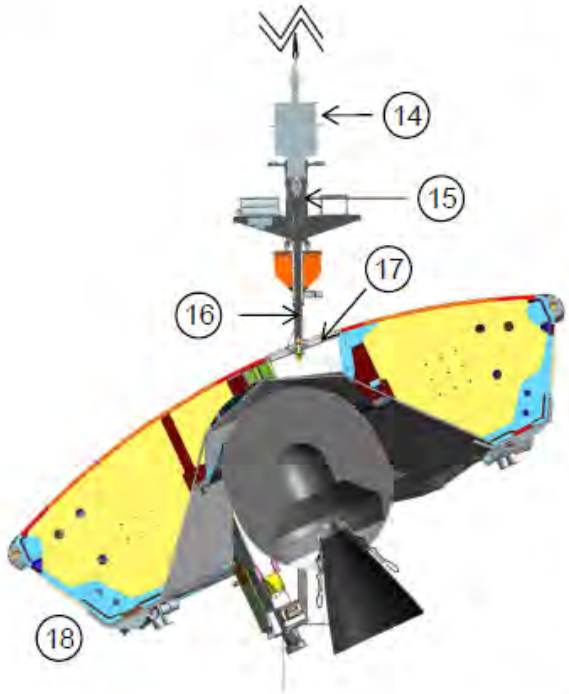
2.4 *Non-Recovered Balloon Flight Train*

Nearly all LDSD expended flight hardware (i.e., TV, balloon) would be recovered from the open ocean, with the exception of the balloon flight train (items 2-17 depicted in **Figure 7**). This flight train connects the TV to the balloon, and consists of a burst parachute (a safety instrument), sensors, connections, and Kevlar® cabling. This system would sink rapidly in the ocean, as described in more detail below.

2.4.1 Detailed Description of Flight Train

The balloon flight train weighs approximately 375 kg (827 lb) and is approximately 300 m (1,000 ft) long from the connection to the balloon through the connection to the TV. Stainless steel connectors, an electronic balloon burst detector for sensing a sudden drop in balloon altitude, a Micro Instrumentation Package (comprised of global positioning system, uplink and downlink telemetry, line of sight ultra-high frequency transceiver and an Iridium unit for over the horizon commanding and telemetry, electronic controlling units for venting the balloon, and small electrically-actuated charges for separating the balloon flight train from the balloon), and 1.5 m (5 ft) of Kevlar® line, connect the balloon to a 22 m (72 ft) diameter (canopy) nylon parachute. Parachute suspension cables connect to interface rings at both the top and bottom of the parachute. Three sections of Kevlar® cable "ladders" interspaced with aluminum anchor plates connect the parachute to the TV's rotator, electronics deck, and release hardware. Each strand of Kevlar® is approximately 1.27 cm (0.5 in) diameter with 0.5 m (1.6 ft) long strands attached perpendicularly between two parallel strands. The three ladder sections are 21, 39, and 4.5 m (69, 128, and 15 ft) long. The TV's electronics deck carries the leak-proof ballast hopper containing approximately 110 kg (243 lb) of 0.3 to 0.5 millimeter (mm; 0.01 to 0.02 in) steel shot ballast (roughly the diameter of beach sand), and controls the slow, complete release of ballast during the ascent phase of LDSD. The TV release hardware contains additional small, electrically-actuated charges for separation of the TV from the balloon flight train.





Train item no.	Assembly	Description
1	Balloon Train	Balloon B 36.73-3H-02
2	Balloon Train	Balloon Interface Hardware
3	Balloon Train	CLS1 12 Metric Ton Kevlar Rope (2 Top)
4	Balloon Train	Cable Loop Terminate Fitt. Standard
5a	Balloon Train	Parachute 72' Canopy
5b	Balloon Train	Parachute Suspension Lines
6	Balloon Train	Bottom Harness Interface
7	Balloon Train	CLS2 12-Metric Ton Kevlar Rope (70 ft. Lg)
8	Balloon Train	LDSD Tower Anchor Plate
9	Balloon Train	CLS3 12-Metric Ton Kevlar Rope (128 ft. Lg)
10	Balloon Train	Connector Rope
11	Balloon Train	Release Plate
12	Balloon Train	CLS4 12-Metric Ton Kevlar Rope (15 ft Lg)
13	Balloon Train	Upper Rotator Hardware
14	Balloon Train	NASA Rotator
15	Balloon Train	Bottom Universal Hardware
16	Balloon Train	Gondola (with Ballast)
17	Test Vehicle	Balloon Fitting
18	Test Vehicle	TV (CSA)

Figure 7: Balloon Flight Train

2.4.2 Estimated Flight Train Sink Rate

To estimate the sink rate of the unrecoverable flight train once in the water, **Shreves & Wilcox (2015)** performed a conservative assessment that included the following primary assumptions:

- The parachute remained 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; and
- The density of seawater remained constant at a value expected at 6,000 m (19,685 ft) depth (1.05 g per cubic cm [65.5 lb per cubic ft]), increasing both the drag and the buoyant forces acting upon the entire system, when, in actuality, the density of seawater would be less at shallower depths.

This assessment determined that, assuming 170 kg (375 lb) of buoyant force, the flight train would sink at a rate between about 0.10 and 0.12 m per second (0.33 to 0.39 ft per second), equating to approximately 375 to 420 m (1,230 to 1,380 ft) per hour (**Figure 8**).

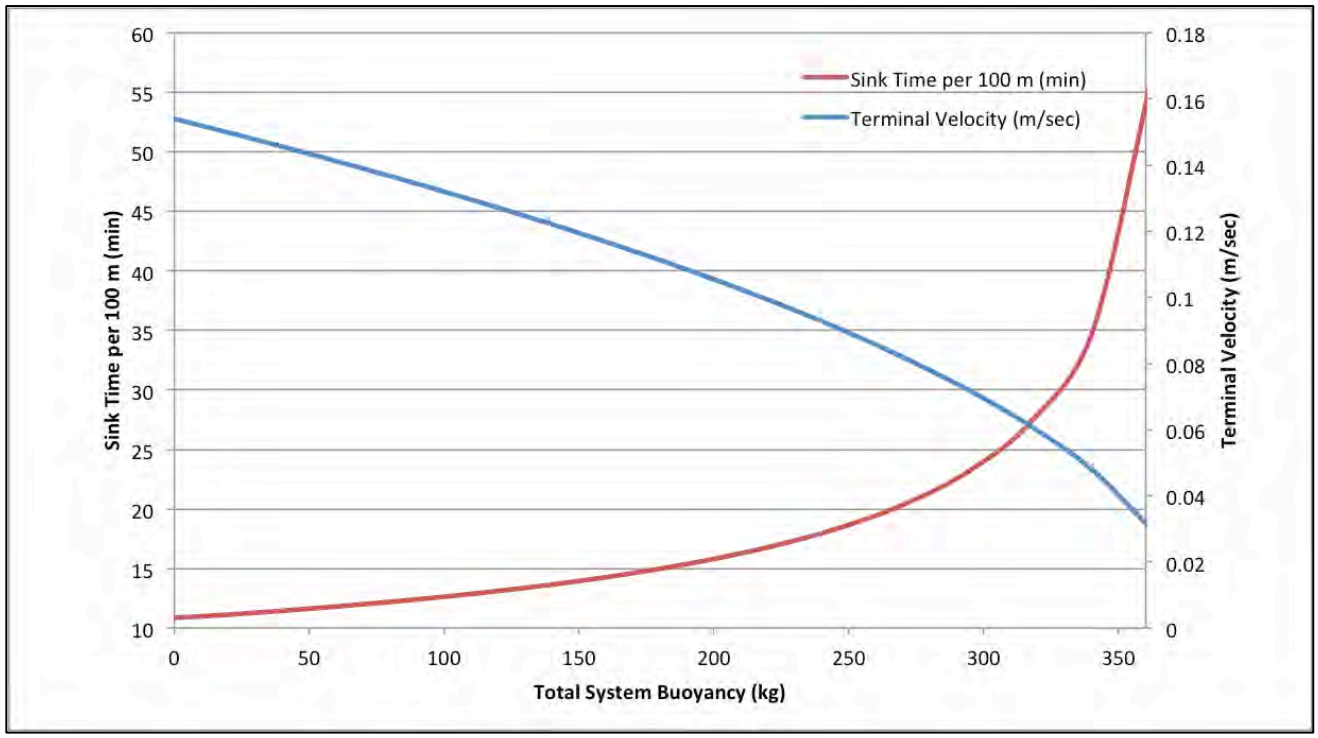


Figure 8: Estimated Sink Rates of Unrecoverable Flight Train

The time required to reach the ocean floor would depend on the depth of the ultimate landing location. However, based on the most commonly encountered depth "bins" within the action area (3,000 to 5,000 m [9,800 to 16,400 ft]: **IOC et al. 2003**), the descending flight train assembly would likely take between approximately 7.5 and 12.5 hours to reach such depths.

2.4.3 Fate of Balloon Flight Train Materials

2.4.3.1 Pyrotechnics

During each SFDT, two distinct separation events must occur: 1) release of the TV and 2) release of the balloon flight train with burst parachute. To enable such separations, the LDSD system contains a series of small explosive charges that are used to sever mechanical connections. To provide perspective on size, the largest charge currently employed is just less than 180 milligrams (0.0004 lb).

Each separation event uses two charges. Under normal flight conditions, all charges would be expended during flight. In an off-nominal flight condition (anomaly event), the charges for separation would not be expended; however, upon water impact, all unexpended charges would short out in the "safe" position, effectively eliminating the possibility of an in-water ignition.

2.4.3.2 Electrical System Components

Small electrical systems are required on the flight train to enable the separation functions described above and to power scientific instruments and flight tracking systems. The entire flight train contains approximately 23 kg (50 lb) of lithium sulfur dioxide ($LiSO_2$) batteries (comparable to approximately 710 "CR-V3" lithium cells typically used in consumer photographic and electronic devices: **Energizer Holdings, Incorporated n.d.**).

Very small quantities of lead-containing solder are used on other parts of the LDSD electrical systems. Although the majority of electrical systems are connected with crimps, some soldered connections are still employed, including those in the battery packs. Approximately 100 g (0.22 lb) of solder would be used on a balloon's entire electrical system, with 40 percent (40 g [0.09 lb]) of this solder consisting of lead. This quantity of lead is slightly more than what is contained in one 12-gauge shotgun shell used for small-game hunting. Therefore, in summary, there would be approximately 40 g (0.09 lb) of lead on each SFDT flight.

2.4.3.3 Nylon Burst Parachute

The parachute's primary material, nylon, is in the family of high molecular weight polymers known as polyamides (**Hegde et al. 2004**), which are not easily degraded by abiotic (physical or chemical) or biotic processes (**Haines & Alexander 1974**). More specifically, LDSD parachutes are made of "ripstop" nylon that is woven with a double or extra-thick thread at regular intervals, creating a pattern of small squares. This structure keeps small tears from spreading (**Hall 2015**).

Photo-oxidative degradation, the process of decomposition of the material by light (most effectively by near-UV and UV wavelengths), would be the most effective source of damage exerted on the nylon parachute. Once initiated by exposure to sunlight, the degradation can continue thermo-oxidatively for some time without the need for further UV exposure as long as oxygen is available (**Andrady 2011**). However, upon entering the water column, the entire balloon flight train system would rapidly sink below the depths to which UV radiation in clear Pacific Ocean waters has been reported to penetrate (50 to 60 m [160 to 200 ft]: **Ahmad et al. 2003**), eventually resting on the

ocean floor where exposure to UV light would also not occur (**Gregory & Andrady 2003**), making photo-oxidation improbable. Once on the ocean floor, the relatively constant temperatures (lacking diurnal cycling) and the 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 that 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 (which could cause a "mass" release of particles), 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 & Silver 1988**). Sinking rates of marine snow are estimated to range from 1 to 368 m (3 to 1,200 ft) per day (**Alldredge & 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 more than decades.

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 (**Derraik 2002**) to even thousands of years (**Barnes et al. 2009**), particularly in deep, cold, dark oceans (**Barnes et al. 2009; Bergmann & Klages 2012)**.

Because of the expected rapid descent toward the light-deficient ocean floor (**Wahl 1989**), fouling of a nylon burst 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**; **Moret-Ferguson et al. 2010**), though at the cost of replacing existing species and leading to non-natural alterations of community composition (**Bergmann & Klages 2012**). The epibionts of benthic polymer (i.e.,

plastic) debris are not as well-known as those of pelagic items. Accounts are limited (e.g., **Hollström 1975**), but indicate a hard ground biota dominated by broyzoans.

2.4.3.4 Kevlar® Ladder

Kevlar® is a negatively buoyant material that is highly resistant to mechanical degradation by abrasion or stretching (**Terry & Slater 1999**). Although studies have shown immersion in seawater causes fibers to swell and consequently lose tensile strength (**Fowler & Reiniger 1979; Riewald et al. 1986; Gopalan et al. 1989**), it is not expected that the material would be exposed to extreme mechanical loading once on the seafloor. As such, the material is expected to remain intact for the foreseeable future.

2.4.3.5 Metallic Components

Once the balloon flight train system is in contact with seawater, structural metallic components (i.e., aluminum and steel alloys) would corrode. Likewise, based on research conducted by **Rosak (1985)**, the $LiSO_2$ batteries would corrode, releasing their electrolytes (e.g., SO_2, acetonitrile, and lithium salt) into the water column and expose the internal lithium metal strips to seawater.

As corrosion rates in seawater are from the cumulative effect of multiple site-specific factors, including temperature, pH, dissolved oxygen, currents, and extent of biofouling (**Guedes Soares et al. 2011**), absolute corrosion rates of metallic balloon flight train hardware cannot be accurately estimated. However, some general observations can be made about the fate of these materials. When comparing potential corrosion rates of the balloon flight train system metals, due to the relatively high dissolved oxygen concentrations of the Pacific Ocean water at depth (**Joos et al. 2003**), ferrous materials would undergo corrosion more rapidly (**Melchers 2005**) than the aluminum components, which tend to form a protective oxide coating that can preserve the material (**Reinhart 1969**). Similarly, items containing lead (e.g., solder), a metal often regarded as highly resistant to corrosion in the marine environment (**Tylecote 1977**), would form a protective inorganic coating on their surfaces, slowing dissolution. Finally, given lithium metal's highly reactive nature in water, some of the corroded $LiSO_2$ batteries (i.e., those not fully discharged) could exhibit characteristic, short-duration lithium-water exothermic burning and popping, forming lithium chloride and releasing hydrogen gas (**Rosak 1985**). In the instance of fully discharged batteries, they would be unreactive due to the lithium metal being converted to a lithium oxide (**Aral & Vecchio-Sadus 2008**).

2.5 *Measures to Reduce Potential for Adverse Effects on Listed Species*

To reduce the potential for adverse effects on listed species, NASA has included the following measures as integral components of its proposed action.

2.5.1 Recovery of Expended Flight Hardware

As discussed in Section 2.3.1 of this BE, NASA requires that all major flight hardware components be tracked during flight until splashdown, at which point surface vessels (i.e., propeller-driven ships) will be deployed to recover the balloon and TV. The rapid recovery of such items would limit the timeframe within which listed species could interact with (and therefore be exposed to stressors from) the expended flight hardware.

2.5.2 Employment of Vessel Operating Protocols

To ensure that in-water species are not exposed to ship-induced stressors (e.g., ship strike), constant vigilance would be maintained for the presence of ESA-listed marine mammals and sea turtles. Vessels would remain at least 92 m (300 ft) from Hawaiian monk seals and humpback whales and at least 46 m (150 ft) from all other marine mammals and sea turtles. Vessel speeds would be reduced to 18.5 km/hr (10 kt) or less when piloting in the proximity of marine mammals and further reduced to 9.25 km/hr (5 kt) or less when piloting in areas of known or suspected sea turtle activity. If marine mammals or sea turtle approach a vessel, activity would stop, allowing the animal to safety depart the immediate area prior to resuming operation. Additionally, to prevent the introduction of marine alien species, all submerged and waterline surfaces would be cleaned of algae or other organisms prior to vessel use and ballast water would be managed in accordance with U.S. Coast Guard Regulations (33 CFR Part 151).

Likewise, the operators of LDSD search and recovery aircraft are required to operate at an altitude greater than 457 m (1,500 ft), at which the effects of overflight (e.g., startle) would be minimal. Furthermore, should aircraft operators observe marine mammals or sea turtles, they would not undertake potentially harassing (e.g., repeated circling) patterns until the individuals are no longer under the aircraft's flight path.

2.5.3 Reporting

Under the ESA (and the PMNM Permit General Terms and Conditions), NASA has a continuing duty to monitor the effects of its ongoing actions on listed species. As such, by December 31 of each year between the years 2015 and 2019, NASA will submit to USFWS a report on the outcomes of its proposed action. Annual reports will include the following: (a) the dates of all SFDT launches; (b) locations (GPS coordinates) of all SFDT flight terminations and resultant recoveries; (c) any available information on the fate of expended flight hardware after flight termination, including sink rate, evidence that components failed to sink, or evidence that components later reappeared on the surface; (d) information on attempts to recover hardware after flight termination; and (e) any evidence that listed species were adversely affected by the action.

2.6 *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." **Figure 9** depicts the action

area for the proposed SFDTs, which includes the airspace, land, water column, and seabed within which the balloon and TV could fly and expended flight hardware could land and ultimately come to rest. The action area also accounts for where the flight and deposition of meteorological support equipment (i.e., MET balloons, Super Loki rockets, ROBIN spheres) could occur.

The action area is defined by the addition of three shapes. The basic shape, depicted in light pink in **Figure 9**, is the LDSD operations area defined by a 315 km (170 nm) arc centered on Mākaha Ridge, Kauaʻi, which is the TV to PMRF telecommunications limit. This operations area is wholly inside the USN Hawaiian Range Complex, and is where the balloon would loft the TV, the TV would perform the SFDT, and expended flight hardware would land. The second orange shape is an approximately 11 km (6 nm) buffer along the western and northern PMRF to TV telecommunications arc. If the TV and balloon were to land at the northern or western boundary of the telecommunications limit, this buffer accounts for a conservative estimate of the distance floating hardware could drift with westerly flowing surface currents (**Flament 1996**) for the 12 hours it could take for recovery vessels to reach them. This buffer also includes a conservative estimate of potential lateral drift of the unrecovered flight train as it descends to the ocean floor. The third shape is a dark pink circle, having a 17 km (9 nm) radius centered at the MET balloon release location on PMRF, within which 2,000 gram and 30 gram MET balloons would land upon bursting at altitude.

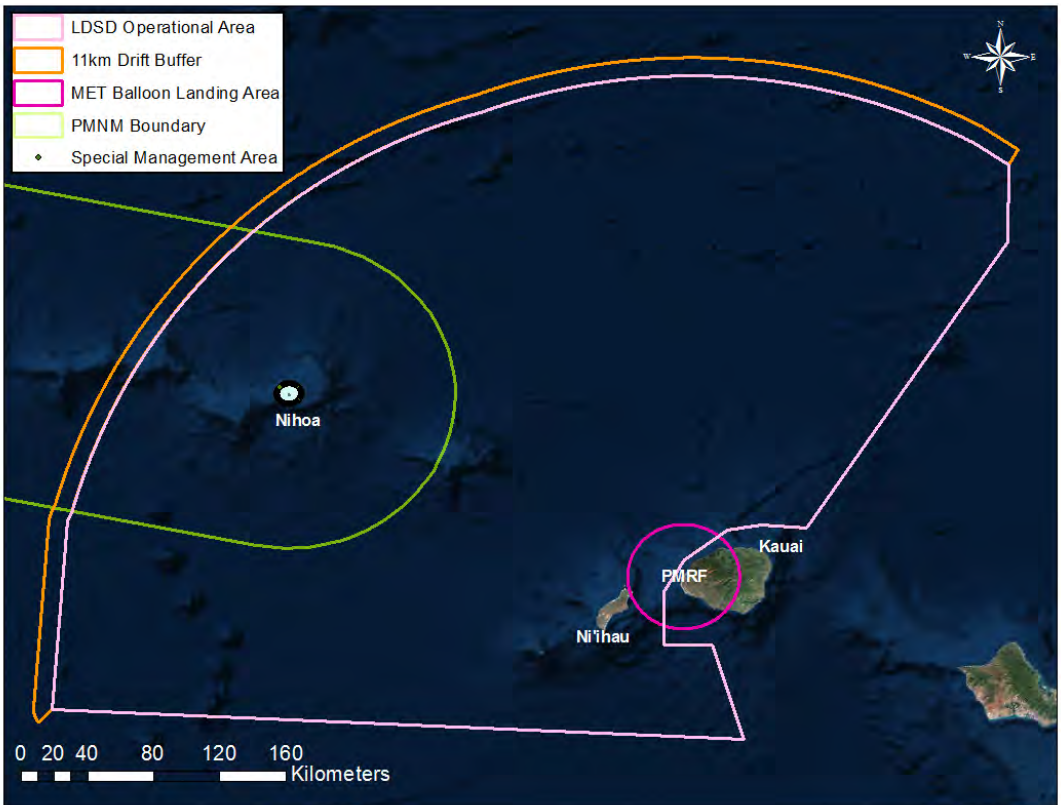


Figure 9: LDSD SFDT Action Area

It should be noted that under nominal flight conditions, the action area would not include the terrestrial or marine areas comprising Ni‘ihau, Nihoa Island, and the Special Management Area within 5.6 km (3.0 nm) surrounding Nihoa Island. To ensure that flight hardware does not land within these areas, one of two scenarios would occur: (1) the LDSD Project would initiate the SFDT in such a manner that expended flight hardware would be recovered or sink before drifting into either area or (2) the flight system would overfly these areas and the TV would be dropped outside either area. Therefore, with the exception of an in-flight system failure, expended flight hardware would not be deposited on Ni‘ihau, Nihoa Island, or within the Special Management Area surrounding Nihoa Island.

2.7 *Connected Federal Action Also Considered in This BE*

As the action area would include a portion of the PMNM, on January 27, 2015, NASA submitted to the PMNM permit coordinator an application seeking authorization to allow for access to PMNM waters. NASA is seeking this authorization via the established permitting process defined in Presidential Proclamation 8031 and codifying regulations in 50 CFR Part 404. PMNM issues permits in six categories (Research, Education, Conservation and Management, Native Hawaiian Practices, Special Ocean Use, and Recreation). Per recommendation of the PMNM permit coordinator, NASA is requesting authorization under Permit Category-Conservation and Management. The permit application seeks the ability to potentially drop and recover floating expended flight hardware from five years of future flights beginning with two scheduled SFDTs in 2015 within the boundary of PMNM, but outside of the Special Management Area surrounding Nihoa Island (**Figure 9**). This permit would also allow NASA to enter the PMNM for recovery purposes if the flight hardware is dropped outside the PMNM but carried into the PMNM by ocean currents.

Under the assumption that all possible trajectories were allowed to fly, NASA estimates the balloon has approximately a 0.4 percent chance of reaching float altitude within PMNM and a 20 percent chance of entering PMNM after reaching float altitude. These probabilities are reduced when NASA and the USN apply the project’s established Go/No Go criteria (e.g., safety restrictions, proper weather conditions, operational status of all LDSD subsystems, telemetry checks, and readiness of recovery systems). These test rules eliminate trajectories that are predicted to fly out directly over large populated areas or follow a trajectory outside boundaries established by NASA, the USN and the Federal Aviation Administration.

3.0 Listed Species & Critical Habitat in the Action Area

The following ESA-listed or candidate species and critical habitat could occur within the action area, or may be affected by the proposed action.

3.1 *Kaua‘i*

Four listed plant species, one mammal species, two listed insect species, eight listed and one candidate bird species, and two listed sea turtle species are known to occur on Kaua‘i. Designated, currently unoccupied critical habitat for one plant species is also located on the island.

3.1.1 Plants

3.1.1.1 Na Pali Beach Hedyotis

Na Pali Beach hedyotis (*Hedyotis st.-johnii*) is ESA-listed as endangered throughout its range (**56 FR 49639**). Found only on Kaua‘i within the Na Pali Coast State Park (approximately 19 km [12 mi] from PMRF) and Pu`u Ka Pele Forest Reserve (approximately 10 km [6 mi] from PMRF), this succulent perennial herb is a member of the coffee family (**USFWS 2009**).

3.1.1.2 Mā‘oli‘oli

The mā‘oli‘oli (*Schiedea apokremnos*) is ESA-listed as endangered throughout its range (**56 FR 49639**). Found only on Kaua‘i within the Na Pali Coast State Park (approximately 19 km [12 mi] from PMRF), including 20 plants found on Mākaha Point, and within Pu`u Ka Pele Forest Reserve (approximately 10 km [6 miles (mi)] from PMRF), this flowering plant in the carnation family grows in crevices on nearly vertical coastal cliffs, between elevations of 60 and 330 meters (200 to 1,100 feet: **USFWS 2010c**).

3.1.1.3 Spermolepis hawaiiensis

Spermolepis hawaiiensis (no common name) is ESA-listed as endangered throughout its range (**59 FR 56333**). In 1999, *S. hawaiiensis* was thought to be extinct on Kaua‘i but subsequent field surveys confirmed this species still exists within nine valleys on the island. On Mākaha Ridge, along the north-northeast-facing cliffs at PMRF, about 500 individuals of *S. hawaiiensis* were seen between elevations of 396 and 457 meters (1,300 to 1,500 feet). A second colony containing about 200 individuals was found on the steep north-facing valley walls to the south of the PMRF Helicopter Landing Zone. This grouping occurred at around 350 meters (1,150 feet) elevation (**USFWS 2010b**).

3.1.1.4 Dwarf Iliau

The dwarf iliau (*Wilkesia hobdyi*) is ESA-listed as endangered throughout its range (**57 FR 27859**). Found only on Kaua‘i, this short-lived, perennial shrub in the aster family, occurs within PMRF at Mākaha Ridge. In 2006, a study was undertaken for the planning of the PMRF

that summarized extant populations and their numbers. That study indicated that there are presently ten populations of *W. hobdyi*, with a total of 759 to 809 individuals (**USFWS 2010a**).

3.1.1.5 Lau'ehu Critical Habitat

Portions of beach dune areas at PMRF have been designated as critical habitat for the ESA-endangered grass, Lau'ehu (*Panicum niihauense*) (**68 FR 9116**). The primary constituent elements of *P. niihauense* critical habitat include, but are not limited to, the habitat components provided by: (1) sand dunes in coastal shrubland and containing one or more of the associated native plant species and (2) elevations between 0 and 29 m (0 and 95 ft) (**68 FR 9116**). *P. niihauense* critical habitat on PMRF is currently unoccupied by the species, but the grass does occur on State of Hawai'i land north of PMRF (**USN 2014**). Surveys for *P. niihauense* were conducted in March, April, and May 2014 within the area designated as critical habitat but no plants were found (**USN 2014**).

3.1.2 Insects

3.1.2.1 Picture-wing Fly (Drosophila musaphilia)

The picture-wing fly (*D. musaphilia)* is ESA-listed as endangered throughout its range (**71 FR 26835**). Found only on Kaua'i, the primary constituent elements for *D. musaphilia* habitat are: (1) mesic, montane, ohia (*Metrosideros polymorpha*) and koa (*Acacia koa*) forest between the elevations of 790 and 1,130 meters (2,600 and 3,700 feet); and (2) for the larval stage, the host plant koa, which exhibits one or more life stages from seedlings to senescent plants (**USFWS 2012**), as koa slime fluxes are the only food source for *D. musaphilia.*

3.1.2.2 Picture-wing Fly (Drosophila sharpi)

The picture-wing fly (*D. sharpi*) is ESA-listed as endangered throughout its range (**75 FR 18960**). Found only on Kaua'i, *D. sharpi* inhabits wet forest in the montane mesic and montane wet ecosystems at elevations generally between 914 and 1,200 m (3,000 and 3,940 ft). Like most picture-wing flies, the adult flies are believed to be generalist microbivores (microbe eaters) and feed upon a variety of decomposing plant material. The host plants for *D. sharpi* are believed to be species of native *Cheirodendron* and *Tetraplasandra* (**75 FR 18960**).

3.1.3 Birds

3.1.3.1 Hawaiian Duck

The Hawaiian duck (*Anas wyvilliana*) is ESA-listed as endangered throughout its range (**32 FR 4001**). The Kaua'i population has been estimated to be around 2,000 birds (**Engilis et al. 2002**). Hawaiian ducks breed year-round, but the majority of nesting records is from March through June (**USWFS 2011b**). Many Hawaiian ducks on Kaua'i use lowland ponds and wetlands primarily for feeding and loafing, and nest along montane streams (**USFWS 2011c**). Within the action area, the species has been observed in the agricultural drainage ditches on southern PMRF's Main Base. However, no nesting has been documented in these areas (**USFWS 2014**).

Seasonal movement of Hawaiian ducks to ephemeral wetlands on Niʻihau has been reported (**Engilis et al. 2002**). Forage items include aquatic invertebrates and seeds and leaves of wetland plants (**Engilis et al. 2002**).

3.1.3.2 Hawaiian Goose

The Hawaiian goose (*Branta sandvicensis*) is ESA-listed as endangered throughout its range (**32 FR 4001**). The estimated statewide population size is approximately 1,300 individuals, of which there are currently four population centers on Kauaʻi, each resulting from releases of captive-bred birds at different times (**USWFS 2004**). Most of the Kauaʻi populations are found at low elevations, ranging from sea level to 180 meters (600 feet). The species has an extended breeding season with eggs laid within all months between August and April (**Banko et al. 1999**). Nesting peaks in December and most goslings hatch from December to January (**USFWS 2004**). The species forages primarily on leaves and seeds of grasses and sedges, and fruits of several species of shrubs (**Banko et al. 1999**). Within the action area, the species presence has increased, with multiple recent nesting events documented near the PMRF runway and within the Hawaiʻi Air National Guard complex (**USFWS 2014**). The species is also found at the PMRF Kōkeʻe and Mākaha Ridge sites (**USFWS 2014**).

3.1.3.3 Hawaiian Coot

The Hawaiian coot (*Fulica alai*) is ESA-listed as endangered throughout its range (**35 FR 16047**). The species is endemic to the Hawaiian Islands, breeding on Kauaʻi and Niʻihau, among others (**Pratt & Brisbin 2002**). Its total population fluctuates between 2,000 and 4,000 individuals, with the vast majority on Kauaʻi, Oʻahu, and Maui (**Pratt & Brisbin 2002**). Nesting occurs year-round (**Pratt & Brisbin 2002**). Within the action area, the species has been observed in the agricultural drainage ditches and sewage oxidation pond on southern PMRF's Main Base. However, no nesting has been documented in these areas (**USFWS 2014**). Individuals are also found in and around the lakes (playas) on the southern part of Niʻihau. The species feeds on plant material (i.e., seeds and leaves) as well as mollusks (**Pratt & Brisbin 2002**).

3.1.3.4 Hawaiian Gallinule

The Hawaiian gallinule (also known as Hawaiian common moorhen; *Gallinula chloropus sandvicensis*) is ESA-listed as endangered throughout its range (**32 FR 4001**). This non-migratory species has been extirpated from Maui, Molokaʻi, and the island of Hawaiʻi, but populations persist on Oʻahu and Kauaʻi (**USFWS 2011c**). **DesRochers et al. (2008)** provided a rangewide population estimate between approximately 200 and 500 individuals. Birds are widely distributed in lowland wetlands and valleys on Kauaʻi, including the Hanalei and Wailuā River valleys, Waiakalua Reservoir, Wilcox Ponds, and irrigation canals on the Mānā Plain (**USFWS 2011c**). Nests are typically constructed in emergent vegetation above shallow water. Nesting occurs year-round, but most activity is from March through August and is influenced by water levels and vegetation growth (**USFWS 2011c**). Hawaiian gallinules are primarily

herbivorous, consuming seeds and stems of wetland plant species (**DesRochers et al. 2009**). Within the action area, the species has been observed in the agricultural drainage ditches on southern PMRF's Main Base. However, no nesting has been documented in these areas (**USFWS 2014**).

3.1.3.5 Hawaiian Stilt

The Hawaiian stilt (*Himantopus mexicanus knudseni*) is ESA-listed as endangered throughout its range (**35 FR 16047**). Hawaiian stilts occur in lowland coastal wetlands on six of the eight major Hawaiian Islands, including Kaua'i. The species is non-migratory except for seasonal movements between adjacent islands (**Robinson et al. 1999**). Within the action area, the species has been observed in the agricultural drainage ditches and sewage oxidation pond on southern PMRF's Main Base. However no nesting in these areas has been documented (**USFWS 2014**). Nesting occurs from mid-February through late August with peak nesting varying among years (**Robinson et al. 1999**). Their diet consists primarily of aquatic invertebrates and fish (**Robinson et al. 1999**).

3.1.3.6 Short-tailed Albatross

The short-tailed albatross (*Phoebastria albatrus*) is ESA-listed as endangered throughout its range (**65 FR 46643**). Little is known about the ecology of this seabird species when in the open ocean (**Piatt et al. 2006**). Birds apparently move seasonally around the North Pacific, with high densities near Japan during the breeding season (December to May), and migration of adults during the non-breeding season through the North American west coast up to Alaska (April to December) waters (**McDermond & Morgan 1993**).

Midway Atoll is likely the only area within U.S. jurisdiction where short-tailed albatross have attempted to breed (**USFWS 2008**). Observations of individual short-tailed albatross have also been made during the breeding season in the Northwest Hawaiian Islands (NWHI) of Laysan Island, Green Island at Kure Atoll, and French Frigate Shoals, but there is no indication that this species breeds in these locations (**USFWS 2008**). The diet of this species during breeding season is not well known. However, available records indicate that it forages primarily on squid, fish, and crustaceans (**USFWS 2008**).

3.1.3.7 Hawaiian Petrel

The Hawaiian petrel (*Pterodroma phaeopygia sandwichensis*) is ESA-listed as endangered throughout its range (**32 FR 4001**). The total population including juveniles and subadults in 1995 was estimated at 20,000 with a breeding population of 4,500 to 5,000 pairs. Hawaiian petrels are colonial seabirds, nesting in burrows, crevices in lava, or under ferns (**Simons & Hodges 1998**). After a period of burrow maintenance and social activity, they return to the sea until late April, when egg laying begins. Non-breeding birds visit the colony from February until late July. Chicks begin hatching in late June and fledge between late September and late November (**Simons & Hodges 1998**). The status of the species on Kaua'i is unknown.

However, grounded Hawaiian petrel fledglings have been collected as part of the Newell's shearwater recovery program. Most birds have been found near the mouth of Waimea Canyon, indicating that some birds still breed in the vicinity. The species forages primarily on squid, fish, and crustaceans, caught at or near the sea surface (**Simons & Hodges 1998**).

3.1.3.8 Newell's Shearwater

Newell's shearwater (*Puffinus auricularis newelliis*) is ESA-listed as threatened throughout its range (**40 FR 44149**). The most recent population survey from **Spear et al. (1995)** estimates the total population to be around 84,000 birds, with approximately 75 percent occurring on the island of Kaua'i. The Newell's shearwater nests from April to November in burrows under ferns on forested slopes in the interior mountains of Kaua'i (**Ainley et al. 1997**). A single egg is laid in late May or early June, which both sexes incubate for approximately 45 days. Daily flights to and from the colonies occur only at night. Fledglings leave the nesting grounds at night in October and November and head for the open ocean (**Ainley et al. 1997**). When not at breeding colonies, Newell's shearwater is pelagic, spending much of its time in waters overlying depths greater than 2,000 m (6,560 ft), mostly to the east and south of the Hawaiian Islands (**Ainley et al. 1997**). The species forages primarily on squid (**Ainley et al. 2014**), likely caught within the upper 10 m (33 ft) of the water column (**Ainley et al. 1997**).

3.1.3.9 Band-Rumped Storm-Petrel

The band-rumped storm-petrel (*Oceanodroma castro*) is a small seabird recognized as a candidate species under the ESA. Within the Main Hawaiian Islands (MHI), the species is currently known to nest only in remote cliff locations on Kaua'i and Lehua Islet, and in high-elevation lava fields on the island of Hawai'i (**USFWS 2011a**). Band-rumped storm-petrels nest in burrows or natural cavities in a variety of high elevation, inland habitats (**Slotterback 2002**). The population on Kaua'i is estimated at between 171 and 221 breeding pairs. Adults establish nesting sites in April or May, females lay a single egg per season between May and June, and chicks fledge in October (**Slotterback 2002**). When not at nesting sites, adults spend their time foraging in the open ocean, particularly over areas of deep water and high productivity (**Slotterback 2002**). Within the action area, such foraging areas occur within only a few kilometers of breeding colonies. Based on records from the Galapagos Islands, band-rumped storm-petrels feed on small fish, squid, and crustaceans. However, diet information is not available for Hawaiian birds (**Slotterback 2002**).

3.1.4 Mammals

3.1.4.1 Hawaiian Hoary Bat

The Hawaiian hoary bat (*Lasiurus cinereus semotus)* is ESA-listed as endangered throughout its range (**35 FR 16047**). It roosts in native and non-native trees throughout all MHI but has no strong preference for any single species. It is widespread at all elevations sampled from 10 to 2,000 m (33 to 6,560 ft). It has also been observed in coastal areas, rainforests, dry forest

habitats, and above wetlands and streams. Within the action area, observations of Hawaiian hoary bats have occurred at PMRF, Barking Sands at the oxidation pond in the southern area of the base and over open ocean near the Nohili Ditch outfall (**USFWS 2014**). Lepidoptera (moths and butterflies), followed by Coleoptera (beetles), make up 67 and 32 percent (respectively) of the Hawaiian hoary bat's diet (**USFWS 2011b**).

3.1.5 Sea Turtles

3.1.5.1 Green Turtle

The Hawaiian population of green sea turtle (*Chelonia mydas*) is ESA-listed as threatened throughout its range (**43 FR 32800**). The green sea turtle is the most common sea turtle species occurring in the waters around the Hawaiian Islands. The species' breeding and nesting season ranges from mid-April to mid-August of each year (**Balazs 1976**). During the breeding season, males and females swim 800 to 1,300 km (430 to 700 nm) from their feeding grounds in the MHI to their nesting beaches in the NWHI. More than 90 percent of all green sea turtle breeding and nesting activity in Hawaiian waters occurs at French Frigate Shoals (**Balazs 1980**), with the main rookery on East Island (**Tiwari et al. 2010**). Upon nesting, most adults migrate to the coastal waters surrounding the MHI (especially around Maui and Kaua‘i: **Balazs 1976**). Hatchling green turtles emerge from their nests and enter the ocean, after which little is known until they enter neritic foraging grounds approximately five to ten years later (**Reich et al. 2007**).

Adult green sea turtles are unique among sea turtles in that they are primarily herbivorous, feeding on seagrasses, sea lettuce, and algae, and, to a lesser extent, jellyfish, salps, and sponges (**Bjorndal 1997**). During the oceanic phase of life, young green turtles are primarily carnivorous, foraging on prey items commonly found within the first 100 m (330 ft) of the water column, including zooplankton, crustaceans, and mollusks **(Parker et al. 2011)**.

Within the action area, green turtles use areas of the beaches at PMRF (e.g., Nohili Ditch outfall) for basking and resting, and, to some extent, foraging (**USN 2014**). In addition, three green turtle nests were laid in the summer of 2010, one in the summer of 2011, and three in the summer of 2012 on PMRF's beaches (**USN 2014**).

3.1.5.2 Hawksbill Turtle

The hawksbill sea turtle (*Eretmochelys imbricate*) is ESA-listed as endangered throughout its range (**35 FR 8491**). Hawksbill sea turtles are the second most common species in the offshore waters of the Hawaiian Islands; although, they are far less abundant than green sea turtles. In Hawai‘i, hawksbills nest on MHI beaches, primarily along the east coast of the island of Hawai‘i and, to a much lesser extent, Maui, O‘ahu, and Moloka‘i (**NMFS & USFWS 1998a**). Peak nesting activity occurs from late July to early September (**Katahira et al. 1994**). Similar to other species of sea turtles, upon hatching, young hawksbills inhabit an oceanic habitat, returning years later to neritic habitats as larger juveniles (**Musick & Limpus 1997**).

Studies of hawksbill diet have identified sponges (Caribbean: **Meylan 1988**) and, to a lesser extent, tunicates (eastern Pacific: **Carrión-Cortez et al. 2013**) as primary forage items.

3.2 *Nihoa Island*

Four listed and two candidate plant species, two listed landbird species, and two listed sea turtle species may occur on Nihoa Island. Additionally, the entire island is designated critical habitat for four listed plant species.

3.2.1 Plants

3.2.1.1 Amaranthus brownii

Species

Amaranthus brownii (no common name), is ESA-listed as endangered throughout its range (**61 FR 43178**). A member of the amaranth family, *A. brownii* is an annual herb with leafy upright or ascending stems. Its growing season extends from December to June or July. It is found in fully exposed locations at elevations between 30 and 240 m (100 and 800 ft), typically growing in shallow soil on rocky outcrops. The species is endemic to the island of Nihoa in the NWHI. The two known populations last identified in 1983 are separated by a distance of 0.4 km (0.25 mi) and contain approximately 35 plants: about 23 plants near Millers Peak and about 12 plants in Middle Valley.

Critical Habitat

Within the action area, critical habitat for *A. brownii* has been designated as the entire island of Nihoa (totaling 69 hectares [ha; 171 acres (ac)]) (**68 FR 28054**).

3.2.1.2 Loulu

Species

The loulu (*Pritchardia remota*) is ESA-listed as endangered throughout its range (**61 FR 43178**). A member of the palm family, the species is found on Nihoa Island at the base of cliffs and on high cliff terraces ranging from an elevation of 200 to 800 m (660 to 2,620 ft).

Currently, *P. remota* is known from two populations on Nihoa that are found along 0.2 km (0.1 mi) of the length of two valleys on opposite sides of the island, approximately 0.6 km (0.4 mi) apart. Approximately 680 plants are found in scattered groups on the island. The largest population grows in the West Palm Valley (approximately 387 plants), while the three smaller populations (approximately 293 plants, total) are found in the East Palm Valley (**Gemmill 1998**).

Critical Habitat

Within the action area, critical habitat for *P. remota* has been designated as the entire island of Nihoa (totaling 69 ha [171 ac]) (**68 FR 28054**).

3.2.1.3 Schiedea verticillata

Species

Schiedea verticillata (no common name) is ESA-listed as endangered throughout its range (**61 FR 43178**). It is a perennial herb that dies back to an enlarged root during dry seasons. *S. verticillata* typically grows in soil pockets and cracks on coastal cliff faces at elevations between 30 and 270 m (100 and 890 ft). Approximately 10 colonies occur on Nihoa, primarily on the western half of the island.

Critical Habitat

Within the action area, critical habitat for *S. verticillata* has been designated as the entire island of Nihoa (totaling 69 ha [171 ac]) (**68 FR 28054**).

3.2.1.4 ʻOhai

Species

ʻOhai (*Sesbania tomentosa*) is ESA-listed as endangered throughout its range (**59 FR 56333**). A member of the pea family, it is usually a low, spreading shrub with horizontal or arching branches. However, it can also be a small tree, up to approximately 5 m (15 ft) tall.

ʻOhai are endemic to the Hawaiian Islands and naturally found on sandy beaches, dunes, soil pockets on lava, and, only at Mānā, Kauaʻi, along pond margins. ʻOhai is considered rather common (i.e., several thousand individuals) in the shrubland on Nihoa.

Critical Habitat

Within the action area, critical habitat for *S. tomentosa* has been designated as the entire island of Nihoa (totaling 69 ha [171 ac]) (**68 FR 28054**).

3.2.1.5 ʻIhi

ʻIhi (*Portulaca villosa*), a candidate species under the ESA, is a perennial, succulent herb that grows on Nihoa in dry sites at elevations of up to approximately 300 m (1,000 ft).

3.2.1.6 Popolo

Popolo (*Solanum nelsonii*), a candidate species under the ESA, is a sprawling or trailing shrub found in coral rubble or sand in coastal sites. On Nihoa, the species occurs on rocky ridges and gulches with soil of basaltic (volcanic rock) origin. Between approximately 8,000 and 15,000 plants occur on the island.

3.2.2 Birds

3.2.2.1 Nihoa Millerbird

The Nihoa millerbird (*Acrocephalus familiaris kingi*), is ESA-listed as endangered throughout its range (**32 FR 4001**). It is a small land bird found only on Nihoa Island (**Morin et al. 1997**). The population has remained stable within its extremely small range (40 ha [100 ac]. The most recent population estimate from 2012 was 384 individuals (**VanderWerf 2012**). On Nihoa Island, millerbirds are known to prefer dense shrub cover near the ground, where they search for food and build nests. The nesting season is suspected to span from January to September. Their food consists entirely of insects and larvae, especially moths and caterpillars (**Morin et al. 1997**).

3.2.2.2 Nihoa Finch

The Nihoa finch (*Telespyza ultima*) is ESA-listed as endangered throughout its range (**32 FR 4001**). They are medium-sized finches restricted to Nihoa Island (**Morin & Conant 2002**). The most recent population estimate based on surveys in 2012 is 4,475 individuals (**VanderWerf 2012**). The species prefers open but vegetated habitat, nesting in small holes in rock outcrops 30 to 244 m (100 to 800 ft) above sea level (**Morin & Conant 2002**). Egg laying begins in February and may extend to early July, with an average clutch size of three eggs. Nihoa finches are omnivorous, feeding on seabird eggs, seeds, flowers, and insects (**Morin & Conant 2002**).

3.2.3 Sea Turtles

As the two species of sea turtles potentially occurring on Nihoa Island are discussed in detail under Kaua‘i species, they are not further discussed in this section beyond noting that no information exists about green turtle nesting activity at Nihoa Island (**Maison et al. 2010**).

Similarly, sightings of hawksbills in the NWHI are rare (**NMFS & USFWS 1998a**). Summarizing historic and contemporary sightings of hawksbill sea turtles in the NWHI, **Van Houten et al. (2012)** identified six definitive observations and three potential nesting records. Based on this information, the authors concluded that hawksbills currently occur within the NWHI (albeit in low numbers), with a lack of regular monitoring within this geographic area likely contributing to the infrequency of documented observations (**Van Houten et al. 2012**).

3.3 *Ni‘ihau*

Eight listed plant species, six listed and one candidate bird species, and two listed sea turtle species may occur on the island of Ni‘ihau. Additionally, designated critical habitat for one plant species is on the island. Because Ni‘ihau is privately owned, comparatively less is known about the current status of its species protected under the ESA.

3.3.1 Plants

3.3.1.1 ōlulu

Species

Olulu (*Brigharnia insignis*) is ESA-listed as endangered throughout its range (**59 FR 9304**). A member of the bellflower family, it is an unbranched plant 1 to 5 m (3 to 16 ft) tall (**USFWS 1995**). *B. insignis* grows from sea level to 400 m (1,300 ft) on rocky ledges with little soil or steep sea cliffs in lowland dry grassland and shrubland (**USFWS 1995**). Historically, *B. insignis* was known to occur at Kaali Spring on the island of Niʻihau.

Critical Habitat

Approximately 144 ha (357 ac) of the northern portion of Niʻihau has been designated as critical habitat for *B. insignis* (**68 FR 9116**). The currently known primary constituent elements of this critical habitat include, but are not limited to, the habitat components provided by:

(i) Rocky ledges with little soil or steep sea cliffs in lowland dry grasslands or shrublands with annual rainfall that is usually less than 170 cm (65 in) and containing one or more of the contributing native plants; and

(ii) Elevations between 0 and 748 m (0 and 2,453 ft).

3.3.1.2 ʻAwikiwiki

ʻAwikiwiki (*Canavalia pubescens*) is ESA-listed as endangered throughout its range (**78 FR 32065**). A climbing plant in the pea family, this species is found in open lava fields and lowland dryland forest. Although it was historically known from Niʻihau (last observed in 1949) and Kauaʻi (last observed in 1977), it is currently found only on the island of Maui, from Puu o Kali south to Pohakea, with a population size of fewer than 200 individuals in a single location.

3.3.1.1 Puʻukaʻa

Puʻukaʻa (*Cyperus trachysanthos*) is ESA-listed as endangered throughout its range (**61 FR 53108**). A member of the sedge family, the species is a perennial grass-like plant with a short rhizome. The species is usually found in wet sites on coastal cliffs. On Niʻihau, an unknown number of individuals is known from an area west of Mokouia Valley.

3.3.1.2 ʻIhiʻihi

ʻIhiʻihi (*Marsilea villosa*) is ESA-listed as endangered throughout its range (**57 FR 27863**). It is an aquatic to semi-aquatic fern that grows in small shallow depressions on level or gently sloping terrain. Although the species was historically (late 1940s) found on Niʻihau, currently it is only found on Oahu.

3.3.1.3 Wahane

Wahane *(Pritchardia aylmer-robinsonii)* is ESA-listed as endangered throughout its range (**61 FR 41020**). A member of the palm family, this species is currently known to occur on Niʻihau in very low numbers (two plants) on the steep, rugged area of Kaali cliff.

3.3.1.4 ʻOhai

On Niʻihau, ʻohai (*S. tomentosa*; described in more detail under *Nihoa*) is known to occur from the south tip of the island at the headland west of Kaumuhonu Bay. The size of this population has not been determined.

3.3.1.5 Lauʻehu

Lauʻehu (*Panicum niihauense*) is ESA-listed as endangered throughout its range (**68 FR 9116**). Although *P. niihauense* historically was known to occur on Niʻihau, currently this species is only known from State-owned land at Polihale State Park on Kauaʻi.

3.3.1.6 Vigna o-wahuensis

Vigna o-wahuensis (no common name) is ESA-listed as endangered throughout its range (**59 FR 56333**). A member of the pea family, the species is a slender annual or perennial herb. Although historically known to occur on Niʻihau, there are currently no known populations on the island.

3.3.2 Birds

The Hawaiian duck, Hawaiian gallinule, Hawaiian stilt, and Hawaiian coot are found in and around the lakes (playas) on the southern part of Niʻihau. The Hawaiian petrel, Newell's shearwater, and band-rumped storm-petrel have been observed in low numbers at Lehua Islet, approximately 1.2 km (0.75 mi) north of Niʻihau (**VanderWerf et al. 2007**). Based upon the findings of **VanderWerf et al. (2007),** Newell's shearwaters and band-rumped storm-petrels probably nest on Lehua.

3.3.3 Sea Turtles

During the preparation of this BE, NASA was unable to locate recent documented occurrences of either green or hawksbill sea turtles on Niʻihau Island. However, as Niʻihau does contain suitable beach habitat for either nesting or basking, it is assumed that the species could occur there. Conversely, Lehua Islet's rocky and generally steep shoreline does not offer any areas where turtles can easily crawl out (**Wood et al. 2004**); therefore, on-land sea turtles would not occur at Lehua.

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4.0 Effects of the Action

This section addresses potential impacts on listed and candidate species and critical habitat that USFWS has identified as having the potential to occur within the action area. In preparing this analysis, the proposed action is divided into the stressors it could impart upon listed and candidate species and critical habitat. Species are grouped, when possible, under each stressor instead of providing a repeated analysis of effects for each species. Despite this "grouping" analytical approach, species-specific considerations are elucidated when they could have a bearing on either the likelihood or significance of the stressor.

It should be noted that in some portions of this Section, avian species are divided into two groups: landbirds and waterbirds. Despite the more common convention of referring to only the Hawaiian stilt, gallinule, coot, and duck as "Hawaiian waterbirds" (e.g., in **USFWS 2014**), the analysis contained herein groups all avian species reliant on the aquatic environment (i.e., Anseriformes, Procelliformes, etc.) into one "waterbird" group with the passerine species grouped as "landbirds." Even with this grouping approach for avian species, when a potential aspect of a stressor only applies to a seabird species, for example, it is given treatment as appropriate and differentiated from those species (e.g., Gruiformes) largely contained within the terrestrial boundaries of Kaua‘i or Ni‘ihau.

4.1 *Supersonic Flight*

Once a MET rocket is launched, and again when the TV is released from the scientific balloon, they would be accelerated to a velocity beyond the sound barrier, at which point they would create sonic booms. When heard at the ground, a sonic boom consists of two shock waves of approximately equal strength. The complete ground pattern of a sonic boom depends on the size, shape, speed, and trajectory of the vehicle creating it. Since typical aircraft fly supersonically with relatively low horizontal angles, the boom is directed toward the ground. However, for the TV ascent trajectory, which would have a much higher horizontal angle (i.e., between 60 and 72 degrees), the boom would be directed laterally. This causes the sonic boom to propagate much further downrange when compared to typical aircraft sonic booms. Extended propagation usually results in very shallow propagation angles, relatively lower sonic boom levels, and negligible energy being transmitted to the earth's surface.

Of all factors affecting the intensity of sonic booms, altitude has the most significant influence. The magnitude of the sonic boom will decrease with increasing altitude of the vehicle, as this requires the boom to travel further through the atmosphere. Given that the TV's flight would become supersonic at altitudes in excess of 35,000 m (115,000 ft), and, when considered in conjunction with the high angle of attack during ascent, the resultant energy transferred to the water's surface would be negligible. Comparatively, given the MET rocket's small mass, aerodynamic shape, and high launch and steep descent angles, the resultant energy transfer would be less than that of the TV. Therefore, the remainder of the discussion focuses on the sonic boom created by the TV.

Atmospheric reentry of an object can also generate a sonic boom on the ground as the body falls back to Earth. For this case, the propagation is directed toward the ground, so the boom is more concentrated around the impact site. As the descent of the TV would also be at supersonic speeds (yet still above 30,500 m [100,000 ft] above ground level [AGL]), this portion of flight would create a more intense (in terms relative to the ascent phase) sonic boom. However, in absolute terms, the potential overpressure felt at the ocean's surface would also be minor for the following reasons.

Herron (2007) modeled the re-entry of NASA's Crew Exploration Vehicle, also a "blunt body vehicle", although substantially heavier (6,700 kg [14,800 lb]) than the TV (3,040 kg [6,700 lb] at drop; 1,300 kg [2,900 lb] when solid propellant is consumed). The results of her work predicted maximum overpressure values ranging from 15.8 to 20.6 pascals (Pa; 0.33 up to 0.43 pounds per square foot [psf]). Similarly, **Hilton & Henderson (1974)** measured the overpressures created by the reentry of the 5,800-kg (12,800-lb) Apollo 15 capsule into the Pacific Ocean, recording values ranging from approximately 9.6 to 38.3 Pa (0.2 to 0.8 psf), depending on lateral distance from the impact location and altitude of the descending spacecraft. By comparison, the NASA Space Shuttle generated maximum overpressures in excess of 59.9 Pa (1.25 psf: **NASA 1989**) and typical supersonic aircraft generate maximum overpressures in the range of 47.9 to 143.6 Pa (1.0 to 3.0 psf: **Richardson et al. 1995**). In an unrelated study of sonic booms of similar magnitude (i.e., 9.6 Pa [0.2 psf]) to those presented in **Herron (2007)** and **Hilton & Henderson (1974)**, observers on the ground who were operating the sonic boom recording equipment within the predicted footprint of the sounding rocket boom "heard the boom but felt that they would not have noticed it had they been engaged in an unrelated activity" (**Plotkin et al. 2006**).

It is expected that the overpressure values generated by the TV reentry would be even less than those predicted by **Herron (2007)** or recorded by **Hilton & Henderson (1974)**, as larger and heavier objects must displace more air and create more lift to sustain flight, thereby creating sonic booms stronger than those of smaller, lighter items. In summary, all other variables being equal, the larger and heavier the object in flight, the stronger the shock waves will be. Therefore, given that both studies indicated only minor overpressures from substantially heavier vehicles of generally the same geometry, it is reasonable to conclude that the TV's overpressures at the Earth's surface would also be minor.

4.1.1 Aspects of Stressor Common to All Species

Animals exposed to a sonic boom could potentially change their behavior, such as becoming alert or moving.

4.1.2 Considerations Specific to Plants

Should plant species or critical habitat be exposed to SFDT-induced sounds, they would not respond to the stimulus and would, therefore, be unaffected.

4.1.3 Considerations Specific to Mammals and Insects

The potential for exposing Hawaiian hoary bats or *Drosophila* spp. to the TV-generated sonic boom would be unlikely as both flight and re-entry (during which there would be the most focused energy) would occur over the open ocean. Coupled with the low intensity of the sonic boom, even if directly under the re-entering TV, the potential for Hawaiian hoary bats or *Drosophila* spp. to modify their behavior in response to the brief acoustic stimulus would be highly unlikely.

4.1.4 Considerations Specific to Avifauna

The flight of the TV would generate sonic booms that could propagate to the ground on Nihoa Island or within the oceanic portion of the action area. However, due to their weak nature, these sonic booms would not be expected to damage eggs (**Ting et al. 2002**), but they could potentially be heard by avian species. Again, due to their weak nature and infrequent occurrence, the resultant effect would at most be a change to an alert posture, though it would be short in duration and would not have a measurable effect on the birds' fitness. Similarly, birds nesting within the action area on Kaua‘i or Ni‘ihau/Lehua Islet would not likely be exposed to sonic booms as TV supersonic flight and re-entry would occur over the open ocean.

4.1.5 Considerations Specific to Sea Turtles

The potential for exposing nesting or basking sea turtles to the TV-generated sonic boom would be unlikely as both flight and re-entry (during which there would be the most focused energy) would occur over the open ocean. Between Kaua‘i, Ni‘ihau, and Nihoa, the probability of sonic boom sound energy propagating to nesting or basking beaches would be greatest at Nihoa. Should a hauled out sea turtle be exposed to a sonic boom, it is unlikely to evoke much, if any, of a physiological or behavioral response at the levels and frequencies that would be propagated to the ground.

Physiologically, although not specific to sea turtles, but using the best proxy available, **Bowles et al. (1999)** exposed desert tortoises to single and repeated simulated sonic booms. None of the eight individuals experienced temporary hearing loss after exposure to single or paired sonic booms (143 dB peak; greater than that expected under the proposed action). As such, in consideration of the low magnitude and infrequent occurrence of the sonic booms under the proposed action, it may be reasoned that sea turtle species would not be exposed to sound levels resulting in measurable physiologic effects.

Likewise, behaviorally, the majority of energy in a sonic boom is less than 100 Hz. Early research on the hearing of green sea turtles by **Ridgway et al. (1969)** identified their maximum hearing sensitivity to be at higher frequencies, namely between 300 and 400 Hz. Consequently, while the potential for a sea turtle detecting the audible stimulus, should it be exposed to it, cannot be completely ruled out, it may be concluded that the resultant behavioral effect, if one even were to occur, would be minor to non-existent.

4.2 *Direct or Proximate Strike*

4.2.1 Aspects of Stressor Common to All Species

There would be only a remote likelihood of the TV or balloon striking or landing near a listed terrestrial species as flight hardware would nominally land in the ocean. Only on the case of a catastrophic failure would the hardware land within terrestrial areas. Although MET balloons could land within terrestrial areas on Kaua‘i or Ni‘ihau, due to their small size they would not possess enough kinetic energy to inflict injurious effects on species in the unlikely event they were to land on them. As such, they will not be discussed further in this Section.

4.2.2 Considerations Specific to Plants

Species

The primary stressor the proposed action could impart upon the listed plants within the action area would be the inadvertent crushing or burial of plants by descending SFDT flight hardware. Similarly, the TV’s hot rocket motor, if coming into contact with dried plant material, could either singe or burn vegetation. Recovery operations could also result in trampling or burial of individual plants. However, the potential for this to occur is highly unlikely.

To reduce the potential for environmental impact to Nihoa Island, one of two scenarios would occur: (1) the LDSD Program would initiate the SFDT in such a manner that expended flight hardware would be recovered before entering Nihoa; or (2) the flight system would overfly the Nihoa, and the TV would be dropped more than 5.5 km (3 nm) from Nihoa Island. It would be only in the condition of a catastrophic failure that flight hardware would land within Nihoa or the 5.5 km (3 nm) buffer around it. Additionally, under the assumption that all possible trajectories were allowed to fly, it is estimated that the balloon has approximately a 0.4 percent chance of reaching float altitude within PMNM and a 20 percent chance of entering PMNM after reaching float altitude. In consideration of these facts, the probability of exposing an individual plant to either project-inducted stressor is so low as to be discountable. Likewise, listed plant species on Kaua‘i or Ni‘ihau would be unaffected by the proposed action unless there were a catastrophic failure of the balloon flight system during its initial ascent phase.

Critical Habitat

Potential stressors on designated critical habitat for either plant species within the action area would be limited to physical damage by the descending flight hardware in the event of a failure. The resultant effect on substrate would be an indentation, or “divot.” Recovery operations could also result in small-scale land disturbance. However, as discussed above under *Species*, the potential for landing on Nihoa, Ni‘ihau, or Kaua‘i and, therefore, potentially affecting designated critical habitat, would be very low and would only occur in the event of a catastrophic failure.

4.2.3 Considerations Specific to Mammals and Insects

With the exception of landing within habitat occupied by the species in the event of a catastrophic failure of the balloon system while ascending over Kaua‘i and, thereby, possibly crushing or disturbing an individual, there would be no potential for a direct or proximate strike by descending flight hardware.

4.2.4 Considerations Specific to Avifauna

Landbirds

Should the descending flight hardware land within an area inhabited by either Nihoa finches or millerbirds, it could result in injury or mortality. Should descending flight hardware land in close proximity to individuals, it could startle them, potentially disrupting breeding, foraging, or resting behaviors. Similar, although more intense, disturbance could also result from recovery activities that required multiple persons to enter Nihoa Island. The Nihoa finch’s egg laying begins in February and may extend to early July, and the nesting season for the Nihoa millerbird is suspected to span from January to September. As such, these species would be particularly sensitive to disturbance during the time of year the proposed action would occur. However, as discussed under *Plants*, the potential for a direct or proximate strike would be very low due to 1) the infrequent nature of the action; 2) the low probability of the SFDT entering the PMNM; and 3) the categorical avoidance of intentionally terminating a flight over Nihoa Island and its surrounding Special Management Area, should the balloon and TV even float that far to the west of Kaua‘i.

Waterbirds

Similar to the discussion under *Landbirds*, nesting waterbirds within terrestrial areas could only be exposed to a proximate or direct strike in the event of a catastrophic failure. Under nominal circumstances, nesting areas would only be overflown by the ascending balloon system. While theoretically possible, the probability of flight hardware landing on or immediately adjacent to in-water listed (e.g., short-tailed albatross) or candidate (i.e., band-rumped storm-petrel) seabirds under nominal flight circumstances would be extremely low due to the infrequent nature of the action and the low density of individuals within the action area.

4.2.5 Considerations Specific to Sea Turtles

Both green and hawksbill sea turtles could be in the action area when the proposed action would occur. However, the vast majority of nesting occurs outside the action area. Moreover, nesting and basking beaches would only be overflown (imparting no stressors on the species) under nominal circumstances. It would be only in the case of a catastrophic failure that flight hardware could have the potential to land within terrestrial areas. When considered within the context of the infrequent nature of the action, and the low density of individuals within the action area, the probability of a direct or proximate strike would be very low.

4.3 *Entanglement*

4.3.1 Aspects of Stressor Common to All Species

According to the literature (major reviews by **Laist 1987, 1997; and Derraik 2002**), entanglement of animal 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 locomotion 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.

4.3.2 Considerations Specific to Plants

This potential stressor is not applicable to listed or candidate plant species or designated critical habitat.

4.3.3 Considerations Specific to Mammals and Insects

No records exist of bats becoming entangled in small items such as the MET balloons. Likewise, the potential for *Drosophila* spp. encountering a small latex balloon within Kaua‘i and becoming entangled would be highly improbable.

4.3.4 Considerations Specific to Avifauna

Landbirds

Although landbird species have been reported as becoming entangled in anthropogenic materials, including twine and ribbon (**Townsend & Barker 2014**), the potential for its occurrence under the proposed action is highly unlikely. As discussed under *Direct or Proximate Strike*, the probability of the balloon or TV landing in a terrestrial area on Nihoa would be very low and only in the event of a catastrophic flight termination. Furthermore, in the unlikely event that a landing on Nihoa was to occur, the flight hardware would be recovered rapidly, negating the potential for individuals to be exposed to this stressor. Although meteorological equipment (e.g., latex balloons) could land within terrestrial areas of the action area (i.e., Kaua‘i), listed passerine species would not be present within those areas, and there would be no probability of interaction with those items.

Waterbirds

Seabirds have also been reported as becoming entangled in marine debris. However, entanglement harms fewer species than ingestion (**Laist 1997**). According to entanglement records reviewed by **Laist (1997)**, Charadriiformes are less likely to become entangled in marine debris, followed by Procellariiformes. It is most likely that seabirds become entangled accidentally when seeking natural prey items in the entangling debris. However, in consideration of the infrequency of the activity, the low density of individuals within the action

area, and the fact that the majority of buoyant items would be recovered, the probability of entangling a listed or candidate species would be very low.

4.3.5 Considerations Specific to Sea Turtles

While theoretically possible that a sea turtle on Kaua‘i or Ni‘ihau could become entangled in cordage on a radiosonde MET balloon or expended flight hardware when traveling between the beach and the marine environment, it would be highly unlikely due to the low numbers of sea turtles observed on either Kaua‘i or Ni‘ihau (radiosondes would not reach Nihoa), the infrequent nature of the action, and the fact that SFDTs (and resultant terminations) would only occur in the open ocean. It would only be in the case of a catastrophic failure that SFDT hardware would land within terrestrial areas, and, in such a case, the hardware would be removed immediately. Likewise, if a radiosonde balloon were identified on the PMRF or Ni‘ihau beaches, it would be recovered immediately.

4.4 *Ingestion*

4.4.1 Aspects of Stressor Common to All Species

Main flight hardware items (i.e., balloon, TV, flight train) would be substantially larger than forage items targeted by listed species in the action area. Additionally, they would be recovered (i.e., balloon and TV) or sink to the ocean floor (i.e., flight train). As such, there would be no probability for ingesting these items. However, foraging individuals could attempt to ingest portions of the expended MET support items, particularly MET balloons floating on the water’s surface. 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; Derraik 2002**).

4.4.2 Considerations Specific to Plants

This potential stressor is not applicable to listed or candidate plant species or designated critical habitat.

4.4.3 Considerations Specific to Mammals and Insects

In consideration of the forage items consumed by Hawaiian hoary bats (insects) and *Drosophila* spp. (microbes), there would be no probability of either species ingesting a small latex balloon or a piece thereof.

4.4.4 Considerations Specific to Avifauna

Landbirds

As smaller, ingestible items (e.g., MET balloons) would not reach terrestrial areas inhabited by listed landbirds on Nihoa Island, there would be no potential for this stressor to occur.

Waterbirds

Of the listed and candidate waterbirds potentially occurring within the action area, the Procellariiformes (e.g., Newell's shearwater) would be at the greatest risk for ingesting floating MET items because of their tendency to forage at or near the ocean's surface (**Azzarello & Van Vleet 1987**; **Day et al. 1985**; **Ryan et al. 1987)**. Due to their preference for plant materials and aquatic invertebrates, the Anseriiformes (e.g., Hawaiian duck) and Gruiformes (e.g., Hawaiian coot) would not be expected to ingest small MET balloons should they encounter them. Similarly, the Hawaiian stilt, a Charadriiforme, would not be expected to ingest the MET balloons due to its preference for small aquatic invertebrates.

Fry et al. (1987) suggest that two classes of plastic debris pose the greatest risk of ingestion by seabirds: 1) debris ranging from 1 to 5 mm (0.04 to 0.20 in) in diameter, which seemed to be most frequently ingested by plankton-feeding seabirds; and 2) larger items up to 20 by 80 mm (0.8 by 3.1 in), which are principally encountered by larger marine birds, such as albatrosses. Additionally, it has been suggested that if the color of a debris item resembles the preferred prey of foraging seabirds, it is more likely to be ingested (**Day et al. 1985**; **Ryan et al. 1987**; **Verlis et al. 2013**). For example, in a recent study, **Verlis et al. (2013)** found that white-colored debris items were most frequently ingested by Australian shearwaters, suggesting that they resembled fish and/or squids. As such, the potential exists for a listed seabird (e.g., Newell's shearwater) to ingest a floating latex MET balloon or portion thereof. However, in consideration of the infrequent nature of the proposed action, the dispersed nature of the expended MET support items within the action area, and eventual degradation and fouling of the balloons (causing the items to sink), the probability of a listed or candidate waterbird ingesting an item would be very low.

4.4.5 Considerations Specific to Sea Turtles

Sea turtles in terrestrial areas within the action area primarily would be nesting or basking. Accordingly, when considered within the context of the infrequency of the action and low density of individuals within the action area, as well as the lack of resemblance between MET balloons and preferred forage items (i.e., greens: aquatic vegetation and hawksbills: sponges), there would be little potential for ingestion of these items should either land within or adjacent to a Kaua‘i or Ni‘ihau beach.

4.5 *Aircraft Overflight*

4.5.1 Aspects of Stressor Common to All Species

Transmission of noise from aircraft to terrestrial areas would be possible. Likewise, a visual stimulus from overflight could also lead to a change in an animal's behavior, although this would likely be temporary.

4.5.2 Considerations Specific to Plants

Should plant species or critical habitat be exposed to recovery aircraft-induced sounds or overflight, they would not respond to the stimulus, and would therefore be unaffected.

4.5.3 Considerations specific to Mammals and Insects

Project related fixed-wing surveillance and recovery aircraft flying at altitudes greater than 457 m (1,500 ft) AGL would generally be expected to cause minimal, if any, response from Hawaiian hoary bats or *Drosophila* spp. on the ground. Additionally, the Hawaiian hoary bat forages primarily just before or after sunset. As the LDSD balloon launch and initiation of aircraft surveillance would occur near dawn, the probability of an aircraft encountering a flying bat is extremely low.

4.5.4 Considerations specific to Avifauna

Project related fixed-wing surveillance and recovery aircraft flying at altitudes greater than 457 m (1,500 ft) AGL would generally be expected to cause minimal, if any, response from birds on the ground or sea surface (based on data provided in reviews, including **NPS 1994; Manci et al. 1988; Larkin et al. 1996; Gladwin et al. 1987**). Additionally, in consideration of the infrequency of the activity, the low density of individuals within the action area, and the fact that the majority of aircraft operations would be over the open ocean, the probability of an aircraft encountering a bird in flight is extremely low.

4.5.5 Considerations Specific to Sea Turtles

Species-specific studies on the reaction of sea turtles to fixed wing aircraft overflight are lacking. Based on sea turtle sensory biology (**Bartol & Musick 2003**), sound from low flying aircraft could likely be heard by a sea turtle at or near the ocean surface. Turtles might also detect low flying aircraft via visual cues such as the aircraft's shadow (similar to the findings of **Hazel et al. [2007]** regarding watercraft), potentially eliciting a brief startle reaction such as a dive or lateral movement. However, in consideration of the infrequent nature of the surveillance flights, the probability of exposing an individual to an acoustically- or visually-induced stressor from aircraft overflight would be very low. Furthermore, because the surveillance and recovery aircraft would be flown at altitudes (i.e., above 457 m [1,500 ft] AGL), well above those which are employed by wildlife agencies when performing aerial surveys of in-water sea turtles (e.g., 152 m [500 ft]: **Epperly et al. 1995**), it can be reasoned that potential effects on a nesting or basking individual, even should it be overflown, would be insignificant.

4.6 *Recovery Vessel Operation*

With the exception of seabirds, no other ESA-listed or candidate species within USFWS jurisdiction would be exposed to potential stressors imparted by recovery vessels. In the case of seabirds, it is expected that project recovery vessels would at most evoke a brief startle reaction. However, due to the infrequent nature of the action and low density of individuals within the oceanic portion of the action area, effects would be negligible.

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5.0 Conclusions

Following ESA consultation guidance developed by **NMFS** (**2013**), NASA applied the following rationale to arrive at its final determinations of effect on listed and candidate species and designated critical habitat in the LDSD SFDT action area:

First, based on the analysis in this BE, the proposed action is likely to produce stressors to which listed or candidate individuals would respond if exposed. However, the likelihood of such exposure has been determined to be extremely remote. Therefore, NASA's determination process is based on "Proposition B" in the NMFS guidance document, which is:

> *The action is likely to produce potential stressors..., endangered or threatened individuals are not likely to be exposed to one or more of those potential stressors or subsidies or one or more of the Action's direct or indirect consequences on the environment;*

Next, once NASA accepted Proposition B as true, NASA identified the first of four potential determination outcomes (identified as outcome 3.1 in the NMFS guidance document) as being applicable to the action considered in this BE, which is:

> *If an agency … accepts Proposition B as true (the action produces stressor or subsidies, but the probability of exposing listed individuals to those stressors is so small that it would not be reasonable to expect them to occur) and can defend that acceptance based on all of the relevant evidence available and the appropriate background, the agency is justified in a "may affect, but not likely to adversely affect" determination (because the probability of effects would be discountable).*

As such, NASA concludes that the proposed action "may affect, but is not likely to adversely affect," all listed and candidate species and designated critical habitat in the action area. **Table 3** on the following page presents a summary of determinations for each species and critical habitat potentially affected by NASA's action:

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Table 3: Summary of Endangered Species Act Determinations

Common Name	Scientific Name	ESA Status	NASA ESA Determination
Plants			
NCN	*Amaranthus brownii*	Endangered	NLAA
ōlulu	*Brigharnia insignis*	Endangered	NLAA
ʻAwikiwiki	*Canavalia pubescens*	Endangered	NLAA
Puʻukaʻa	*Cyperus trachysanthos*	Endangered	NLAA
Nāpali beach hedyotis	*Hedyotis st.-johnii*	Endangered	NLAA
ʻIhiʻihi	*Marsilea villosa*	Endangered	NLAA
Lauʻehu	*Panicum niihauense*	Endangered	NLAA
Wahane	*Pritchardia aylmer-robinsonii*	Endangered	NLAA
Loulu	*Pritchardia remota*	Endangered	NLAA
Māʻoliʻoli	*Schiedea apokremnos*	Endangered	NLAA
NCN	*Schiedea verticillata*	Endangered	NLAA
ʻOhai	*Sesbania tomentosa*	Endangered	NLAA
NCN	*Spermolepis hawaiiensis*	Endangered	NLAA
NCN	*Vigna o-wahuensis*	Endangered	NLAA
Dwarf iliau	*Wilkesia hobdyi*	Endangered	NLAA
ʻIhi	*Portulaca villosa*	Candidate	NLAA
Popolo	*Solanum nelsonii*	Candidate	NLAA
A. brownii critical habitat	N/A	Designated	NLAA
Lauʻehu critical habitat	N/A	Designated	NLAA
Loulu critical habitat	N/A	Designated	NLAA
ʻOhai critical habitat	N/A	Designated	NLAA
ōlulu critical habitat	N/A	Designated	NLAA
S. verticillata critical habitat	N/A	Designated	NLAA
Insects			
Hawaiian picture-wing fly	*Drosophila musaphilia*	Endangered	NLAA
Hawaiian picture-wing fly	*Drosophila sharpi*	Endangered	NLAA
Birds			
Nihoa millerbird	*Acrocephalus familiaris kingi*	Endangered	NLAA
Hawaiian duck	*Anas wyvilliana*	Endangered	NLAA
Hawaiian goose	*Branta sandvicensis*	Endangered	NLAA
Hawaiian coot	*Fulica alai*	Endangered	NLAA
Hawaiian gallinule	*Gallinula chloropus sandvicensis*	Endangered	NLAA
Hawaiian stilt	*Himantopus mexicanus knudseni*	Endangered	NLAA
Hawaiian petrel	*Pterodroma sandwichensis*	Endangered	NLAA
Short-tailed albatross	*Phoebastria albatrus*	Endangered	NLAA
Nihoa finch	*Telespyza ultima*	Endangered	NLAA
Newell's shearwater	*Puffinus auricularis newelli*	Threatened	NLAA
Band-rumped storm-petrel	*Oceanodroma castro*	Candidate	NLAA
Mammals			
Hawaiian hoary bat	*Lasiurus cinereus semotus*	Endangered	NLAA
Sea Turtles			
Green sea turtle	*Chelonia mydas*	Threatened	NLAA
Hawksbill sea turtle	*Eretmochelys imbricate*	Endangered	NLAA

Key: NCN = No common name NLAA = May affect, not likely to adversely affect

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6.0 Literature Cited

Ahmad, Z., Herman, J. R., Vasilkov, A. P., Tzortziou, M., Mitchell, B. G., & Kahru, M. (2003). Seasonal variation of UV radiation in the ocean under clear and cloudy conditions. In *Optical Science and Technology, SPIE's 48th Annual Meeting* (pp. 63-73). International Society for Optics and Photonics. November.

Ainley, D.G., Telfer, T.C. and Reynolds, M.H. (1997). Townsend's and Newell's Shearwater (*Puffinus auricularis*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/297 doi:10.2173/bna.297

Ainley, D.G., Walker, W.A., Spencer, G.C., & Holmes, N.D. (2014). The prey of Newell's Shearwater *Puffinus newelli* in Hawaiian waters. *Marine Ornithology, 44*, 69-72.

Alldredge, A. L., & Silver, M. W. (1988). Characteristics, dynamics and significance of marine snow. *Progress in Oceanography*, 20(1), 41-82.

Allen, N. S., Edge, M., Mohammadian, M., & Jones, K. (1994). Physicochemical aspects of the environmental degradation of poly (ethylene terephthalate). *Polymer Degradation and Stability*, *43*(2), 229-237.

Andrady, A.L. (1990). Environmental Degradation of Plastics under Land and Marine Exposure Conditions. In R. S. Shomura & M. L. Godfrey (Eds.), *Proceedings of the 2nd International Conference on Marine Debris, vol. 1* (pp. 848-869). United States Department of Commerce, Honolulu, Hawaii, USA.

Andrady, A. L. (1994). Assessment of environmental biodegradation of synthetic polymers. *Journal of Macromolecular Science, Part C: Polymer Reviews, 34*(1), 25-76.

Andrady, A. L. (2011). Microplastics in the marine environment. *Marine Pollution Bulletin, 62*(8), 1596-1605.

Andrady, A. L., Hamid, H. S., & Torikai, A. (2003). Effects of climate change and UV-B on materials. *Photochemical & Photobiological Sciences*, *2*(1), 68-72.

Aral, H., & Vecchio-Sadus, A. (2008). Toxicity of lithium to humans and the environment—a literature review. *Ecotoxicology and Environmental Safety*, *70*(3), 349-356.

Azzarello, M. Y., & Van Vleet, E. S. (1987). Marine birds and plastic pollution. *Marine Ecology Progress Series, 37*, 295-303.

Balazs, G. H. (1976). Green turtle migrations in the Hawaiian Archipelago. *Biological Conservation*, *9*(2), 125-140.

Balazs, G.H. (1980). *Synopsis of biological data on the green turtle in the Hawaiian Islands*. NOAA-TM-NMFS-SWFC-7. 141 pp.

Balazs, G. H. (1985). Impact of ocean debris on marine turtles: entanglement and ingestion. In *Proceedings of the Workshop on the Fate and Impact of Marine Debris* (Vol. 2729).

Balazs, G. H., & Hau, S. (1986). Geographic distribution: *Lepidochelys olivacea* in Hawai‘i. *Herpetological Review*, *17*(2), 51.

Banko, P.C., Black, J.M, and Banko, W.E. (1999). Hawaiian Goose (*Branta sandvicensis*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/434 doi:10.2173/bna.434

Bannor, B.K. and Kiviat, E. (2002). Common Gallinule (*Gallinula galeata*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/685 doi:10.2173/bna.685

Barnes, D. K., Galgani, F., Thompson, R. C., & Barlaz, M. (2009). Accumulation and fragmentation of plastic debris in global environments. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *364*(1526), 1985-1998.

Bartol, S.M., and Musick. J.A. (2003). Sensory biology of sea turtles. In P. L. Lutz, J. A. Musick, & J. Wyneken (Eds.), *The biology of sea turtles, Volume II (*pp. 79-102). CRC Press, Boca Raton, Florida.

Bergmann, M., & Klages, M. (2012). Increase of litter at the Arctic deep-sea observatory HAUSGARTEN. *Marine Pollution Bulletin*, *64*(12), 2734-2741.

Bowles, A.E., Eckert, S.E., Matesic, Jr., J., Starke, L., Francine, J., and Stinson, H. (1999). *Effects of flight noise from jet aircraft and sonic booms on hearing, behavior, heart rate, and oxygen consumption of desert tortoises* (*Gopherus agassizii*). Report by Hubbs-Sea World Research Institute and Parsons Engineering Science for U.S. Air Force, Armstrong Laboratory, Brooks Air Force Base TX, on Contract F33615-89-D-4003, Order 0132, May. 131 pp.

Bjorndal, K. (1997). Foraging ecology and nutrition of sea turtles. In P. L. Lutz and J. A. Musick (Eds.), *The biology of sea turtles (*pp. 199-232). CRC Press, Boca Raton, Florida.

Burchette, D. K. (1989). A study of the effect of balloon releases on the environment. National Association of Balloon Artists.

Carr, A. (1987). Impact of nondegradable marine debris on the ecology and survival outlook of sea turtles. *Marine Pollution Bulletin*, *18*(6), 352-356.

Carrión-Cortez, J., Canales-Cerro, C., Arauz, R., & Riosmena-Rodríguez, R. (2013). Habitat Use and Diet of Juvenile Eastern Pacific Hawksbill Turtles (*Eretmochelys imbricata*) in the North Pacific Coast of Costa Rica. *Chelonian Conservation and Biology*, *12*(2), 235-245.

Day, R.H., Wehle, D.H.S., & Coleman, F.C. (1985). Ingestion of plastic pollutants by marine birds. In R. S. Shomura & H. O. Yoshida (Eds.), *Proceedings of the workshop on the fate and impact of marine debris* (Vol. 2729) (pp. 344-386). (Publication No. NOAA-TM-NMFS-SWFC-54). Honolulu, HI: U.S. Department of Commerce.

DesRochers, D. W., Gee, H. K., & Reed, J. M. (2008). Response of Hawaiian Moorhens to broadcast of conspecific calls and a comparison with other survey methods. *Journal of Field Ornithology*, *79*(4), 448-457.

DesRochers, D. W., McWilliams, S. R., Silbernagle, M. D., & Reed, J. M. (2009). Macronutrient profiles of wetland plants consumed by the Hawaiian Moorhen (*Gallinula chloropus sandvicensis*). *Wetlands*, *29*(3), 845-853.

Edge, M., Hayes, M., Mohammadian, M., Allen, N. S., Jewitt, T. S., Brems, K., & Jones, K. (1991). Aspects of poly (ethylene terephthalate) degradation for archival life and environmental degradation. *Polymer Degradation and Stability*, *32*(2), 131-153.

Energizer Holdings, Incorporated. (n.d.). Energizer CRV3 Product Datasheet. 2 pp.

Engilis, Jr., A., Uyehara, K.J, and Giffin, J.G. (2002). Hawaiian Duck (*Anas wyvilliana*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/694 doi:10.2173/bna.694

Environmental Systems Research Institute. (2010). ArcGIS 10.0. Redlands, California.

Epperly, S. P., Braun, J., & Chester, A. J. (1995). Aerial surveys for sea turtles in North Carolina inshore waters. *Fishery Bulletin*, *93*(2), 254-261.

Ezuber, H., El-Houd, A., & El-Shawesh, F. (2008). A study on the corrosion behavior of aluminum alloys in seawater. *Materials & Design*, *29*(4), 801-805.

Flament, P. (1996). *Ocean Currents*. In: Ocean Atlas of Hawai‘i. Available online at: http://oos.soest.hawaii.edu/pacioos/outreach/oceanatlas/currents.php

Foley, A.M. (1990). *A Preliminary Investigation on Some Specific Aspects of Latex Balloon Degradation*. Florida Department of Natural Resources, Florida Marine Research Institute. St. Petersburg, FL. August 3. 4 pp.

Fowler, G. A., & Reiniger, R. F. (1981). Some field and laboratory results obtained with Kevlar mooring lines. In *OCEANS 81* (pp. 151-155). IEEE. September.

Fry, D. M., Fefer, S. I., & Sileo, L. (1987). Ingestion of plastic debris by Laysan albatrosses and wedge-tailed shearwaters in the Hawaiian Islands. *Marine Pollution Bulletin, 18*(6), 339-343.

Gemmill, C. (1998). *Pritchardia remota*. 2011 IUCN Red List of Threatened Species. [Online]. Available http://www.iucnredlist.org/details/38652/0.

Gaos, A. R., Lewison, R. R., Wallace, B. P., Yañez, I. L., Liles, M. J., Baquero, A., & Seminoff, J. A. (2012). Dive behaviour of adult hawksbills (*Eretmochelys imbricata*, Linnaeus 1766) in the eastern Pacific Ocean highlights shallow depth use by the species. *Journal of Experimental Marine Biology and Ecology, 432*, 171-178.

Gladwin, D.N., Asherin, D.A., and Manci, K.M. (1988). *Effects of Aircraft Noise and Sonic Booms on Fish and Wildlife: Results of a Survey of U.S. Fish and Wildlife Service Endangered Species and Ecological Services Field Offices, Refuges, Hatcheries, and Research Centers,* NERC-88/30, U.S. Fish and Wildlife Service, National Ecology Research Center, Fort Collins, CO. 24 pp.

Godard, H. P. (1960). The corrosion behavior of aluminum in natural waters. *Canadian Journal of Chemical Engineering*, *38*(5), 167-173.

Gopalan, R., Somashekar, B. R., & Dattaguru, B. (1989). Environmental effects on fibre—Polymer composites. *Polymer Degradation and Stability, 24*(4), 361-371.

Gregory, M.R., & Andrady, A.L. (2003). Plastics in the marine environment. In: *Plastics and the Environment* (ed A.L. Andrady), John Wiley and Sons, 379-401.

Guedes Soares, C., Garbatov, Y., & Zayed, A. (2011). Effect of environmental factors on steel plate corrosion under marine immersion conditions. *Corrosion Engineering, Science and Technology*, *46*(4), 524-541.

Haines, J. R., & Alexander, M. (1974). Microbial degradation of polyethylene glycols. *Applied Microbiology, 29*(5), 621-625.

Hall, L. (2015). *Parachute*. In: *How Products are Made, Volume 5*. Online at: http://www.madehow.com/Volume-5/Parachute.html.

Hazel, J., Lawler, I. R., Marsh, H., & Robson, S. (2007). Vessel speed increases collision risk for the green turtle *Chelonia mydas*. *Endangered Species Research*, *3*, 105-113.

Hegde, R. R., Dahiya, A., Kamath, M. G., Kanaguli, M., & Kotra, R. (2004). *Nylon fibers*. Online at: http://www.engr.utk.edu/mse/Textiles/Nylon% 20fibers.htm.

Herron, M. (2007). Sonic Boom Assessment for the Crew Exporation Vehicle. AIAA Atmospheric Flight Mechanics Conference and Exhibit, 20-23 August 2007, Hilton Head, SC. AIAA-6635. 23 pp.

Hilton, D. A., & Henderson, H. R. (1974). Measurements of sonic-boom overpressures from Apollo space vehicles. *The Journal of the Acoustical Society of America*, *56*(2), 323-328.

Holmström, A. (1975). Plastic films on the bottom of the Skagerack. *Nature*, *255*, 622-623.

IOC, IHO, & BODC (International Oceanographic Commission, International Hydrographic Organization, and British Oceanographic Data Centre). (2003). *Centenary Edition of the GEBCO Digital Atlas*, published on CD-ROM on behalf of the Intergovernmental Oceanographic Commission and the International Hydrographic Organization as part of the General Bathymetric Chart of the Oceans, British Oceanographic Data Centre, Liverpool, U.K.

Irwin, S.W. (2012). *Mass Latex Balloon Releases and the Potential Effects on Wildlife*. Doctoral Dissertation. Clemson University Department of Wildlife and Fisheries Biology, Clemson, SC. August. 73 pp.

Joos, F., Plattner, G. K., Stocker, T. F., Körtzinger, A., & Wallace, D. W. (2003). Trends in marine dissolved oxygen: Implications for ocean circulation changes and the carbon budget. *Eos, Transactions American Geophysical Union*, *84*(21), 197-201.

Katahira, L.K., Forbes, C.M., Kikuta, A.H., Balazs, G.H., & Bingham, M. (1994). Recent findings and management of hawksbill turtle nesting beaches in Hawai‘i. Page 69 in K.A. Bjorndal, A.B. Bolton, D.A. Johnson, and P.J. Eliazar (compilers), *Proceedings of the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation.* NOAA Technical Memorandum NMFS-SEFSC-351. 323 pp.

Keuper-Bennett, U., & Bennett, P. A. (2002). Home sweet home: Aspects of green turtle and hawksbill presence in their feeding, resting and cleaning areas off Honokowai, West Maui, Hawai‘i (1989–1999). In A. Mosier, A. Foley, and B. Brost, comps. *Proceedings of the 20th Annual Symposium on Sea Turtle Biology and Conservation.* NOAA Technical Memorandum NMFS-SEFSC-477 (pp. 57-59).

Kubota, M. (1994). A mechanism for the accumulation of floating marine debris north of Hawai‘i. *Journal of Physical Oceanography*, *24*(5), 1059-1064.

Laist, D.W. (1987). Overview of the biological effects of lost and discarded plastic debris in the marine environment. *Marine Pollution Bulletin* 18(6): 319–326.

Laist, D.W. (1997). Impacts of marine debris: entanglement of marine life in marine debris including a comprehensive list of species with entanglement and ingestion records. Pp. 99–140. In J. M. Coe and D. B. Rogers (Eds.), *Marine Debris: Sources, Impacts and Solutions*. Springer, New York, NY, USA.

Larkin, R.P., Pater, L.L., and Tazik, D.J. (1996). *Effects of Military Noise on Wildlife: A Literature Review*, USACERL Technical Report 96/21, January.

Lobelle, D., & Cunliffe, M. (2011). Early microbial biofilm formation on marine plastic debris. *Marine Pollution Bulletin, 62*(1), 197-200.

Lutcavage, M.E. & Lutz, P.L. (1997). Diving Physiology. In P. L. Lutz and J. A. Musick (Eds.), *The biology of sea turtles* (pp. 277-296). CRC Press, Boca Raton, Florida.

Maison, K.A., Kinan Kelly, I. and Frutchey, K.P. (2010). Green Turtle Nesting Sites and Sea Turtle Legislation throughout Oceania. U.S. Dep. Commerce, NOAA Technical Memorandum. NMFS-F/SPO-110, 52 pp.

Manci, K.M., Gladwin, D.N., Villela, R., and Cavendish, M.G. (1988). *Effects of Aircraft Noise and Sonic Booms on Domestic Animals and Wildlife: A Literature Synthesis.* U.S. Fish and Wildlife Service. National Ecology Research Center, Ft. Collins, Colorado, NERC-88/29. 88 pp.

McDermond, D.K., Morgan, K.H. (1993). Status and conservation of North Pacific albatrosses. In: Vermeer, K., Briggs, K.T., Morgan, K.H., Siegel-Causey, D. (Eds.), *The Status, Ecology and Conservation of Marine Birds in the North Pacific*. Canadian Wildlife Service Special Publication, Ottawa, pp. 70–81.

Melchers, R. E. (2005). Effect of immersion depth on marine corrosion of mild steel. *Corrosion, 61*(9), 895-906.

Meylan, A. (1988). Spongivory in hawksbill turtles: a diet of glass. *Science (Washington), 239*(4838), 393-395.

Mordecai, G., Tyler, P. A., Masson, D. G., & Huvenne, V. A. (2011). Litter in submarine canyons off the west coast of Portugal. *Deep Sea Research Part II: Topical Studies in Oceanography, 58*(23), 2489-2496.

Morét-Ferguson, S., Law, K. L., Proskurowski, G., Murphy, E. K., Peacock, E. E., & Reddy, C. M. (2010). The size, mass, and composition of plastic debris in the western North Atlantic Ocean. *Marine Pollution Bulletin, 60*(10), 1873-1878.

Morin, M.P. and Conant, S. (2002). Nihoa Finch (*Telespiza ultima*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/639b

Morin, M. P., Conant, S. and Conant, P. (1997). Laysan and Nihoa Millerbird (*Acrocephalus familiaris*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/302

Musick, J.A. & Limpus, C.J. (1997). Habitat utilization and migration in juvenile sea turtles. In P. L. Lutz and J. A. Musick (Eds.), *The biology of sea turtles* (pp. 137-163). CRC Press, Boca Raton, Florida.

NASA (National Aeronautics and Space Administration). (1989). *Descent Sonic Boom Measurements For STS-26.* Document Number: JSC-23579. Houston, TX. April.

NASA. (2013). *Final Environmental Assessment Low Density Supersonic Decelerator Technology Demonstration Mission Pacific Missile Range Facility*. Space Technology Mission Directorate, Washington, DC. May.

NMFS (National Marine Fisheries Service). **(**2014). *Biological Opinion and Conference Report on U.S. Navy Hawai'i-Southern California Training and Testing*. Endangered Species Act Interagency Cooperation Division of the Office of Protected Resources, National Marine Fisheries Service. FPR-2012-9026. April 23. 446 pp.

NMFS. **(**2013). *Effects Determination Guidance.* Pacific Islands Regional Office, NOAA Fisheries Service. Retrieved from http://www.fpir.noaa.gov/Library/PRD/ESA%20Consultation/Effects_Determination_Guidance_05-06-2013.pdf

NMFS & USFWS (National Marine Fisheries Service and U.S. Fish and Wildlife Service). (1998a). Recovery Plan for U.S. Pacific Populations of the Hawksbill Turtle (*Eretmochelys imbricata*). National Marine Fisheries Service, Silver Spring, MD.

NPS (National Park Service). (1994). *Report to Congress on Effects of Aircraft Overflights on the National Park System*. September.

Parker, D. M., Balazs, G. H., King, C. S., Katahira, L., & Gilmartin, W. (2009). Short-Range Movements of Hawksbill Turtles (*Eretmochelys imbricata*) from Nesting to Foraging Areas within the Hawaiian Islands 1. *Pacific Science*, *63*(3), 371-382.

Parker, D. M., Dutton, P. H., & Balazs, G. H. (2011). Oceanic diet and distribution of haplotypes for the green turtle, *Chelonia mydas*, in the Central North Pacific. *Pacific Science*, *65*(4), 419-431.

Pegram, J. E., & Andrady, A. L. (1989). Outdoor weathering of selected polymeric materials under marine exposure conditions. *Polymer Degradation and Stability*, *26*(4), 333-345.

Piatt, J. F., Wetzel, J., Bell, K., DeGange, A. R., Balogh, G. R., Drew, G. S., ... & Byrd, G. V. (2006). Predictable hotspots and foraging habitat of the endangered short-tailed albatross (*Phoebastria albatrus*) in the North Pacific: Implications for conservation. *Deep Sea Research Part II: Topical Studies in Oceanography*, *53*(3), 387-398.

Plotkin, K. J., Haering Jr, E. A., & Murray, J. E. (2006). Low-Amplitude Sonic Boom From a Descending Sounding Rocket. In Innovations in Nonlinear Acoustics: *ISNA17-17th International Symposium on Nonlinear Acoustics including the International Sonic Boom Forum* (Vol. 838, No. 1, pp. 615-618). AIP Publishing.

Pratt, H.D. and Brisbin Jr., I.L. (2002). Hawaiian Coot (*Fulica alai*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/697b doi:10.2173/bna.697b

Reich, K. J., Bjorndal, K. A., & Bolten, A. B. (2007). The 'lost years' of green turtles: using stable isotopes to study cryptic lifestages. *Biology Letters*, *3*(6), 712-714.

Riewald, P., Walden, R., Whitehill, A., & Koralek, A. (1986). Design and Deployment Parameters Affecting the Survivability of Stranded Aramid Fiber Ropes in the Marine Environment. In *OCEANS'86* (pp. 284-293). IEEE. September.

Reinhart, F. M. (1969). *Corrosion of Materials in Hydrospace-Part V-Aluminum Alloys* (No. NCEL-TN-N-1008). Naval Civil Engineering Laboratory, Port Hueneme, CA.

Rice, M. R., & Balazs, G. H. (2008). Diving behavior of the Hawaiian green turtle (*Chelonia mydas*) during oceanic migrations. *Journal of Experimental Marine Biology and Ecology, 356*(1), 121-127.

Richardson, W.J., Greene Jr., C.R, Malme, C.I., & Thomson, D.H. (1995). *Marine Mammals and Noise*. Academic Press, San Diego, CA.

Ridgway, S. H., Wever, E. G., McCormick, J. G., Palin, J., & Anderson, J. H. (1969). Hearing in the giant sea turtle, *Chelonia mydas*. *Proceedings of the National Academy of Sciences, 64*(3), 884-890.

Robinson, J.A., Reed, J. M., Skorupa, J. P., and Oring, L.W. (1999). Black-necked Stilt (*Himantopus mexicanus*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/449 doi:10.2173/bna.449

Rosak, D. A. (1985). *Evaluation of Lithium Sulfur Dioxide Batteries. US Army Communications-Electronics Command and US Army Electronics Research and Development Command, Fort Monmouth, New Jersey, 1 May-1 October 1984* (No. USAEHA-37-26-0427-85). Army Environmental Hygeine Agency, Aberdeen Proving Ground, MD. 17 pp.

Rose, K,. & Steinbüchel, A. (2005). Biodegradation of natural rubber and related compounds: recent insights into a hardly understood catabolic capability of microorganisms. *Applied and Environmental Microbiology, 71*(6), 2803-2812.

Ryan, P. G. (1987). The incidence and characteristics of plastic particles ingested by seabirds. *Marine Environmental Research, 23*(3), 175-206.

Sadove, S. S., & Morreale, S. J. (1990). Marine mammal and sea turtle encounters with marine debris in the New York Bight and the northeast Atlantic. In R. S. Shomura & M. L. Godfrey (Eds.), *Proceedings of the 2nd International Conference on Marine Debris, vol. 1* (pp. 562-570). United States Department of Commerce, Honolulu, Hawai'i, USA.

Seminoff, J.A., Benson, S.R., Arthur, K.E., Dutton, P.H., Tapilatu, R., & Popp, B.N. (2012). Stable isotope tracking of endangered sea turtles: validation with satellite telemetry and δ15N analysis of amino acids. *PLoS ONE*, 7(5): e37403

Shreves, C., & Wilcox, D. (2015). *Assessment of Low Density Supersonic Decelerators (LDSD) balloon flight train/gondola sink rate in an oceanic environment*. NASA Technical Memorandum: 548-TM-1501. March 2. 4 pp.

Simons, T. R. and Hodges, C.N. (1998). Hawaiian Petrel (*Pterodroma sandwichensis*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/345 doi:10.2173/bna.345

Slotterback, J. W. (2002). Band-rumped Storm-Petrel (*Oceanodroma castro*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/673a doi:10.2173/bna.673

Spear, L. B., Ainley, D. G., Nur, N., & Howell, S. N. (1995). Population size and factors affecting at-sea distributions of four endangered procellariids in the tropical Pacific. *Condor*, 613-638.

Terry, B., & Slater, K. (1998). Comparative analysis of synthetic fibres for marine rope. *Journal of Consumer Studies & Home Economics*, *22*(1), 19-24.

Thompson, R. C., Olsen, Y., Mitchell, R. P., Davis, A., Rowland, S. J., John, A. W., & Russell, A. E. (2004). Lost at sea: where is all the plastic? *Science*, *304*(5672), 838-838.

Ting, C., Garrelick, J., & Bowles, A. (2002). An analysis of the response of Sooty Tern eggs to sonic boom overpressures. *The Journal of the Acoustical Society of America*, *111*(1), 562-568.

Tiwari, M., Balazs, G. H., & Hargrove, S. (2010). Estimating carrying capacity at the green turtle nesting beach of East Island, French Frigate Shoals. *Marine Ecology Progress Series*, *419*, 289-294.

Townsend, A. K., & Barker, C. M. (2014). Plastic and the Nest Entanglement of Urban and Agricultural Crows. *PloS one*, *9*(1), e88006.

Tylecote, R. F. (1977). Durable materials for sea water: the archaeological evidence. *International Journal of Nautical Archaeology*, *6*(4), 269-283.

USFWS (U.S. Fish and Wildlife Service). (1995). *Recovery Plan for the Kaua‘i Plant Clusters*. U.S. Fish and Wildlife Service, Pacific Region. Portland, OR. 270 pp.

USFWS. (2004). *Draft Revised Recovery Plan for the Nene or Hawaiian Goose* (*Branta sandvicensis*). U.S. Fish and Wildlife Service, Portland, OR. 148 + xi pp.

USFWS. (2008). *Short-tailed Albatross Recovery Plan*. Anchorage, AK. 105 pp.

USFWS. (2009). 5-Year Review, Short Form Summary *Hedyotis st.-johnii* (Na Pali beach hedyotis). Pacific Islands Fish and Wildlife Office, Honolulu, HI.

USFWS. (2010a). 5-Year Review, Short Form Summary *Wilkesia hobdyi* (*dwarf iliau*). Pacific Islands Fish and Wildlife Office, Honolulu, HI.

USFWS. (2010b). *Spermolepis hawaiiensis* (no common name) 5-Year Review Summary and Evaluation. Pacific Islands Fish and Wildlife Office, Honolulu, HI.

USFWS. (2010c). *Schiedea apokremnos* (maolioli) 5-Year Review Summary and Evaluation. Pacific Islands Fish and Wildlife Office, Honolulu, HI.

USFWS. (2011a). *Biological and Conference Opinions for the Proposed Intercept Test Facility, Pacific Missile Range Facility, Kauai*. 28 March.

USFWS. (2011b). Ōpe`ape`a or Hawaiian Hoary Bat (*Lasiurus cinereus semotus*) 5-Year Review Summary and Evaluation. Pacific Islands Fish and Wildlife Office, Honolulu, HI.

USFWS. (2011c). *Recovery Plan for Hawaiian Waterbirds, Second Revision*. U.S. Fish and Wildlife Service, Portland, Oregon. xx + 233 pp.

USFWS. (2012). Picture-wing fly (*Drosophila musaphilia*) 5-Year Review Summary and Evaluation. Pacific Islands Fish and Wildlife Office, Honolulu, HI.

USFWS. (2014). *Biological and Conference Opinion for Pacific Missile Range Base-wide Infrastructure, Operations, and Maintenance, Kaua‘i*. Pacific Islands Fish and Wildlife Office. September 9.

USN (U.S. Navy). (2014). *Revised Biological Assessment, Effects of Base Infrastructure Operations and Maintenance on Federally Threatened and Endangered Species at Pacific Missile Range Facility Kaua‘i, Hawai‘i*. Naval Facilities Engineering Command Pacific, Pearl Harbor, HI. August 25.

Van Cauwenberghe, L., Vanreusel, A., Mees, J., & Janssen, C. R. (2013). Microplastic pollution in deep-sea sediments. *Environmental Pollution*, *182*, 495-499.

VanderWerf, E.A. (2012). *Hawaiian Bird Conservation Action Plan*. Pacific Rim Conservation, Honolulu, HI.

VanderWerf, E. A., Wood, K. R., Swenson, C., LeGrande, M., Eijzenga, H., & Walker, R. L. (2007). Avifauna of Lehua Islet, Hawai'i: Conservation Value and Management Needs 1. *Pacific Science*, *61*(1), 39-52.

Van Houtan, K. S., Kittinger, J. N., Lawrence, A. L., Yoshinaga, C., Born, V. R., & Fox, A. (2012). Hawksbill sea turtles in the northwestern Hawaiian Islands. *Chelonian Conservation and Biology*, *11*(1), 117-121.

Vargel, C. (2004). *Corrosion of aluminum*. Oxford: Elsevier Ltd.

Verlis, K. M., Campbell, M. L., & Wilson, S. P. (2013). Ingestion of marine debris plastic by the wedge-tailed shearwater *Ardenna pacifica* in the Great Barrier Reef, Australia. *Marine Pollution Bulletin*, *72*(1), 244-249.

Wahl, M. (1989). Marine epibiosis. I. Fouling and antifouling: some basic aspects. *Marine Ecology Progress Series*, *58*, 175-189.

Wood, K.R., VanderWerf, E.A., Swenson, C., LeGrande, M., Eijzenga, H., & Walker, R.L. (2004). *Biological Inventory and Assessment of Lehua Islet, Kauaʻi County, Hawaiʻi*. Final Report Prepared for the U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office. USFWS Research Grant No: 12200-1-J014. May 24. 62 pp.

Work, T. M., & Balazs, G. H. (2010). Pathology and distribution of sea turtles landed as bycatch in the Hawaiʻi-based North Pacific pelagic longline fishery. *Journal of Wildlife Diseases*, *46*(2), 422-432.

Ye, S., & Andrady, A. L. (1991). Fouling of floating plastic debris under Biscayne Bay exposure conditions. *Marine Pollution Bulletin*, *22*(12), 608-613.

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